To,

My Guide

find

Megha, Manasa

CERTIFICATE

This is to certify that the dissertation entitled

ANALYSIS OF SINGING VOICE

is the born fide work in part fulfilment for the degree of Master of Science [Speech & Hearing], of the student with Register No, M 8710

Director 19/5/89

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CERTIFICATE

This is to certify that this dissertation entitled

ANALYSIS OF SINGING VOICE

has been prepared under my Supervision and guidance.

Dr. N.P. NATARAJA
Guide

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Dr. N.P. Nataraja, Reader and Head Of the Dept. of Speech Science, All India insutitute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

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CHAPTER - I

INTRODUCTION

PLEASURE CAN BE EXPERIENCED

BY THE SINGERS

BY THE LISTENERS

THAT IS THE GREATNESS ENTITLED TO SONGS

"Nearly all mankind regardless of the degree of civilization indulges and derives pleasure from song. But the question is, what is it that judges the music as good? Is it just enough if the singer wins the appreciation of audience? Or being able to sing regularly? These controversies lead us to the study of factors that help the singers to win the audience appreciation and at the same time maintaining the source of voice too" (Proctor,1780).

Singing is still a mystery as life it, eventhough attempts have been made to search the mystery behind by scientific communities, musicologists, acoustic engineer* and physiologists. Yet for some it is a sensory motor phenomenon that requires a particular physical skill (Bunch 1782) or predominantly a product of meticulous breath control (Proctor 1778) or simple as act. According to Carol (1774) "the science of singing consists simply of palate up, tongue down, larynx as low as is comfortably possible and phonating vowel as closely as possible to the point where sound originates, therafter inhaling abdominally, one allows the sound to float in continuous stream on the breath with no interference from the consonant".

There is a communication gap between vocal pedagologists and voice scientists since the former gives more importance to the perceptual aspects where as voice scientists give equal importance to the mechanism underlying the process of singing as well as the perceptual aspect. There is no set rule which can be taught during training that improves the quality of voice and even help to maintain the source because of lack of knowledge in this area.

But as the science and technology has progressed, more and more attention has been given by voice scientists and specific areas like Japanese group led by Hirano and others, have been exclusively interested in neuromuscular (E.M.G) findings related to singing. The Stockholm group led by Sundberg has concentrated mostly on acoustic properties. The Europeans and American groups that of Proctor, Bunch, Bouhgyas, Sears and Large are interested in specific aspects like physiology, laryngeal behaviour, aerodynamics, registers.

In India very little has been done in the true sense of scientific enquiry. For example by Deva, Sankaran and Singh.

Research in past few decades as grown up predominantly as the singers and the concerned have noticed that

1. The singers partially or totally get incapacitated from singing due to abuse of voice.
2. That it is possible to prevent for the damage and can be reversed by therapy and growing awareness among singers and professionals about vocal hygine.

Thus intensive enquiries are going on in acoustics of singing and aerodynamic factors and trying to focus on the parameters differentiating the trained from untrained singers.

Acoustic analysis of the voice signal is one of the most attractive methods for assessing the phonatory or laryngeal function, because, it is non-invasive and provides objective and quantitative data. On the other hand for well trained laryngologists, phoniatricians or speech pathologists listening to the voice can identify the variations and underlying pathophysiology. Thus the acoustic analysis has promising future in helping to identify the normal and pathological voices.

The acoustic analysis when supplimented by aerodynamic measurements, the understanding of the process of singing will be better.

Studies on acoustics and aerodynamics of singing are scant particularly no reports are available on Indian music.

Few studies on fundamental frequency, frequency range, vowel duration, off-pitch phenomenon have been conducted and vital capacity and mean airflow rate with the reference to the aerodynamic factors have been conducted (Ragini, Gupta, Sheela).

The fundamental frequency was found to be higher in singing compared to speaking and reading. The fundamental frequency increases starting from phonation, speaking, reading and singing (Nataraja, Jagadeesh and Kumar; 1985). Ragini's study (1986) supported the above findings.

Very limited studies have been carried out in transition and mean airflow rate in singers.

Gupta (1984) found out that singers go off-pitch above and below octave range and more so at the lower end.

Regarding aerodynamic factors, Sheela (1974) did not find any significant difference between trained and untrained singers when vital capacity was compared. Thus there is thirst for knowledge in this area.

The present study aims at investigating the differences in acoustic and aerodynamic factors stated below in trained and untrained singers. Namely, fundamental frequency and the range in singing octave range, a sample of song and reading condition, transition pattern when singing octave range using swaras, energy concentration above and below 1 KHz region in LTAS, vital capacity, mean airflow rate in low, mid and high pitches.

Hypothesis:

There is no significant difference between trained and untrained singers in terms of acoustic and aerodynamic factors in singing.

