COMPARISON OF DYSPHONIA SEVERITY INDEX IN PRE PUBERTAL FEMALE TRAINED CARNATIC CLASSICAL SINGERS AND NON-SINGERS

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Manasagangothri

Mysore

MAY-2015

CERTIFICATE

This is to certify that this dissertation entitled "**Comparison of Dysphonia Severity Index in Pre-pubertal Female trained Carnatic Classical singers and non-singers**" is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech-Language Pathology) of the student (Registration No: 13SLP009). 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 Diploma or Degree.

Mysore

May 2015

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Mysore
May 2015

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DECLARATION

This is to certify that this dissertation entitled "**Comparison of Dysphonia Severity Index in Pre-Pubertal Female trained Carnatic Classical siners and non-singers**" is the result of my own study under the guidance of Dr. Geetha, Professor in Speech Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any Diploma or Degree.

Mysore
May, 2015

Register No: 13SLP009

Dedicated to My Loving Father, who is a source of strength and support right from the very start day of my life.

Your Guiding Hand on My Shoulder Will Remain Forever...

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Every time I count my blessings, my love for God becomes more and Every time I count my struggle my faith in God becomes more...

I will take a minute to thank God for his blessings throughout the completion of this work. I owe my gratitude through my prayer.

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Amma and Appa thank you so much for encouraging me and supporting me in each and every step of my life, without your blessings everything is incomplete . Love you both and am really blessed to have parents like you.

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CHAPTER I

INTRODUCTION

Singers utilize their voice in very unique ways giving aesthetic impression. Singer's voice seems so unique that common conclusions concerning voice are almost certainly tough to conclude from the way they utilize their voices.

Like any other professional voice users, singers are also known to experience voice problems. Timmerman's (2004) study revealed that with intensive voice training there will be noticeable improvement in voice quality in potential professional voice users. The voice training effect is most significant after 9 months and seems to strengthen in the subsequent 9 months. Since the professional voice users have inadequate perception of their own voices they fail to recognize the significance of their voice for their future jobs. Hence, to validate the effectiveness of voice training, a long term follow-up is very much essential.

Review of literature have shown that there is a difference in physiological (Respiratory, laryngeal, articulatory) methods with respect to trained and untrained singers and these differences in physiological aspects are noted in terms of singing and not in terms of speech. In additional Brown, Elizabeth, William (2005) studied on self-generated air pressures and how it differs among trained singers and untrained individuals in terms of creating and maintaining a balanced level of air pressure. Results revealed that there was no much difference between the two groups with respect to their capacity to discriminate and or to control breath pressure and they attributed this to voice training alone and not due to physiological difference.

Voice problems in singers may cause changes in their pitch, loudness and voice quality which can adversely affect the singer's voice. For ex., slight change in voice quality can get noticed while singing and this can ruin the song. Singers may not be able to reach their upper or lower end of singing scale. Hence, voice problems in singers need to be identified early and appropriate management strategies need to be initiated.

One can perceive and differentiate an individual's normal voice in two stages that is, before and after the onset of puberty. The structural and functional changes in voice in

normal individuals will influence their phonatory and respiratory capabilities. There are studies about the voice changes with ageing (Muller 1997).

Rinta et al, (2009) examined on pre-pubertal aged children to investigate the perceptual association between speaking and singing behaviours of children. A total of 60 children with the age range of 10 years participated in the study and their voice were recorded in terms of singing and speaking tasks. Voice assessment protocol was used and individually analysed the samples perceptually. Findings showed that there was a significant connection in the vocal functions and voice quality of the children, voice quality between the tasks (there was a correlation between speaking and singing). This shows that the two tasks focusing on singing and speaking behaviours are connected perceptually through their voice quality and vocal functioning. They suggested that children have only one voice which is used differently for both singing and speaking behaviour.

There is no much research on adolescent female voice compared to the changes noticed in male voice, though the need at present is especially required in female teachers. There will be change in female voice also and hence it is necessary and there is need to investigate on it.

There is a difference in terms of males and females with respect to the anatomical and physiological changes and reported findings noticed that change in voice persists for four years in females and the changes begins at the age of 10 years. Further, they also reported that in females, the growth spurts approximately two years before males and many physical changes like increase in size of the larynx with respect to thickness and length.

Other differences between males and females noticed in terms of vocal physiology during puberty are increase in the size of the vocal folds in females (3 to 4 millimetres) than males. At this stage incomplete glottis closure was seen in females because of unevenness in the vocal folds and further they attributed to the breathy or weak voice in females (Hoffer, 1991). Further, author also reasoned out for the breathy vocal quality to "muscular immaturity, which indicates lack of ability to control and coordinate the muscles responsible for breathing, and insufficient voice development".

A decrease in voice presentation may have serious consequences for actors, singers, and other voice professionals. Hence It is necessary to evaluate and analyze these problems in the initial stages so that further problems could be prevented before more permanent damages occur. The two main voice assessment tools to analyse the limitations of vocal performance are the hoarseness profile and voice range profile . The Ling WAVES VDC measures both quantitative and qualitative voice parameters. The Ling WAVES VDC is a time saving analysis solution which helps in diagnostic evaluation of functional voice disorders, and provides the baseline measure for a voice treatment and it can be used to measure the multiple measurements for the control of therapy effectiveness. Therefore, it is especially helpful in everyday use and practice.

Assessment of voice can be conducted using different approaches. Previously, perceptual analysis of voice was used extensively and was considered as the gold standard for the measurement of voice. This is because perceptual analysis was easy and it provided the global evaluation of voice of the person (Orlikoff, Dejonckere & Dembowski, et al., 1999). However, because of its poor reliability, problems in scale validity, and problems with the credibility of the assessment, this procedure was not used alone. Other additional measures such as acoustical analysis of voice have added accountability to the measurement of voice. Acoustic analysis is a non-invasive

procedure, which can be used both for voice assessment and for assessing treatment efficacy. Over the years, different multi parametric acoustic analysis procedures have been developed for the quantification of voice (Awan & Roy, 2005; Awan & Roy, 2006; Awan & Roy, 2009; Callan, Kent, Roy, & Tasko, 1999; Frolich, Michaelis, Stube, & Kruse, 2000; Michaelis, Gramss, & Strube, 1997). Dysphonia Severity Index (DSI) is one such widely used measure.

Dysphonia Severity Index (DSI) (Wuyts, De Bodt, Molenberghs, Remacle, Heylen, Millet, et al., 2000) is an objective and quantitative measure of voice quality. It has been reported that DSI correlates with the perceived voice quality and is very sensitive to slight change in the voice quality and vocal function (Wuyts et al., 2000). The DSI parameters are relatively easy and quick to be obtained. The Dysphonia Severity Index calculates 4 voice parameters: jitter (%), maximum phonation time (MPT in seconds), lowest intensity (I-Low in dB) and highest frequency (F0-High in Hz), and these parameters are measured based on sustained vowel /a/. The values of 4 parameters are obtained and DSI is calculated using the following formula:-

DSI = 0.13xMPT (seconds) + 0.0053xFo high (Hz) – 0.26xI low (dB) – 1.18xjitter (%) +12.4

The values of DSI may range from +5 (indicating normal voice) to -5 (indicating severe dysphonia). DSI has been used as a tool to differentiate normal versus disordered voice (Wuyts et al., 2000), to identify the effect of age and gender (Hakkesteegt, Brocaar, Wieringa, & Feenstra, 2006), and to document the effect of specific management (Marieke, Hakkesteegt, Michael, Brocaar, Wieringa, 2008) for voice problems. Although DSI has been found to significantly correlate with GRBAS scale (Hakkesteegt, Brocaar, Wieringa, & Feenstra, 2008), there was no significant correlation

between voice handicapped Index (VHI) and DSI scores (Hakkesteegt, Brocaar &Wieringa, 2010; Wuyts et al., 2000).

1.1 Need for the study:

- There is very limited literature available on singing voice of children, especially in young professional voice users compared to adult singers using DSI. Further there is no data available regarding comparison of DSI in trained Carnatic and non Carnatic classical singers in female pre-pubertal population in the Indian context.
- Pre-pubertal voice comparatively differs with adult population in respiratory, phonatory capabilities which might affect their voice parameters. Like Western classical singers, Carnatic singers undergo regular training and practice to achieve proficiency in singing. Like any other professional voice users, trained Carnatic classical singers also experience voice problems. However, because of their increased vocal capabilities, their DSI values may range within the normal limits of non-singers (Awan & Ensslen, 2010).
- Hence, there is a need to compare DSI values for trained carnatic singers with non-singers in pre-pubertal population. It will be interesting to see if early intensive training in music will have any effect on DSI parameters which may facilitate fine tuning of voice quality in young children. For this purpose, the present study was planned as there is limited database with regard to pre-pubertal female singers. This is the most crucial age at which most female singers appear for their junior/senior music examination requiring intensive practice.

The aim of the present study is to see if female pre-pubertal trained classical singers differ from non-singers on Dysphonia Severity Index scores.

The specific objectives of the study are:

1. To investigate the differences if any in pre-pubertal trained female classical singers and non-singers on Dysphonia Severity Index scores.
2. To investigate the differences if any in pre-pubertal trained female classical singers and non-singers on various measures of the Dysphonia Severity Index.

CHAPTER II

REVIEW OF LITERATURE

Speech production is a complex activity which is made possible by intricate and collective work of the four systems. They are respiratory, phonatory, articulatory and resonatory systems (Zemlin 1998), which are under the overall control of the nervous

system for the smooth, sustained coordination. The movement of the air which is expelled from the lungs is the major source of energy for voice production. This balanced air stream is modulated by vocal cords into sequence of puffs. Finally this become as an audible buzz Thus, the aerodynamic energy in the subglottic area is transformed to sound energy at the glottis.

To change the pressure and flow of the pulmonary system into acoustic power Vocal efficiency is a quantitative measure. It is the capability of the larynx that is transmitted through the vocal tract and which is measured at the lips (Tang & Stathopoulos, 1995). Energy has many diverse forms and the human body absorbs energy in one form and releases it in another (Titze, 1992). According to (Koyama, Harvey, & Ogura 1972) singing voice is one of those forms of released energy.

2.1 Age related changes in voice

A constant change will be happening with respect to voice which is quite unique in female population. Aging can affect few aspects pertaining to voice like loudness, quality and vocal pitch, but such effects are highly unpredictable across the aging population (Muller, 1997).

In a study by Raming and Ringel (1982) considered 48 men representing three chronological ages (age ranging from 25–75) and they were also further considered as good and poor according to their physic. In addition they also studied acoustic characteristics (mean fundamental frequency, jitter and shimmer) which were measured using a fundamental frequency analysis program (SEARP) .They analyzed voice samples of connected speech and sustained vowel production. Significant improvement was noticed in participants in good physical condition with increased maximum duration vowel phonation with significantly less jitter and shimmer and larger phonation

range compared to participants with poor physical condition. These differences were most noticeable in the production of the elderly subjects. These results suggest that age-related changes in body physiology, or physiological aging, also must be considered this is because chronological aging is a major contributor for the changes in the considered acoustical measures.

Awan (2006) studied the aging female voice with respect to acoustic and respiratory data. The study was to extend understanding of the effects of aging on the female voice by obtaining measures of both acoustic and respiratory-based performance in different age groups (18–30, 40–49, 50–59, 60–69, and 70–79-years). The considered acoustic measures were pitch sigma, jitter, shimmer, and signal-to-noise ratio, speaking fundamental frequency (SFF), including respiratory-based measures maximum phonation time (MPT), vital capacity (VC), and phonation quotient (PQ) were measured. Results revealed that there was significant difference for the aging groups with respect to MPT, pitch sigma, SFF, and VC. In addition to this to classify subjects according to age groups, discriminant function analysis was used with the help of a three-variable model which include SFF, VC, and pitch sigma (accuracy of 84%), and to classify into pre versus post-menopausal condition, a two-variable model consisting of pitch sigma and VC (accuracy of 92%) were considered. This suggested decrease in the respiratory and laryngeal mechanisms may occur at the same time in the aging female population.

2.2 Voice in females in singing

According to Vennard (1962) singing is defined as producing musical tone by means of voice. Singing requires variety of phonatory, articulatory and resonatory

adjustment and differs from speaking in terms of both qualitatively and quantitatively specially on parameters like rhythm and melody (Luchsinger, 1965) and requires specific physical skills.

Pre-pubertal voice comparatively differs with that of adult population in respiratory, phonatory capabilities which affect their voice parameters. One can perceive and differentiate an individual's normal voice in two stages- that is, before and after the onset of puberty. The structural and functional changes in voice in normal individuals will influence their phonatory and respiratory capabilities. According to Amir, Ofer Biron-Shental, and Tal (2004) sex hormone fluctuations were shown to affect female vocal folds and laryngeal function. Laryngeal changes are evident throughout the span of life, starting at puberty with the arousal of the hormonal system, fluctuating systematically during the reproductive years with the menstrual cycle, and then changing again with the decline of hormonal activity at menopause. Hence, larynx has been shown to be a hormonal target organ and, as such, sex hormones affect its morphology, histology and function, similar to their effect on the genitals and other organs. Therefore, knowing the relation between sex hormones and the larynx could assist in understanding the mechanisms of voice production, and it could provide the clinician with supplemental diagnostic information on different medical conditions.

2.3 Characteristic features of voice in professional singers

Basicaly, speaking and singing has been regarded as two completely separate sets of behaviours in both clinical and educational settings. Since client's speaking ability is considered to be major concern of vocal behaviour, treatment of speech and voice disorders is very much essential. According to a broader voice-science perspective, which commented that the same vocal structure is used for both speaking

and singing, it may be likely to consider singing in both speech and voice therapy (Rinta, & Welch, (2008).

Research literature review has revealed that during singing the trained singers use different physiological strategies compared to untrained singer and authors noted physiological differences in terms of respiratory, laryngeal, articulatory systems in singers and this usage of different physiological strategies were seen only during singing and not during speech and they attributed this to voice training alone and not due to physiological difference.

According to Mendes (1983) vocal training has been associated with the distinctions in the physiological, acoustic, and perceptual parameters found in singers compared to non-singers.

According to Sataloff (1997) the anatomy of the professional voice users are not limited to trachea and hyoid bone only. In trained professional voice users the extrinsic muscles maintain the larynx in a relatively constant position and the intrinsic muscles, especially in trained professional voice users, maintain the symmetry and regular periodicity of vocal folds. Physiological aspects in singers voice has been reported to have increased sub glottal pressure which controls pitch and loudness, increase in pitch, respiratory and phonatory parameters, increase in MPT and SPL.

Rinta et al, (2009) examined on pre-pubertal aged children to investigate the perceptual association between speaking and singing behaviours of children. A total of 60 children with the age range of 10 years participated in the study and their voice were recorded in terms of singing and speaking tasks. Voice assessment protocol was used and individually analysed the samples perceptually. Findings showed that there was a significant connection in the vocal functions and voice quality of the children, voice

quality between the tasks (there was a correlation between speaking and singing). This shows that the two tasks focusing on singing and speaking behaviours are connected perceptually through their voice quality and vocal functioning. They suggested that children have only one voice which is used differently for both singing and speaking behaviour.

There are very many studies comparing voice proficiency of trained singers with non-singers yet there are limited studies on young professional voice users (children), especially comparing young singers and non-singers vocal proficiency.