Auxilliary hypothesis:

1. There is no significant difference among trained singers between singing and octave range and reading when mean fundamental frequency is compared.
2. There is no significant difference in trained singers between reading and singing song when mean fundamental frequency is compared.
3. There is no significant difference among trained singers in singing song and singing the octave range when mean fundamental frequency is compared.
4. There is no significant difference among untrained singers in singing octave range and reading when mean fundamental frequency is compared.
5. There is no significant difference among untrained singers in reading and singing when mean fundamental frequency is compared.
6. There is no significant difference among untrained singers in singing sample of song and singing the octave range when mean fundamental frequency is compared.

7. There is no significant difference in singing octave range in trained and untrained singers when mean fundamental frequency is compared.
8. There is no significant difference in reading in trained and untrained singers when mean fundamental frequency is compared.
9. There is no significant difference in singing song in trained and untrained singer when mean fundamental frequency is compared.
10. There is no significant difference between singing octave range, reading and singing sample of song in trained singers when mean fundamental frequency range is compared.
11. There is no significant difference between singing octave range, reading and singing sample of song in untrained singers when mean frequency range is compared.
12. There is no significant difference between trained and untrained singers when mean frequency range is compared for singing octave range, reading and singing song.
13. There is no significant difference in transition pattern between trained and untrained singers.
14. There is no significant difference in alpha ratio for trained and untrained singers.
15. There is no significant difference in vital capacity for trained and untrained singer.

16. There is no significant difference in mean airflow rate for phonation in low, mid and high pitches among trained and untrained singers when mean is compared.
17. There is no significant difference in mean airflow rate for phonation in low, mid and high pitches between trained and untrained singers when mean is compared.
18. There is no significant difference in energy concentration below and above 1 KHz among trained and untrained singers when mean energy is compared.
19. There is no significant difference in energy concentration below and above 1 KHz between trained and untrained singers when mean energy is compared.
20. There is no significant difference in the energy concentration at 1-3 KHz region between trained and untrained singers when mean energy is compared.

Implication of the study;

This study provides information on fundamental frequency, frequency range, transition in fundamental frequency, alpha ratio, vital capacity, mean airflow rate and difference among and between trained and untrained singers.

CHAPTER -II

REVIEW OF LITERATURE

"Voice which is the basis for speech, artistic acivities including singing, theatrical performance is produced involuntarily or reflexively, yet involves a complex and precise underlying activity" (Hirano etal 1975). During speech and singing, the higher order centres including the speech centres in the cerebral cortex first determined the sequence of sound production which sends series of commands to the motor neuclei in the brain stem and spinal cord which in turn transmits the commands to respiratory, laryngeal and articulatory muscles. Extrapyramidal system provides additional fine regulation of activity of respiratory, laryngeal and articulatory musculature.

The most unifying theme for Speech and Music is that both of them provide the oldest, most common and most efficient and most universal acoustical means of expression of emotions, feelings, ideas and thoughts. Both of them may be considered as the highest manifestations and human communications.

Understanding of speech in its various connotations with regards to feelings, impressions, sentiments etc. and the appreciation of music in its aesthetic content and expression of feeling are high order tasks involving Linguistics, Syntax

Semantics and other semiotic properties. The tasks of identifying phonetic units of speech, like phonemes (even words) in speech and that of identifying notes and short movements in music are primary in nature. The constant interaction between these two levels enables the attainment of perfection in perception. (Datta, Ganguli and Dutta Manjumder, 1983).

Sunderberg (1977) explains about singer's voice. The voice organ obeys the same acoustic laws in signing that it does in ordinary speech. The radiated sound can be explained by the properties of the voice - source spectrum and the formants in singing as in speech. From an acoustical point of view, there is a major difference between the way formant frequencies are chosen in speech and the way they are chosen in signing, and hence between the way vowels are produced in singing and the way they are produced in speech.

Daniel Boone (1971) states that "The best speakers and singers are often those persons who by natural gift or by training or by a studied blend of both have mastered the art of optimally using the voice mechanism". Singing requires all that speaking does but for greater skills in all spheres (Greene, 1972).

Singing is a highly specialized form of using the vocal organs that produces both the speaking and singing voice. We know less of the singing voice than of speaking voice (Boone, 1971).

"Singing requires more exacting performance in every department than does speech, and it requires a complete mastery of techniques, the control not merely of the mechanize of singing but of fine shades of tome colour which defy analysis but convey the emotional message of the passage. No such extraordinary physical demands are made upon the speaker" (Greene, 1972).

Proctor (1980) and Bunch (1982) believe that singing is specialization over speech. And some theories state that "the human speech took origin from singing" (Critchley, 1975). It is still not clear what led to what.

From this, it can be concluded that singers have specialized themselves in using speech apparatus more efficiently for singing.

Comparison of respiration during quiet breathing, speaking and singing, have shown that more air is used in singing as compared to quiet breathing. Alveolar pressure ranges from high negative pressure during inspiration to relatively high positive pressures during expiration while singing. But fluctuates on a few cm of water in quiet breathing. It has also been found that expiratory air flows are low in speech and singing, higher inspiratory air—flow , have been found to be associated to speech and much higher in singing. Further Proctor (1980) states, that phonation either for speech or singing does not demand high degree of pressure but delicacy of use of breathing mechanism is required.