2.4 Voice problems in singers

Among the classical music, Carnatic music is known to be learnt by most of the singers in the Indian context. It is a classical south Indian style of music that involves rigorous training to produce an “open throated” loud, predominantly low-pitched singing, embedded with vocal nuances in higher pitches. Like the Western classical singers, Carnatic singers undergo regular training and practice to achieve proficiency in singing. Like any other professional voice users, trained Carnatic classical singers also experience voice problems.

Adkins, Michel and Carpentert (1979) studied the maximum phonation duration of /s/ and /z/ in children. As reported by clinical literature, in determining the contributions of respiratory vocal mechanisms to disordered voice population, a ratio of the maximum duration of /s/ to /z/ has been helpful. The study focused on obtaining initial normative data for the maximum phoneme duration (MPD) of /s/ and /z/ and further to determine the ratio of /s/ to /z/ in male and female children in the age range of 5, 7 and 9 years . Results revealed no significant differences in MPD for either /s/ or /z/ between males and females at any age level, and in addition significant increase in the MPD of /s/

and /z/ for both males and females as a function of age. Whereas no significant difference was seen in terms of ratio of /s/ to /z/ between males and as a function of age.

Wilcox and Horii (1980) studied changes in vocal jitter in 20 young and 20 older adults with age. Further the vocal jitter was measured for sustained phonations of vowels (/i, a, and u/). With the help of an automatic fundamental frequency tracking program which utilized a peak-picking method of voice analysis Jitter was measured. The results revealed that the older adults had significantly greater vocal jitter for older adults compared to young adults with difference in jitter magnitudes among the considered vowels.

Vocal training has been associated with the differences in the physiological, acoustic, and perceptual parameters especially for singers compared to the voices of non-singer, Mendes (1983). This study reported there will be noticeable changes in the singing voice as a function of vocal training over time. Study considered singing voice samples of 14 individuals in which 12 were females and 2 were males age ranging from 17–20 years for four consecutive semesters. Fundamental frequency (F_0) and sound pressure level (SPL) of the maximum phonational frequency range (MPFR), vibrato pulses per second, vibrato amplitude variation, and the presence of the singer's formant were the acoustic measures which were considered. The results showed significant effect of vocal training on the MPFR, F_0 and SPL acoustical parameters. On the other hand, as a function of vocal training there was no significant improvement on vibrato or singers' formant.

Watson and Hixon (1985) examined respiratory kinematics in 12 adult male intensive classical opera singers, those who work in combination with musicians and perform a theatrical work along with combining text and they refer it as libretto and

musical score. Authors recorded the changes in the anterior and posterior diameter of the rib cage and abdomen in three conditions, one was respiration, secondly while speaking and thirdly those aspects were measure during singing. Further, the measurements obtained from the recordings of the volumes were subjected to analysis for the three conditions. Results revealed that abdomen served as major element for the correct posture and which mechanically tunes the diaphragm along with rib cage in the direction of best configurations for concert. They also reported that rib cage serve towards generating the pressure-flow which mainly helps in regulating the exhalatory force. Another, major muscle responsible for inhalatory mechanism is diaphragm which helps in re-inflating the lungs during the muscular actions. Hence the results can be inferred as role of each parts of respiration is different and vital in nature for the singing task specifically. There was also slight correlation between the singers description on breathing and obtained patterns.

Glaze, Bless, Milenkovic, and Susser (1988) measured acoustic characteristics in 121 children's voice between the ages of 64 and 134 months. Voice recording of these children were acoustically analysed on a sustained neutral /a/ vowel, where they were instructed to phonate at normal pitch and loudness. The considered acoustical parameters were jitter, shimmer, fundamental frequency and signal to noise ratio. This study information is presented mainly to differentiate effects of age, sex, height, and weight on the considered acoustic parameters. Results showed statistically significant relationships between frequency and sex, with frequencies being higher for girls. In addition noticeable positive relationship was present between shimmer and height and a negative relationship between SNR and height.

To focus on medical assessment and management of singers voice, Spiegel, Sataloff, Cohn, and Hawkshaw (1988) studied respiratory function in singers. Study

highlighted on the assessment of respiratory function by considering the complaints of the singers which included general history, physical examination, laboratory testing, and endoscopic procedures. Allergy testing and pulmonary function test were majorly considered and they were evaluated in detail. Respiratory function difficulties due to mild disease states, exposure to environmental irritants, and the athletic demands of performance were majorly seen in singers. Hence the treatment for common ailments such as allergic rhinitis and bronchitis should be focussed towards treatment of the active singer.

Stathopoulos and Sapienza (1993) used respiratory and laryngeal measures of children during vocal intensity variation. Simultaneous aerodynamic, acoustic, and kinematic measurements from the laryngeal and respiratory systems were made in order to study mechanisms for changing vocal intensity. Aerodynamic and acoustic measures included an approximation of open quotient, maximum flow declination rate, alternating glottal airflow, estimated tracheal pressure, sound pressure level, and fundamental frequency. The respiratory measures included lung volume, rib cage, and abdominal displacements. Adults were used as a comparison group to twenty 4-year-olds and twenty 8-year-olds. Laryngeal and respiratory results indicated that speech production differences between the children and adults are based both on size and function. For example, children's absolute anterior-posterior diameters of the rib cage are smaller than adults, but their rib cage movement is larger and encompasses a different range during speech breathing. Since children are functionally different than adults, age specific speech production models need to be developed.

Caroll, Sataloff, Heuer, Spiegel, Radionff, and Cohn (1995) considered trained classical solo singers who had experience in formal classical singing for more than 3

years and in addition they also studied respiratory and glottal efficiency measures. They considered 40 classically trained singers with normal laryngeal function. To assess glottal efficiency; Mean flow rates, Maximum phonation times and Phonation quotients were obtained from all the subjects. In addition they also considered pulmonary function test which gave information on forced expiratory volume forced vital capacity and forced expiratory flow. The results obtained were compared with previous published normal values, which were not specially derived from trained singers, but which were used commonly in voice laboratories. The differences found suggested the need for separate normative data to be used for evaluation of the vocal participants.

Ptacek, Sander, Maloney and Jacksonet (1996) studied phonatory and related changes with advance age. The performances of younger adult (under age 40) and geriatric (over age 65) subjects were assessed on the following tasks: (a) maximum pitch range, (b) diadochokinesis, (c) maximum vowel intensity, (d) maximum vowel duration, (e) maximum intraoral breath pressure, and (f) vital capacity. On all of these tasks the geriatric subjects showed reduced scores when compared with younger adults.

Barlow and Howard (2002) evaluated the voice source changes of child and adolescent subjects undergoing training in singing. Voice sample of 127 child singers and non-singers in the age range of 8-18 years were analysed using electro-laryngographic measures. The results showed that it was possible to divide subjects in to groups with respect to gender, age, and the period of vocal training received. Female subjects showed a noticeable development of voice source production based on the length of training received, whereas male subjects showed patterning with respect to both age (in addition related pubertal development), and period of training received. It was concluded that training a young voice has a scientific measureable effects on the

singing voice production of the child, especially on female voice, while pubertal development also creates quantifiable special effects on the voice source production of the male.

Leborgne (2002) noticed Phonetogram contour changes in 21 trained singers, and mainly focused on two aspects that is frequency range expansion and/or intensity control for a duration of 9 months. Findings revealed that 9 months of vocal training would result in more positive effects in voice quality (wider frequency range and greater intensity) for singers.