While discussing perception of vowels, Sundberg (1979) states that singers learn to adopt vowels which are typically different from that of normal speech.

In singing the vowels are prolonged since they are especially suited to carry melody, it follows that the rhythmical, dynamic and melodic qualities of speaking and singing differ only in regard to quantity and quality. These formal elements are complicated by additional psychological factors and aesthetic requirements. (LUCHSINGER, 1965). On the whole isochronism that is, regularity in the vibration of vocal fold, more controlled breathing, greater vocal range, vibrato and singer's formant are noticed in singers which is not observed during speaking that is, vocal apparatus is used under great stress during singing than speech.

attributes of voice are, pitch, loudness and quality, knowledge of pitch, its control mechanism, modulation and maintainance is important for a singer.

Pitch is the psychological correlate of frequency. There is no one to one relation between the two, as Stevens and Davis (1938) say that the frequency of sound does not uniquely determine its pitch. The relationship between frequency and pitch is logarithmic with intensity held constant; doubling the frequency raises the pitch by an octave (Judson and Weaver 1965).

According to Stevens and Davis (1935) the pitch of complex tone depends upon the frequency of its dominant component, that is, the fundamental frequency in a complex tone. Plomp (1967) found that even in a complex tone, where the fundamental frequency is absent or weak, the ear is capable of perceiving the fundamental frequency based on periodicity of pitch.

Ohala (1978) states that pitch and fundamental frequency are interchangeable as it means the rate of vibration of vocal cords during phonation. The production of pitch and its variation are not as simple, the lacuna is still there in understanding of there mechanisms in speech and little is known regarding this mechanism in singing.

". . . . both quality and loudness of voice are mainly dependent upon the frequency of vibration. Hence it seems apparent that frequency is an important parameter of voice (Anderson, 1961)

Pitch is determined by the number of vibrations (per second) of the vocal cords, and thus in turn is determined by the length, mass and stiffness of the vocal cords. Thus the mass, length and tension of the vocal cords determine the fundamental frequency of voice.

Anatomically the average pitch of human voice varies with length and stiffness of the cords and also age and sex. (Van Riper and Irwin, 1758). Zimmerman (1867) studied the vocal fold length in fifty singers. The soprano voice ranges from 14 to 18 mm in length, and tenor voice never exceeded 22 mm and a maximum length of 25 mm was found in Bass voice. The child's vocal cords are short and in woman usually shorter than in man. Although less is known about mass per unit length, this probably varies with age and sex (Borma, 1975). Various investigators have studied the changes in fundamental frequency of voice with age. Some among those age Fairbanks (1740, 1949) Curry (1940), Sindecor (1943), Hanky (1949), Mysak (1950), Samuel (1973), Usha Abraham (1978), Gopal (1980), Kushal Raj (1983) and Rashmi (1985). Michel, Hollien and Moore (1965) studied the speaking fundamental frequency characteristics of 15, 16 and 17 years old girls, in order to determine the age at which adult female speaking fundamental frequencies are established. Their results indicated that females attain adult speaking fundamental frequencies by fifteen years of age. In order to determine when adult frequencies are first evidenced, it is necessary to study the girls of fourteen years and younger. (Michel, Hollien and Moore, 1965).

Hudson and Holbrook (1981) investigated the mean modal fundamental frequency, in reading, in two hundred young black adults whose age ranged from 18 to 29 years and found it to be 110.13 Hz in males and 193.10 in females. Compared to a similar white population studied by Pitch and Holbrook (1970), the black population had lower mean model fundamental frequencies.

The fundamental vocal frequency is recognized as an important characteristic of expressive language in a society that is becoming increasingly dependent on the spoken work to convey information.

Past research on this topic have shown that the fundamental vocal frequency is dynamic and provided important clues regarding the emotional state, type of speech, activity, race, sex and physical maturity of the speaker.

It has been shown that different emotional states produce distinctive differences in the fundamental (Cowan, 1936, Fairbanks and Pronovast, 1937, Williams and Sevens, 1772) that the mean fundamental is higher for reading than speaking (Hanley 1951, Hollien and Jackson, 1973, Mysak 1959, Schultzcoulon 1975, Suidecor 1943) that fundamental characteristics which differentiate the sex of the speakers are most noticeable during puberty when the fundamental drops approximately one octave but a less noticeable change occurs in females (Duffy 1970, Fitch and Holbrook 1970, Hollien, Malcik and Hollien 1965 kHollien and Paul 1969, Hollien and Shipp 1972).

Hollien and Colenman (1970) studied the vocal fold area and thickness as a function of fundamental frequency of phonation using Stroboscopic Laminograph (STROL). Result* indicated a moderate trend for vocal fold area to decrease with increasing fundamental frequency and vocal thickness to decrease with increasing fundamental frequency. The fundamental frequency of voice is referred to as pitch, is an important feature of speech conveying both linguistic and non linguistic informations. In singing, the role of fundamental frequency is crucial, since fundamental frequency carries the melodic information. (Fujisaki, Tatsumi, Higuchi, 1980).