Akerlund, Grammind, and Sundberg (2005) studied changes in mean fundamental frequency and mean loudness of phonation in 10 female professional singers and 10 untrained women. All participants were instructed to read continuous texts at three different vocal loudness levels and also when exposed to white noise and filtered noise. The singers group increased their mean fundamental frequencies and sound pressure levels significantly more from the normal to the loud conditions than the non-singers. In both noise conditions, a significant increase was observed from the normal condition for the frequency parameter only, and not for the loudness. The singers also produced a significantly higher upper phonetogram contour than the non-singers. The total dynamic range was better reflected by the phonetogram if single pitches were given to the subjects as an alternative of triads.

Namitha and Savithri (2005) studied fundamental frequency and intensity control in singers and non-singers and investigated whether the pitch and loudness were independent. Two groups were taken. Group one consisted of five professional singers with singing experience of minimum three years and group two consisted of non-singers without any vocal training and their age ranged from 23 to 50 years, The authors used

two tasks, one in which the participants were asked to phonate /a/ from low to high pitch and in task two they were asked to sing swara /sa/ in three different levels of loudness. Using ‘FBAS’ program of SSLPPro2 V2 software F0 and intensity were extracted. The results showed no significant difference between singers and non-singers. The participants in both the groups could maintain same loudness with increase in F0 and could maintain same F0 with increase in loudness.

Heide, Gelbrich, Tascher, and Dietz (2006) in their study, A total of 164 healthy children and adolescents age ranging from 11-16 years, in which 86 participants without singing activity formed group A and 78 members who were youth choirs formed group B. With the help of voice range profile fundamental frequency and dynamic range of voice and its borders, mean frequency which includes normal and loud phonation, maximum voice intensity, and maximum duration of intonation (the extent to which the amount of physical power used in an activity) were measured. Their results showed significantly higher ranges of frequency and intensity in singing children and adolescents. For group B the borders of the dynamic range and the upper border of the frequency range were significantly higher and further they also used a higher mean fundamental frequency during loud phonation. No significant differences were noticed between groups in terms of maximum voice intensity but an affinity towards higher values in singing children. As an unpredicted result, they found significantly higher values in maximum duration of intonation in group A free of age and gender which seems to be linked to the methods used. It was concluded that Regular training of the singing voice results in positive effects on several voice parameters in children as well as adolescents.

Preakup (2012) aimed to see whether there were differences in acoustic measurements between older and amateur singers and non-singers and further to see whether there were significant correlation between acoustic measurements and listener's perceptual judgement of speaker's age. The study included 60 speaker participants 30 males and 30 females and another group included 60 participants which included 30 males (15 singers and 15 non-singers) and 30 females (15 were singers and 15 non-singers). In addition, 10 speech-language pathology graduate students were taken as listener participants to estimate the age of speaker participants from recorded vowel sounds between the age ranges from 60-85 years without any vocal pathology. The inclusion criterion for singers was that they should have involved in choir singing for 10 years. Listener participants included 10 graduated students from speech pathology and audiology who had not taken voice disorders as subject any of the time and with normal hearing sensitivity. The speakers were asked to say vowel /a/ up to 5 sec which was captured through laptop at a sampling frequency of 44.1 KHz. The parameters assessed were jitter, shimmer, frequency and intensity measurements. The results showed that the speaker participants' voice was perceived to be less than their actual age. Voice perception was better in male and female singers compared to non singers. There was significant difference in jitter and intensity parameters with significantly less jitter percentage and more intensity compared with non-singers. The perceived age was correlated to jitter in male singers and non-singers and female singers and was found correlating to intensity values in female non-singers. No differences were found between singers and non-singers with respect to F0 and shimmer values, and between perceived age and intensity in male singers and non-singers and female singers.

Ravikumar, Arunachalam, and Bhoominathan (2014) aimed to study the nature of voice problems in singers and apply a regular protocol to assess the voice. Their

study included 45 trained performing Carnatic singers (36 females and 9 males) who reported to a care hospital with voice problems and they underwent voice assessment. The results revealed that voice change, difficulty in singing higher pitches, and voice fatigue were chief complaints. Most of the singers suffered laryngo-pharyngeal reflux that coexisted with muscle tension dysphonia and chronic laryngitis. The speaking voices were rated primarily as “moderate deviation” on GRBAS (Grade, Rough, Breathy, Asthenia, and Strain) scale. The maximum phonation time ranged from 4 to 29 seconds (females: M-10.2, SD-5.28 and males: M-15.7, SD- 5.79). The singing frequency range was reduced (females: 21.3 semitones and males: 23.99 semitones). The Dysphonia Severity Index (DSI) scores ranged from 3.5 to 4.91 (females: M-0.075 and males: M- 0.64). The singing frequency range and DSI did not show major differences between genders and across clinical diagnosis. The self-perception using voice disorder outcome profile revealed an overall severity score of 5.1 (SD: 2.7) for both groups. The authors concluded by highlighting the nature of voice problems (hyper functional) and required modifications in assessment protocol for Carnatic singers. The need for regular assessments and vocal hygiene education to maintain good vocal health was also emphasized.

Radishkumar and Balasubramanium (2015) studied cepstral characteristics of voice in female Carnatic singers. The study included 30 Indian female Carnatic classical singers and 30 non-singers. Phonation of vowel /a/ was recorded at their habitual pitch and loudness. The cepstral peak prominence and smoothened cepstral peak prominence were analyzed using the Hillenbrand algorithm available in ***Speech Tool*** software. Mean and standard deviation was calculated for each group. Obtained scores were analyzed using independent ***t*** test. The results showed that the mean raw scores were increased in Carnatic classical singers in comparison with non-singers indicating that cepstral parameters were higher among the singers in comparison with non-singers. The obtained results were attributed to the harmonic organization in the voices of singers.

From the above mentioned studies we can conclude that singers have good respiratory, phonatory and laryngeal capacities. In addition to this we can also conclude that it depends on the duration of training obtained and also the vocal efficiency varies with respect to age, gender and health issues of the individual.

2.5

Dysphonia Severity Index in singers

To see the efficacy of DSI, Wuyts et al (2000) undertook a study where they concluded that DSI is an objective measure of voice considering its parameters (highest frequency, lowest intensity, maximum phonation time and jitter %). The study found that there was a significant correlation between DSI and Voice Handicap Index (VHI). Their study included 387 adult participants (53% females and 47% males) from a data base with participants' age ranging from 18-80 years with no history of any voice pathology. This data base contained the data of patients visiting the voice clinics of four universities. A group of 319 individuals with voice complaints visiting the same

hospitals were considered as experimental group. Perceptual evaluation was done using GRBAS scale. The results revealed that individuals with normal voice had +5 rating and severely dysphonic voices had -5 on DSI scores. Hence, the study concluded that DSI is useful to evaluate therapeutic outcome of patients with dysphonic. The VHI is a questionnaire which contains 30 items that assesses the patient's judgement about the impact of his /her voice abnormality upon daily activities. This was assessed on participants of both the groups. There was a significant correlation between the patient's perceptions of their voice problem to the objective measurement on DSI. Hence, the study concluded that there was a high correlation between DSI and VHI. The DSI values of both VHI and GRBAS devices showed greater differences. 95% of the calculated DSI were within limits of clinical interpretation.

Timmermans et al (2004) considered a total of 46 students and studied the effectiveness of vocal training and also the influence of vocal hygiene program. 23 students who received vocal training at 9 months and subsequently who received vocal hygiene program at 18 months were considered. Another group with 23 subjects who received neither vocal hygiene education nor voice training as such were considered as untrained group and their voice were compared with trained singers. To evaluate the effectiveness of vocal training on voice over the time a pre and post comparison of voice that is before and after 18 months was done using a multidimensional test battery which included (GRBAS scale, video laryngo-stroboscopy, maximum phonation time, jitter, lowest intensity, highest frequency, Dysphonia Severity Index (DSI) and Voice Handicap Index (VHI). The DSI which is an objectively measured test battery showed significant improvement in the voice quality of trained group which was absent in the untrained group. Over the time there was difference in the self-assessed VHI in both the groups. For both trained and untrained groups the VHI scores was high. Therefore study

showed the positive outcome on voice of the singers and henceforth suggested the need for organised voice training program in future professional voice users.