Zinkin (1968) states that fundamental frequency varies depending upon the shape and volume of the resonating tract and is different for different vowels. Alternations of the shape of the vocal tract shifts formant frequencies, and singers use this technique to improve resonance and tone quality.

Optimum frequency is "sine qua non" for singers. Optimum criterion specifies that with less effort the acoustic output should be greater leading to greater vocal efficiency (Perkins, 1975). Sheela (1974) found that all singers were not using their optimum frequency while singing.

Range of pitch is another controversial issue. Range of pitch used for singing by most singers is two to two and a half octaves. The range or compare of the human voice reach, is from the LOW c (64 c/s) of a deep Basso to the C4 of the Soprano results in five octaves. Luchsinger (1965) studied the voice of a female singer and found the range as four and a half octaves. Fairbanks (1749) comments on the fact that very few colarature Sopranos can achieve a range in singing covering three octaves above mid c. The child's singing ranges which varies very little in boys and girls covers the middle octave at the age of seven years and at eight year the lower range is slightly extended and the voice ranges from B2 to BIS. At nine years the range extends a little further in both directions to B2 to D4. Sheela (1974) found that higher frequency range was noticed in trained singers when compared with the untrained singers.

A special classification for the speaking voice does not exist. The singing voice fully justifies a well defined classification because of its notable extension and the vocal texture. However the classification of singing voice presents problems not easily solved. There primarily six main classifications ranging from the lowest to the highest. They are Bass, Baritone tenor, Coutralto, Mezzo soprano and Soprano (Greene, 1964). The laryngeal dimensions are the main determinants of the above type of voice. It also depends on body type, dimensions of supraglottic resonators, artistic inclination, vocal education, personality structure and cultural influences.

Cleveland (1977) considers that the quality of the speaking voice is often an indication of the correct classification for a singing voice.

Fundamental frequency seems to be the main acoustic cue in the classification of voice (Coleman, 1976; Cleveland, 1977). However, formant frequencies typically differ between Bass, Baritone and tenor voices. This difference reflects the differences in the pharynx to mouth length ratio which serves as secondary cue in voice classification. Thus physiologically the maximum range of pitch is determined by the length and shape of the singer's vocal folds, shape of the vocal tract and ability to co-ordinate muscles for phonation.

Vibrato is an essential characteristic of singing voice. The artistic quality of signing is frequently judged by the presence of vibrato in the voice. Sea shore (1932) has defined a good vibrato as a "pulsation usually accompanied with synchronous pulsations of loudness and timbre, of such a extent and rate as to give a pleasing flexibility, tenderness and richness to the tone". Average rage of vibrato of a good singer is six to seven c/s is found by Seashore (1935), Vennard etal (1971), Luchasinger and Arnold (1970) Large and Iwata (1971) and Shipp etal (1980). Human ear can pick up pulsations slower than five per second as separate pitches which are unpleasant and referred as wobble at times and can be result of fatigue, tension or excessive contraction of the intrinsic muscles of the larynx (Sounien, 1970, Sounien etal, 1972).

Bunch (1982) quotes Nadoleizny's view, based on his work of 1923, which it states that an exaggerated vibrato, or a rate more than eight pulsations per second is considered fast and referred as bleat or tremole. This causes too much pressure on vocal folds. Modern rock and discotheque music do not care for vibrato which makes their singing "yelling" like putting more strain on vocal apparatus (Bunch, 1982). Winckel (1971) believes that vibrato is due to fluctuating activity in vocal musculatures. Large (1973) suggests its combined laryngeal and respiratory mechanism with laryngeal factor as being dominant. While singing the song, the Initial and final segments are usually accompanied by vibrato, that is, an almost periodic modulation of the fundamental frequency, whose amplitude is diminished in the transitional segment (Fujisaki, Tatsumi, Higuchi, 1980). Vanden Berg (1968) Vennard etal (1971) etc. have extensively studied the registers in singing. It is defined as series of succeeding sound of equal quality on a scale from low to high produced by the application of the same mechanical principle, the nature of which differs basically from another series of succeeding sounds of equal quality produced by another mechanical principle", still Bunch (1982) further states that this definition of register is considered as comprehensive and classic current concept is that there is three basic registers, the glottal fry, model and Falsetto; flute and whistle are included at the extreme top. Model register includes the middle and high register, (Bunch, 1982). But the presence of middle register is a riddle. Hollien and Carol (1982) have concluded from a study that validity of middle register cannot be established because, there is very less acoustic and physiological evidence that could support the notion that a middle register exists.

Boone (1971) states that "related to the production of voice pitch range of any individual is voice register". It appears that a particular register characterizes a certain pattern of vocal cord vibration with the vocal cords approximated in a similar way through out the pitch range. Once the pitch range reaches its maximum limit the folds adjust to new approximation contour, which produces an abrupt change in vocal quality. Van Den Berg (1959) classifies and describes voice registers as, chest, mid voice and Falsetto; from the perceptual view point voice register is confined to the similar sound of the individual voice at various pitches. Klein (1967) states that the lower tones have been called the chest register and the higher tone has been called as upper register or head register.