A study done by Timmermans,De Bodt,wyuts and Van de Heyning (2004)supported the above findings where they evaluated voice quality change. They considered 68 subjects including 49 individuals, who received voice training where individuals were provided with instruction regarding relaxation, posture, breathing pattern and active articulation and 19 individuals who did not receive voice training served as control group. The results showed increase in DSI scores for vocally trained individuals.

In his subsequent study Timmermans et al (2005) evaluated the effectiveness of a voice training program for 23 professional voice users. Voice samples of pre and post voice training program were considered. There was increase in DSI scores from the time the individuals received training to 9 months post training onset and to 18 months post onset. There was significant increase in DSI scores with increase in duration of voice training program with prominent voice characteristic change with high F0.

A study by Hakkesteegt, Michael, Marjan and Louw(2006,) attempted to find how Dysphonia Severity Index (DSI), an objective measurement, appears to correlate with perceptual evaluation and to investigate whether there was an influence of age and gender on the DSI values. The participants included 118 adult volunteers (69 females and 49 males in the age ranging from 20-79 years) without any voice complaints. These individuals were perceptually evaluated using GRBAS rating scale by qualified SLPs to consider them as having normal voice. Four parameters were measured using Sony digital Audio tape recorder with a Sennheiser microphone. The parameters measured were MPT, frequency, intensity and jitter (jitter was calculated using the multi

parametric speech program). These voice samples were statistically analysed using SPSS statistical program. Means with standard deviation (SD) for the above mentioned four parameters and DSI were calculated for males and females. Regression analysis was done to determine the association of the individual parameters and the DSI with age and gender. The results showed that age had significant effect on DSI and its parameters, ie., highest frequency and low intensity which was seen only in females whereas gender had no effect on DSI. Though there was a significant effect on highest frequency and maximum phonation time it was because of lowering F0-High and higher jitter with advancing age. The findings of this study served as normative DSI for age and gender.

A study done by Awan and Ensslen (2009) compared trained and untrained singers on the DSI and its measures and to provide a normative data for trained singers. The study considered 36 untrained participants where 15 were males and 21 were females and 30 participants with singing experience, where 15 were males and 15 where females (age ranging between 18 and 30 years) with no history of any vocal pathology. Four parameters (highest phonational frequency, lowest intensity level and jitter percentage and Maximum phonation time) were recorded and voice sample analysis was done using SPSS software. The results showed that trained singers had higher DSI scores than untrained singers and significant increase in high F0, low intensity and jitter parameters.

Aichinger et al (2012) did a study to see the reliability of DSI measurements. The DSI values were measured using Ling Waves (WEVOSYS) and DiVAS (XION). The inter reliability of these devices were evaluated. The study included thirty subjects (12 participants without voice complaints and 18 with voice complaints). 18 were females and 12 were males in the age ranging between 19 and 61 years. Initially

subject's voices were rated with GRBAS scale and their DSI values were measured using Ling Waves and DiVAS. To determine the inter reliability both devices were measured simultaneously. High F0, low I0, MPT and Jitter measurements were done. The results were compared for each subject. The DSI values of both the devices showed great differences.

Jayakumar and Savithri (2012) measured DSI based on geographical and ethnic variation and norms were compared between Indian population and European population. Totally 120 participants (60 males and 60 females) in the age range of 18-25 years without any voice pathology were included in the study. Each individuals voice were rated using perceptual rating scale GRBAS, and four parameters were measured (High F0, Low I0, MPT and Jitter %). Findings revealed that there was a reduction in values of MPT and DSI both males and females. Significant differences were obtained for the parameters MPT and High F0 in both the gender groups. The obtained normative values for DSI were higher in European population than for Indian population. Hence, the study suggests to have a individual normative based on their geographical and ethnic variation.

Preethi (2013) compared dysphonia severity index (DSI) and it's other parameters between Carnatic classical singers and non-singers and also investigated the effect of age on DSI and its parameters in both singers and non-singers. The study included 30 female Carnatic classical singers who were subdivided into two more groups based on their age, considering 15 younger singers and 15 older singers. These 30 singers were compared with 30 age and gender matched non-singers. Younger group considered those individuals who are below 50 years and older group considered individuals who were above 50 years. The parameters measured were highest phonational frequency, lowest intensity, jitter, and maximum phonation time. Using

these, DSI values were calculated with the formula. The results revealed that singers had significantly higher phonational frequency, longer maximum phonation time, and higher DSI values. When compared with the younger participants, older participants had significantly reduced highest phonational frequency, maximum phonation time, and DSI values. The results of this study emphasized that the DSI values contrast between Carnatic classical singers and non-singers, and hence separate normative data may need to be established for this group of singers for clinical comparison purposes.

With reference to above studies we can conclude that DSI increases with the increase in vocal efficiency and if it is not associated with any vocal pathology. Also, DSI can be used regularly in the clinical set up and professional voice care centres to make pre and post therapy comparisons.

CHAPTER III

METHOD

The current study was undertaken to investigate the differences if any in pre-pubertal trained female classical singers and non-singers on Dysphonia Severity Index scores and also to investigate the differences if any in pre-pubertal trained female classical singers and non-singers on various measures of the Dysphonia Severity Index. The following method was adopted for this purpose.

3.1 Participants:

Thirty female Carnatic singers in the age range from 08 – 10 years were considered as participants of the study. The selected participants should have minimum of 3-4 years of training in Carnatic singing. Thirty age matched female non-singers in the age range from 08–10 years were considered as the standard group for comparison.

The selected 60 participants (30 Female Carnatic singers and 30 non-singers) were assessed for general speech, language, hearing, neurological, communication disorders and upper respiratory tract infections, asthma, allergies by collecting detailed demographic history through questionnaire. Apart from the questionnaire also included details regarding number of years of experience in singing, number of hours she practices in a day, type of singing (Carnatic/Hindustani) .In addition questions to the parents regarding whether the children have entered their puberty or not. Those fulfilling the criteria were included in the study.

3.2 Instrumentation/Materials used:

1. Ling Waves software

2. Sound level meter with a microphone attached to was used for recording voice samples of the participants. Singing voice sample analyses was done using Ling Waves software. The Ling Waves is high quality software which analyzes human voice. The Ling Waves software is a combined analysis tool for the measurement of quantitative (singing/voice range profile) and qualitative voice parameters. It consists of different modules. It has a separate module for the calculation of the DSI parameters.

3.3 Procedure:

Before collecting the samples from the participants, consent was taken from the parents/caregivers of the children. GRBAS (Hirano, 1981) scale was used to check for any voice problem. The voice quality was rated by a qualified speech-language pathologist. Based on the GRBAS ratings, only those children who had perceptually normal voice ere included for the present study.

3.3.1 Recording:

The SLM was placed on a tripod stand, through which was adjusted to the participant's mouth level. The recording was carried out in a sound treated room with noise level less than 30 dB SPL. As suggested by Ling Waves manual the participants were made to stand in front of SLM and do the following below mentioned tasks. The microphone was adjusted according to the height of the participant. To keep away from any distortions during the recording a distance of 30 cm was maintained between the microphone and the participant's mouth. The participants were explained about the task and the demonstration of each task was given to the participants. The participants were given three trials for each task and the average was taken for each parameter.

3.3.2 The following tasks were recorded from each participant:

1. Highest phonation frequency (F0 high):

The participants were asked to go up the scale using the vowel /a/, until they reach their highest pitch level. The participants should not lose control of voice and was ensured that there were no pitch breaks in between. After demonstration and practice trials, three trails were recorded and the averages of the three trials were considered.