Moses (1954) states that "register, refers to a physical acoustic event which results from an energetic change within the muscular co-ordination of the vocal cords". In singing from the highest tones possible to the lowest, the untrained singer first passes a sequence of tones which seems unified. Then he comes to a node, a switching point from which he continues with a sequence of tone of a different character, then he reaches another node and switches to the lowest third of the range in a specific tone quality. The trained singer does'not reveal these nodes since he has learned to unify the head register, the mixed and the chest register. The mixed register is the combination of the head and chest register. This is used in normal speaking, it is a well balanced co-ordination of the width of the vocal cords. (Moses, 1954). There are various ways of differenciating the registers. That is, by physiologic and acoustic means. Vennard and Hirano (1971) found myoelastic forces acting for the chest voice and for falsetto only the prominent factor was aerodynamic with the muscular effort to maintain the condition. For head register cricothyroid action was more compared to the chest register.

E.M.G. findings has shown that in order to enter and leave chest voice a great vocalists effort is needed, which is relaxed after entering the new register (Vennard and Hirano, 1971).

Pearls (1969) stated the dual concept of registers, that is, whole cord vibrates for model register and portion of vocal cord vibrates for falsetto. That is, falsetto is produced by shortening the active portion of vocal cords.

When a singer is said to have carried the chest voice up to high or trying to carry a heavy sound too far up in the range, it means there is a lot of tension in vocalists of the singer. If he still tries to go higher, the voice breaks (Vennard, 1967).

Studies on acoustic correlates of registers indicate that the phonational range was same for both vocal fry in both males and females (Hollien, Dew, Beatty, 1969). Intensity in the model register was greater when compared to falsetto by an amount of 15 dB. Spectral analysis suggests that there are a greater number of partials exhibiting energy in the model register phonation than in the falsetto register (Cotton, 1969).

Usually a singer adopts two techniques to achieve equalization of register, are is to "cover" or darken the tone at transition point, the other is to modify the vowel sounds. The first is achieved by more space being maintained in pharynx and the larynx remains moderately low (Luchsinger and Arnold, 1965; Bunch, 1977, Sunderberg, 1977).

Formants are the peaks in the sound spectrum which include one or more harmonics, and are independent of the pitch being sung. These can be varied by changing the position of articulators. One can change two lowest formant frequencies two octave or more by changing the position of the articulators. Higher formants frequencies cannot be varied much. They give individuality to the voice characteristics. In singing more or less substantial deviations are observed from vowel ranges. Indeed a male opera singer may change the formant frequencies so much that they enter the area of different vowel. For instance, in vowel (i) as sung the lowest two formant frequencies may be those of vowel (y) still we tend to identify such vowel structure. This shows the frequencies of the two lowest formants do not determine the vowel identity entirely.

Demitriev and Kiselev (1979) studied the relationship between the formant structure of different types of singing voices and the dimensions of supraglottic cavities. Integrated spectra of different type of singing voices were obtained, each type characteristic of a certain frequency range for high and low singing formants. They showed that the formant frequency increases in the following order: Base, Baritone, Mezzo-Soprano and Soprano.

The "singing formant" is a high spectrum envelope peak near 2.8 K characteristic of vowel sounds in male western opera and concert singing. These "singer's formants" have been studied from acoustic and perceptional points by Sundberg (1974). There are strong reasons to assume that there is an acoustic consequence of clustering of the third, fourth and fifth formant frequencies. If formants approached each other in frequency, the ability of the vocal tract to transfer sound increases in the corresponding region. Hence they seem to be primarily due to respiratory phenomenon. An articulatory configuration which clusters the higher formants in such a way that a "singer's formant" is generated by involving a wide pharynx which appears to result from lowering the larynx. (Sundberg, 1974; Holhein etal, 1978).

Bunch (1982) states that the phonetic quality of vowel is due to resonances in the vocal tract altered by the position of the articulator. Singers make use of this in singing also in ascending and descending scale. Minckel (1967) states that a soprano voice that ascends to the level of C3 where the voice will be able to stimulate only the formants of the bright vowels. Small but significant adjustments have to be made in the shape of the resonators to produce appropriate vowel sounds. The gradual and controlled modification is soft palate is also called as "covering". There is controversy on the term, but essentially it means acoustical consequence with basic resonatory changes. This means that the singer has given more pharyngeal space to a sound by keeping the soft palate high while allowing the larynx to remain comfortably low (Bunch and Sonnien, 1977).