2. Lowest intensity level (I low):

The participants were asked to sustain the vowel /a/ at a comfortable pitch as softly as possible. After demonstration and practice trials, three trails were recorded and the averages of the three trials were considered.

3. Jitter:

The participants were instructed to produce sustained phonation of the vowel /a/ three times at a comfortable pitch and loudness for 5 seconds. The selected portion of 3-4 seconds of phonation was used for jitter calculation.

4. Maximum phonation time:

The participants were instructed to inhale deeply and sustain vowel /a/ as long as possible at a comfortable pitch and loudness. After demonstration and practice trials, three trails were recorded and the averages of the three trials were considered.

3.4 Statistical analysis

Available SPSS (statistical package for social science) (IBM, New York, NY) 16.0 version was used for statistical analysis. All the parameters were tabulated for both singers and non-singers for standard group comparison. Test of normality was done to see the normal distribution of data. Descriptive statistics was done. Parametric Independent t test and non-parametric Mann whitney-U test was done to see the significant difference between two groups, when normality was present.

CHAPTER IV

RESULTS AND DISCUSSION

The main objectives of the study were to examine differences in DSI scores and to compare parameters such as highest frequency, lowest intensity, jitter%, Maximum phonation time between prepubertal female Carnatic classical singers and non-singers.

At first, before the statistical analysis perceptual assessment was done using GRBAS (Hirano, 1981) voice perceptual rating scale. It was used to check for any voice problem in the considered participants. The voice quality was rated by a qualified speech-language pathologist. Based on the GRBAS ratings, only those children who had perceptually normal voice were included in the present study. All the total considered participants had perceptually normal voice obtaining a score of ‘0’ suggesting normal voice.

The results are discussed separately under the following heads:

1. Highest frequency (F0_H)
2. Lowest intensity (L0_I)
3. Jitter percentage (JP %)
4. Maximum Phonation Time (MPT)
5. Dysphonia Severity Index (DSI)

For the statistical analysis, SPSS (Statistical Package for the Social Sciences) – Version 16.0 software was used. Descriptive statistics, parametric and non-parametric tests were used to get the statistical values. The scores obtained in the study were tested for normality using the Shapiro-Wilks test of normality. Among all the parameters which were considered, only MPT values satisfied the normality condition and hence parametric independent t test was done. Descriptive analysis was done for the obtained scores. Mean, Median and SD values were obtained and except for jitter% and DSI scores wherein the SD values were high and hence they were further analysed using non-parametric test.

Table 1:

Mean median and standard deviation scores for F0, I0, JP, MPT and DSI between singers and non-singers

Parameters	**Singers**			**Non-Singers**		
	Mean	Median	S D	Mean	Median	S D
F0_H	428.26	424.00	43.20	352.10	368.00	47.26
I0_L	70.50	67.00	12.97	67.30	68.50	13.91
JP%	1.79	0.16	4.45	1.05	0.28	1.60
MPT	10.97	10.72	1.33	6.25	06.22	1.62
DSI	2.79	2.10	2.08	2.58	2.10	3.71

Note: *F0_H-highest phonational frequency, I0_L-lowest intensity, JP-jitter percentage, MPT-maximum phonation time, DSI- dsyphonia severity index*

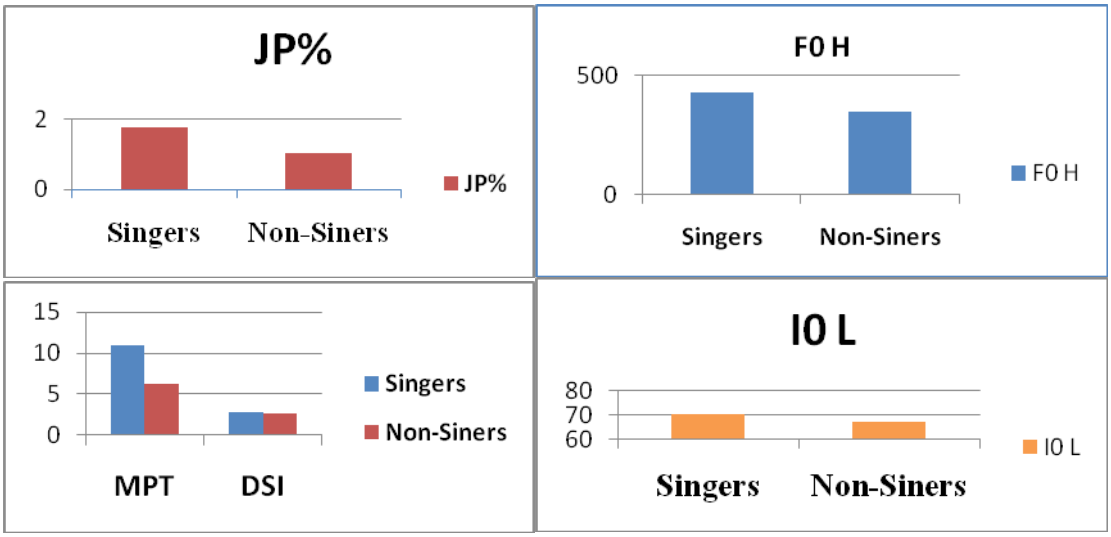

Figure 1: *Mean scores of F0_H (Highest Phonational Frequency), I0_L (Lowest Intensity Level), JP% (Jitter Percentage), MPT(Maximum Phonation Time) and DSI (Dysphonia Severity Indesx) between singers and non-signers.*

From the above table and figure, maximum significance is seen in Highest Phonational Frequency, Maximum Phonation Time and Dysphonia Severity Index.

The results obtained in the present study have few literature studies supporting the same and hence it can be well justified for the results obtained under each parameter by providing reasons with the support of the below mentioned studies.

1. **Highest phonational frequency (F0_H)**

Since this parameter satisfied parametric test, Mann Whitney U test was done to see the significance. The table 2 below shows significant value of highest phonational frequency for singers.

Table 2:
Significant value of Highest Phonational Frequency (F0_H) in Non-Parametric test

Parameter	**Z value**	**Sig (2-tailed)**
Highest phonational Frequency (F0_H)	5.558	0.000**

Mann Whitney U test was done to see the significance between the parameters in which ‘z’ values for F0_H scores were 0.000 (‘z’=0.000 < ‘p’ value 0.05) suggesting maximum significant difference for singers group.

The study supports that of Glaze, Bless, Milenkovic, and Susser (1988) who measured acoustic characteristics of children's voice. The results indicated statistically significant relationships between phonation frequency and sex, with higher frequencies for girls. The reason they attribute for this is due to sex based distinction of pre-pubescent fundamental frequency. This change is mainly due to physical laryngeal mechanism. In addition they also report that there will be sex based difference in vocalization as young as 13 months. Hence, this reason can be attributed to the present findings of the study for increased frequency parameters suggesting the pre-pubescent influences on vocal changes which is significant in females. The findings of the present study would have yielded better results with respect to the above supporting justification taking gender comparison into consideration.

The present results satisfied the considered objectives suggesting that female prepubertal singers have better vocal efficacy. Barlow, and Howard (2002) support this finding where they reported that female subjects have a marked development of voice source production depending on the length of training received, while male subjects exhibited patterning according to both age and related pubertal development, and period of training received in singing. Reasons for the results are attributed to the process of training in singing which influences the young voice that has a quantifiable effect upon the singing voice production of the child, in particular on the female voice. The pubertal development also creates measurable effects on the voice source production of the male which is not seen in females. The study considered only pre-pubertal females, and with

reference to the obtained results it can be said that the considered participants did not have any chance of having influence of pre-pubertal changes on participant's voice based on the considered inclusion criteria. The results of the present study had maximum significance in highest fundamental frequency and values for the same parameter was more for singers compared to non-singers.