Vocal quality is the element in singing which attracts the listener. This quality is determined by two factors - (1) physical characteristics, ideally symmetrical bony structures of head, high wide dental arch, shape and length of the vocal tact including palate, vocal folds, all help in determining the vocal quality. (2) Efficient co-ordination of the various alterable and unalterable parts of the vocal instruments parts eg. the most favorable conditions of the pharynx for vocal quality are an elevated soft palate, comfortable low larynx, relaxed tongue and lack of tension in the neck and chest, facial muscles, position of jaw rigidity of tongue, manipulation of pharyngeal isthumus, emotional and physical health can reflect the quality of voice (Sundberg, 1978; Bunch 1982).

Various aspects of pulmonary function of the professional singers have also been the interest of voice researchers from a long time, the assumption being that the superior vocal quality of trained singers is due to concomittent superiority in vital capacity, in part reflecting and in part stemming from an increased volume. Sheela (1974) observed no significant difference between trained and untrained singers for vital capacity.

Mean airflow rate of a sustained vowel (usually vowel /a/) have also been studied among singers in different registers. The critical region which indicates the possible range for the normal population is approximately 40-200 ml. per sec. (Hirano, 1979). Large etal (1972) compared the mean airflow rate values of five male singers singing in head register and in the falsetto voice at the same fundamental frequency and intensity. Mean airflow rate was much greater in falsetto (ranging from 230-525 ml. per sec. and an average of 398 ml. per sec.) than in the head register (ranging from

100-310 ml. per sec. with an average of 219 ml. per sec.). Hirano (1970) and Hirano etal (1970) reported similar findings. Meglone (1967) measured mean airflow rate in five males and five females subjects during vocal fry phonation and reported that the mean airflow rate ranged between 2-71.9 ml. per sec. He did not find any consistent relationship between mean airflow rate and vocal fry frequency. Isshiki (1964, 1965) reported that mean airflow rate tended to be more closely related to the intensity of voice at high pitch levels than at low pitch levels. Hirano (1970) reported that the increasing mean airflow rate with increasing intensity was much greater in falsetto than in heavy or model voice. Thus acoustic and aerodynamic factors are studied in trained and untrained singers by many authors.

Fields states that there is no appreciable difference between the basic functional components of the larynxs of the singers and non-singers. The apparent ability to sing lies not in the physiological or structural make up of an individual rather, this ability is developed by specialised use of an organ, that is, otherwise identical or nearly so, in singers and non-singers, that is, specialised use is an art of singing. So differences have been noticed in trained and untrained singers.

Arnold (1967) states that the untrained singing voice will have a range of one and half to two octaves or less while trained singers may extend their range as much as an octave or more in some cases.

According to Moses (1954) in singing from highest to the lowest the untrained singer first passes a sequence of tone which seems unified, then he comes to a node, a switching point from which he continues with a sequence of tone of different character and then he switches to the lowest third of the range produced in a specific tone quality. The trained singer does not reveal these nodes since he has learnt to unify the head register, mixed and chest register. Roubeau, Chevrie-miller, Arabia-guided (1987) did not find any difference as stated above.

Spectrograms have also shown distinct differences, that is, presence of "singer's formant" around 2600-3200 Hz region and also clear distinction between vibrato rate of trained and untrained singers.

Spectrograms of singers have shown vowel definition and singers formant which was not present in untrained singers and also absence of partials as high as 5000 Hz which was perceived as undesirable noise which was observed in untrained singers (Schutte and Miller, 1984).

Gupta's study (1984) the findings was most of the singers do not go off-pitch in the octave fifth and octave notes. Most of the singers do go off-pitch at the highest note above the octave range and at the lowest note below the octave range. Magnitude of off-pitch is more at lowest note than at the highest note.

The study of evaluation of voice training by LTAS showed that the subjective changes in quality after training clearly have a substantial foundation in changes in the upper frequency ranges, particularly in terms of volume and Sonority (Svenwedan, Rolf Leanderson and Large Wedin, 1978).

Thus acoustically differences are noticed in trained and untrained singers and training also has an effect on singer's performance.

Indian music is a powerful tool, because, it has born out of Madhyama. Apshal (2000 A.D) states that by restful, alert, relaxed, inspiration with intake of the sufficient volume of breath, so that, the whole body aparatus is involved and the concious act of inspiration must involve major and minor diaphragms within the trunk and along with the upper respiratory passages. During this mind and body are one. The seat of energy is the premodeling of the behaviour of the outgoing breath, expiration, will reflect its homeostasis, resulting in optimum frequency. Such a system of intact autoregulated phonation reflects intact bio feedback mechanism, this is outcome of madhyama. Nandikeswara (1943) has shown how the cardinal vowel /a/, /e/, /u/ are interwoven with musical notes sa, ri, ga. He has further stated the unique postulate of intimacy, inter relation, integration all are born out of auto regulated principle in phonation with Madhyama.

Notes and octaves:

The musical interval between an arbitrarily chosen fundamental note and its first overtone (that is, a note congruent in quality with, but double the frequency of the fundamental) was made made to cover all the known contemporary melody in terms of definite number (7) of natural steps or groups containing their sharp and flats and these are called swaras or notes.

The names of these swaras and the syllables used for solfaing them in Indian music are as follows.

1. Shadja - Sa
2. Rishaba - Ri
3. Gandhara - Ga
4. Madhyama - Ma
5. Panchama - Pa
6. Dhaivatha - Da
7. Nishada - Ni

Indian music recognises seven swaras and two secondary swaras. These notes represent definite internal sound as such from the basic are natural (Shudda) scale. The notes that formed the basic scale are called pure (Shudda) when lowered by half tone are called komal (Flat). Notes raised by half a note are called Tiwara. In this Sa and Pa are tonic (Brihadeshi, 1963). So the basic scale of Indian music is as Sa, Ri, Ga, Ma, Pa, Da, Ni.

According to Deva (1781) our ancients did not talk of frequency ratios. They talked off number which can be added or substracted and ratios are given for 22 shrutis. Denilo (1949) has given the following ratios based on ancient texts.

Sa	Ri	Ga	Ma	Pa	Da	Ni	Sa
1	7/8	5/4	4/3	3/2	S/3	15/B	2

The study is in the area of music is sparse. Yet people have concentrated on the physiology, acoustics, psychology of music.

Studies even have differenciated the singers from non-singers physiologically and acoustically. The contravercial issues of differences in pitch range, presence or absence of singers formant, covering action, that is, smooth transition and the variations based on loudness and quality have been focused on and clear cut difference have been observed in the above said parameters.

Studies done on the effect of training on the quality of voice and the objective evaluation have correlated with the perceptual judgement.

The studies have been extended to the area of pulmonary and laryngeal functions in singers and non-singers focusing on vital capacity and mean airflow rate.

Instrumental analysis of singing will not only confirm the concepts used and accept them but also help to acquire more knowledge in this area. Further this information will be helpful in training the singers and to make them avoid vocal abuse or to maintain vocal hygiene and thus reducing the gap between vocal peadagologist's and voice scientist's view points.

Thus the present study is aimed at analysing the acoustic parameters, namely, the fundamental frequency, frequency range, transition, the energy ratio above and below 1 KHz region and the aerodynamic factors, namely, vital capacity and mean airflow rate in trained and untrained singers.

CHAPTER - III

METHODOLOGY

The present study was aimed at determining the following acoustic and aerodynamic factors in trained and untrained singers.

1. Mean fundamental frequency
2. Frequency range in singing a song, singing the octave range and reading
3. Transition in fundamental frequency from one register to the other in singing the octave range
4. Alpha ratio
5. Energy concentration below and above 1 KHz region
6. Maximum concentration of energy around 2-3 KHz region
7. Vital capacity
8. Mean airflow rate at three different pitch levels, that is, high, mid and low pitches

Subjects:

10 trained female and 10 untrained female singers were taken as subjects in the age range of 19 years to 24 years with a mean age of 21.5 years for trained singers and an age range of 19 - 21 years with a mean of 20 years of untrained singers. The period of training of the subjects in the trained group varied from 4-10 years.The subjects who met the following selection criteria were considered for the study.

1. The subjects should have no hearing loss or vocal pathology at the time of recording.
2. To be considered as trained singers, the person must have undergone training for a minimum period of three years in Carnatic music.
3. Untrained singers were those who could sing but did not have any formal training in classical music.
4. They should have ability to read Kannada.

Recording Material:

1. The octave range by sing   swaras
2. Voiced Kannada passage
3. The first stranza of the song

   "Jivavindu Eno Ondu
   Modake Vashavagide
   Kanasubrameyo Kannanaveyo
   Tharka Kalachi Urulide"

Recordings were done in quiet environment using a cassette tape recorder and cassette (which had good fidility)

Instructions:

1. The subjects were instructed to sing the swaras and they were asked to sing uptill the highest note and the lowest note they could go upto.
2. They were asked to read the passage.

Measurement of vital capacity and mean airflow rate;

These were measured using a wet expirograph. The subjects were asked to exhale air into the mouth piece connected to the expirograph after deep inhalation. The procedure was repeated three times. The maximum of the three readings was considered as the vital capacity of the subject.

Subjects were asked to phonate /a/ at their habitual pitch level into the mouth piece of the expirograph. The duration for which the individual phonated was noted down using a stop watch. Then total volume of air collected during phonation as read from the graph of the expirograph, was divided by the duration of phonation to obtain the mean airflow rate of /a/ at that particular frequency. Each subject was given three trials. The mean of the three readings was considered the mean airflow rate for /a/ for habitual frequency. The mean airflow rate at the highest pitch and the lowest pitch the individual could phonate were determined, using the procedure described to determine the mean airflow rate for /a/ at habitual frequency.

Recording procedure:

Recording mas done using a portable tape recorder (Model Philips 2218) with the electrat microphone and a cassette Meltrack (DR 90).

While recording the sample, the microphone was placed at a distance of three feet from the mouth of the subject. The singers were made to practice the common sample of the song two to three times and then the sample was recorded. The sample of octave range was recorded after which they were made to read the Kannada passage and the same was recorded.