Heide, Gelbrich, Tascher, and Dietz (2006) who evaluated mean fundamental frequency as one of the parameters also noted that frequency and intensity ranges were more in singing children and adolescents who underwent training in singing. The reason they attribute for the result was that regular training of the singing voice results in positive effects on several voice parameters in children as well as adolescents. The singers considered in this study had minimum of 3 years training and therefore the obtained scores for F0_H in this present study can be due to increase in vocal training.

2. Lowest intensity (L0_I):

Since Lowest Intensity Level (I0_L) score had high SD values it satisfied non-parametric test. The Table 3 shows the significant values of Lowest Intensity Level for singers.

Table 3:
Significant value of Lowest Level Intensity (I0_L) in Non-Parametric test

Parameter	Z value	Sig(2-tailed)
Lowest Intensity Level (I0_L)	0.895	0.371

The obtained p value for I0_L was > 0.05 and hence it is not a significance parameter. But the I0_L values were more for singers compared to non-singers.

Leborgne (2002) supported the finding of the present study. He assessed the effects of vocal training for singers over a period of nine months, following which significant differences were revealed in the subjects mean frequency range and minimum vocal intensity across frequency levels. There was no significant difference for the minimum vocal intensity across frequency levels following vocal training. The reason attributed for the result is that the ability of a singer to maintain minimal intensity requires co-ordination of respiration, phonation and resonance. With the training in singing singers will achieve this ability and henceforth they can maintain minimal intensity level. In addition to this few vocal warm up excercises for singers like messa di voice (is a vocal technique that gradually smoothens the loud voice) increase the ability to maintain minimal intensity level. Therefore, this reason can be attributed to the increased minimal intensity in singers compared to non-singers.

Preakup (2012) also observed significant difference in jitter and intensity parameters with lowest intensity level being more in singers compared to non-singers. The reason they attribute for the results is that younger singer population will have greater intensity modulating capacities compared to older singer population. This is because older population will have diminished control of overall modulation of intensity especially to soften the loudness level. In addition they also comment with the increase in vocal training individual will develop to control intensity modulations (phonating softly). Hence, the lowest intensity measure values will be more in singers compared to non-singers. The present study includes pre-pubertal female singers with efficient vocal training hence the lowest intensity measures were better for singers.

3. Jitter values

The jitter% score had high SD values and hence it satisfied non-parametric test and it has been depicted in table 4.

Table 4:

Significant value of Jitter Percentage (JP) in Non-Parametric test

Parameter	**Z value**	**Sig(2-tailed)**
Jitter Percentage (%)	1.244	0.213

The p value for jitter percentage for singers and it was > 0.05 and hence it is not a significance parameter. In this present study results showed jitter percentage is not a significant parameter among the considered parameters. This finding was also supported by Wilcox and Horii (1980) who reported changes in vocal jitter with age. They examined jitter for sustained phonation of vowels (/i, a, and u/) produced by young and older adults. Their findings revealed that that the average jitter values of the older adults were significantly greater than that of the young adults. The reason attributed was with increase in age the variation in frequency is more and therefore it will be significant in older adult groups compared to younger groups. Adults can sustain phonation with fewer pitch variations due to their pitch controlling capabilities compared to younger group population. This finding supported the present study where the subjects had less jitter values and it showed less significant compared to other parameters hence the same reason can be attributed saying younger population has poor in controlling variations in pitch in the present study results.

The obtained score for jitter% and lowest intensity had least significance compared to other parameters included. Preakup (2012) aimed to see whether there were differences in acoustic measurements between older and amateur singers and non-singers. The results showed significant difference in jitter and intensity parameters with

significantly less jitter percentage and more intensity compared with non-singers. The reason they reported for less jitter values were elderly males and females exhibits significantly less vocal intensity than younger males and females, in addition they also commented elderly males having significantly greater vocal intensity than younger. The considered participants in this study were pre-pubertal population falling in to younger population and have lesser values in terms of jitter% and intensity values compared to other parameters which is supporting to the above mentioned study. Younger population group has less vocal intensity hence the singers considered in the study obtained lesser values in terms of jitter and intensity compared to other parameters. Better comparison would have been possible if heterogeneous group was considered.

4. Maximum Phonation Time (MPT)

Table 1 shows the mean, median and standard deviation scores for MPT for singers and non singers. Since MPT values satisfied the normality condition, parametric independent t test was done to see the significance between the MPT scores and as seen in Table 5 it showed 0.000 < than 'p' value 0.05 suggesting that MPT had maximum significance for singers group. In addition, the mean and SD scores were more for singers compared to non-singers.

Table 5:

Significant value of Maximum Phonation Time (MPT) in Non-Parametric test

Parameter	**t value**	**Sig(2-tailed)**
Maximum phonation time	12.314	0.000**

N0TE: ** indicates parameter is highly significant

The results support findings of Caroll, Sataloff, Heuer, Spiegel, Radionff, and Cohn (1995) who measured respiratory and glottal efficiency in classical trained singers. Since singers have increased pulmonary function, forced expiratory volume, forced vital capacity, and forced expiratory volumes, respiratory and phonatory capacities, they have good MPT. Sabo, Lee and Stemple (1993) also used aerodynamic measures of flow rate, phonation volume, and maximum phonation times and the results showed an increase in glottal efficiency and phonatory volume. They noted that with training in singing phonatory, respiratory and glottal efficiency increases along with increased elastic recoil forces of lung tissues, increased vital capacity, increased residual volume, and increased expiratory/ inspiratory volume. This would have yielded increase in MPT values for singers compared to non singers.

5. Dysphonia Severity Index (DSI)

The SD scores for DSI parameter was more and hence non-parametric test was done to see the significance where it showed maximum significance and DSI scores were better for singers compared to non-singers. The increase in DSI values in singers may be mainly because of the increased F0 -high and longer MPT values which contributed to the overall increase in the DSI value. Older singers and non-singers will have less DSI values compared to younger singers. With increase in age there will be reduction in DSI values mainly because of lowering of FO-high, and reduction in MPT values.

Table 6:

Significant value of Dyphonia Severity Index (DSI) in Non-Parametric test

Parameter	**Z value**	**Sig (2-tailed)**
Dysphonia Severity Index (DSI)	5.644	0.000**

N0TE: ** indicates parameter is highly significant

The results of the present study are supported by Timmermans et al (2004) who studied the long-term influence of vocal hygiene education and the effectiveness of voice training. The objectively measured voice quality DSI of the trained group improved significantly over time due to training in singing which was not seen in the untrained group. The participants' voice quality was better after 9 months of training incorporating vocal hygiene program and there was an increase in DSI score.

Timmermans et al (2004) also reported that individuals without any vocal pathology will have 75% improvement in vocal efficiency and those individuals with vocal pathology will have 25% improvement in vocal efficiency. The participants included in the study had singing experience for minimum of 3 years and did not have any history of vocal pathology and therefore the above mentioned supportive findings and reasons attributed for increase in DSI score reflects the findings of the present study. The findings are further supported by Hakkesteegt et al (2006), Awan and Ensslen (2009) and Preethi (2013).

The study compared multiple parameters in which F0_H, I0_L, JP and MPT were independent variables and DSI was dependent variable. With an increase in independent variables there would be increase in dependent variables and hence Regression analysis was done to see the association of independent variable and dependent variable. For this multiple linear regression was done for singers and non-singers. For singers the regression value was less (R square = 0.315) indicating 35% of variation between dependent and independent variables and only I0_L was significant whereas in non-singers it was R square = 0.536 indicating 53% of variation between dependent and independent variables wherein all the four parameters except F0_H (all independent variables) were significant.