Acoustic analysis:

The signal from the tape recorder was fed to pitch analyzer PM 100 which gave visual display of signal of 9 secs, duration on the screen, displaying fundamental frequency and intensity of that signal from the screen, with the help of the cursor, frequency and duration of the required signal were obtained and values were noted.

1. Measurement of fundamental frequency:

To determine the fundamental frequency the segments were fed from the recorder to pitch analyzer and the mean fundamental frequencies were directly noted from the display of PM 100.

2. Measurement of range of fundamental frequency:

The cursor was moved to the lowest point on the frequency curve and then to the highest point on the frequency curve and the readings were noted. The difference between these two readings provided the measure of frequency range in that particular segment. After analysis of the recordings the range for each subject was determined.

To note down the transition in fundamental frequency, thus the sample of octave range (of swaras) was fed into the computer Wipro PC with A/D converter and with inton programme. The analysis was done with the resolution of 20 m.secs. The printout of the frequency at every 100 m.secs. was taken and the transition from the lowest to highest pitch and again from highest to the lowest pitch in terms of hertz were noted down.

The common sample of song "Jivavindu" was fed into computer and analysis was done using "LTAS" programme and alpha ratio was obtained for each subject. . Then the energy concentration at 2-3 KHz region was noted down by moving the cursor to that region.

Thus the mean fundamental frequency, frequency range, in singing a song, singing octave range and reading, concentration of energy in LTAS, vital capacity, mean airflow rate were obtained for all subjects.

CHAPTER - IV

RESULTS AND DISCUSSION

The following acoustic parameters and aerodynamic factors were measured for each subject.

1. Fundamental frequency
2. Range of fundamental frequency

These parameters were measured in reading, singing octave range and singing song " " (Jivavindu).

3. Transition during shift from one note to the other in octave range
4. 'α' ratio and energy concentration at 1-3KHz region in long term average spectrum
5. Vital capacity
6. Mean airflow rate

1. Fundamental frequency:

a) Comparison of MFF under 3 conditions in trained singers

Table (1) shows the mean fundamental frequency of each trained subject in reading, singing octave range and singing song.

The study of table (1) shows that eight subjects (1-8) used higher fundamental frequency while singing the song except for subject '4' where the fundamental frequency during singing octave range and singing song were equal but higher than the fundamental frequency used while reading. Subjects

9 and 10 used higher fundamental frequency during singing the octave range than singing the song.

Subjects	Reading	Octave Range	Song
1	278.33	305.25	308.25
2.	260.66	292.00	304.00
3.	252.00	287.00	298.75
4.	258.00	302.00	302.00
5.	268.66	294.33	325.50
6.	274.00	307.00	350.00
7.	267.33	300.00	301.50
8.	286.66	356.00	362.50
9.	278.00	394.33	350.00
10.	276.00	372.66	350.33
Mean	269.76	321.05	325.28
S.D	10.68	38.53	25.36

Mean fundamental frequency (in Hertz) for each trained subject in reading, singing octave range, singing.

The mean fundamental frequency for trained singers ranged from

1. 252.00Hz to 286Hz in reading,
2. from 287Hz to 394Hz in singing octave range and
3. from 298Hz to 362Hz in singing song

The mean and standard deviation for this group was 269.96 Hz and 10.68 respectively, where as the mean for singing octave range was 321.06 and S.D of 38.33 and mean of 325.28Hz and S.D. 25.36 was noticed for singing song.

When the mean fundamental frequencies of all the three conditions were considered, it was found that in singing song higher fundamental frequency (325.28 Hz) was noticed.

The main fundamental frequency of all subjects were compared between reading and singing octave range, reading and singing song and singing octave range and song using Wilcoxon matched pair test.

The mean difference between reading and singing octave range was significant at 0.005 level. Hence the auxilliary hypothesis stating that "there is no significant difference between reading and singing octave range when the mean fundamental frequency was compared" was rejected.

The mean difference in fundamental frequency between reading and singing song was' significant at 0.005 level. Therefore the null hypothesis stating that "there is no significant difference between reading and singing song when mean fundamental frequency was compared" was rejected-

There was no significant difference between singing song and octave range when mean fundamental frequencies were compared. Thus the hypothesis stating "there is no significant difference between singing octave range and singing song when mean fundamental frequency is compared" was accepted.

Thus statistically there was significant difference between the conditions reading singing octave range and reading and singing song but not between singing octave range and song when mean fundamental frequency value were compared,

b) Comparison of fundamental frequency under 3 conditions in non-trained singers

Table (2) shows the mean fundamental frequency of reading, singing octave range and singing song for untrained singers.

Subject	Reading	Octave Range	Song
1	269.00	329.00	373.00
2	273.00	318.50	329.50
3	284.00	261.00	310.23
4	250.25	326.00	317.00
S	259.25	288.00	286.66
6	244.50	303.50	326.00
7	256.25	336.66	319.00
8	262.25	332.00	362.00
7	243.00	24B.33	290.33
10	247.75	332.00	313.66
Mean	258.98	307.49	322.75
S.D	31.69	27.