Table 7:

The co-efficient and p value for Singers and Non-Singers

Parameters	**p value**	
	Singers	**Non-Singers**
FO_H	0.068	0.556
IO_L	0.041*	0.003*
JP	0.269	0.002*
MPT	0.334	0.031*

Note: *F0_H-highest phonational frequency, I0_L-lowest intensity, JP-jitter percentage, MPT-maximum phonation time.*

To summarise the results, among all the parameters F0_H, MPT and DSI had significant difference wherein F0_H and MPT had maximum significance for singers. The mean scores for the same above parameters had greater values for singers compared to non-singers implying individuals who obtain intensive vocal training at the prepubertal stage will have better vocal output compared to individuals who do not receive any vocal training. .

CHAPTER V

SUMMARY AND CONCLUSION

Pre-pubertal voice comparatively differs with adult population in respiratory, phonatory capabilities which might affect their voice parameters. Like Western classical singers, Carnatic singers undergo regular training and practice to achieve proficiency in singing. Like any other professional voice users, trained Carnatic classical singers also experience voice problems. However, because of their increased vocal capabilities, their DSI values may range within the normal limits of non-singers (Awan & Ensslen, 2010).

There is very limited literature available on singing voice of children, especially in young professional voice users compared to adult singers using DSI. Further, there is no data available regarding comparison of DSI in trained Carnatic and non Carnatic classical singers in female pre-pubertal population in the Indian context.

Hence, there is a need to compare DSI values for trained Carnatic singers with non-singers in pre-pubertal population. It will be interesting to see if early intensive training in music will have any effect on DSI parameters which may facilitate fine tuning of voice quality in young children. For this purpose, the present study was planned as there is limited database with regard to pre-pubertal female singers. This is

the most crucial age at which most female singers appear for their junior/senior music examination requiring intensive practice.

The main objectives of the present study were to investigate the differences if any in pre-pubertal trained female classical singers and non-singers on Dysphonia Severity Index (DSI) scores and on various measures of the Dysphonia Severity Index. 30 pre-pubertal female Carnatic singers in the age range from 08 – 10 years were considered as participants of the study. The selected participants should have minimum of 3-4 years of training in Carnatic singing. 30 age-matched female non-singers were considered as the standard group for comparison. The non-singer group considered in the study did not have any history of formal singing training. The participants' phonation of /a/ was recorded and was played to a speech language pathologist for perceptual evaluation using the GRBAS scale. Those individuals who had normal voice on perception assessment were considered for the study. All the considered participants obtained a score of '0' suggesting perceptually normal voice. The voice recording was done in sound treated room with noise level less than 30 dB. The voice recording was done using Ling waves software (WEVOSYS).

Three trials were recorded for each of the tasks involving highest phonational (F0_H), frequency where participants were asked to go up the scale using the vowel /a/, until they reach their highest pitch level. The participants should not lose control of voice and was ensured that there were no pitch breaks in between. After demonstration and practice trials, three trails were recorded and the averages of the three trials were considered. For lowest intensity level (I0_L), the participants were asked to sustain the vowel /a/ at a comfortable pitch as softly as possible. After demonstration and practice trials, three trails were recorded and the averages of the three trials were considered. To

measure jitter (JP), the participants were instructed to produce sustained phonation of the vowel /a/ three times at a comfortable pitch and loudness for 5 seconds. The selected portion of 3-4 seconds of phonation was used for jitter calculation. And similarly to measure maximum phonation time (MPT) the participants were instructed to inhale deeply and sustain vowel /a/ as long as possible at a comfortable pitch and loudness. After demonstration and practice trials, three trails were recorded and the averages of the three trials were considered and the average of the three trials in every task was considered for DSI calculation.

The Dysphonia Severity Index was calculated based on 4 voice parameters: highest frequency (F0-High in Hz), lowest intensity (I-Low in dB), maximum phonation time (MPT in seconds), and jitter (%). These parameters were measured based on sustained vowel /a/. The values of 4 parameters obtained were used to calculate DSI using the following formula:

DSI = 0.13 x MPT (seconds) + 0.0053 x F0 high (Hz) – 0.26 x I low (dB) – 1.18 x jitter (%) +12.4

The present study revealed the following results:

1. There was increase in the overall DSI scores in singers compared to non-singers.

2. The maximum phonation time and highest fundamental frequency and DSI scores were more for singers compared to non-singers. There was statistically maximum significance for highest fundamental frequency and maximum phonation time between singers and non-singers.

3. There was no significant difference between the two groups for lowest intensity level and jitter parameters.

4. The present study findings show that there is an effect of Carnatic classical singing training on DSI parameters.

5.1 Limitations of the study:

- large group of participants would have yielded better results
- The inclusion criteria for experience in singing should have been considered to have minimum experience in singing for five years to see the better changes in vocal output

5.2 Clinical implications of the study:

- The results of the present study provided normative DSI values for female pre-pubertal trained Carnatic classical singers which would help in assessing the voice problems.
- In addition it will also help us to know which parameter is affected and based on this it will be less time consuming for assessing voice problems.

5.3 Future direction:

- The study can be compared between males and female singers across different age groups.
- This can also be done on male pre-pubertal singers' population.

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APPENDIX - I

Comparison of Dysphonia Severity Index in Pre-Pubertal Female trained Carnatic Classical singers and non-singers

Participant's name: Age:
Date of Birth: Education:
Father's name: Mother's name:
Height: Weight:
Complete address & phone no:

General Speech-language-hearing, oro-facial, voice, breathing and medical history

Sl. No	Questions	Yes	No
G1	Does your child have any speech, language or hearing problems?		
G2	Does anyone in family have any speech, language or hearing problems?		
G3	Does your child have any voice/ breathing problem?		
G4	Is the child on any medication? If so, what and what for?		
G5	Has your child undergone any surgery related to ENT? If yes, specify		
G6	Has your child attained puberty?		
G7	Are there any oro-facial defects? If yes, specify		
G8	Are there any singers in the family?		
G9	Does your child go to formal singing training in Carnatic music?		
G10	Are there any formal/informal singing training at home or school?		

For singers

Sl. No	Questions
S1	How long is your child taking formal training in Carnatic music? 1- <1year; 2 – 1 to 2years 3 – 2 to 3years 4 - >3years
S2	Does your child enjoy listening to music? 0 – No; 1 -Yes
S3	Does your child enjoy singing? 0 – No; 1 –Yes
S4	How many hours of practice will be done per day? 1- <1 hour; 2 – 1 to 2 hours; 3 – 2 to 3 hours 4 - 3 to 4 hours > 4 hours
S5	Any exposure to music at home/outside 0 – No; 1 -Yes
S6	Do you think your child sings well? 0 – No; 1 -Yes

For Non-singers

Sl. No	Questions
NS1	Does your child enjoy listening to music? 0 – No; 1 -Yes
NS2	Does your child enjoy singing? 0 – No; 1 -Yes
NS3	How many hours of singing will be done per day? <1 hour; 2 – 1 to 2 hours; 3 – 2 to 3 hours 4 - 3 to 4 hours > 4 hours
NS4	Any exposure to music at home/outside 0 – No; 1 -Yes
NS5	Do you think your child can sing well? 0 – No; 1 -Yes
NS6	Do you think your child imitate the songs well? 0 – No; 1 -Yes

APPENDIX-II

Consent Form

I have been briefed about this research work, its aim and data collection procedure for my child. I have the knowledge of problems/ inconvenience faced during the process of data collection and also I will have the right to withdraw my child's participation in this work at any point of time.

I have my complete consent to allow my child to participate in this research work.

Parent's/ Guardian's signature (with date) Researcher's Signature (with date)
Name and complete address: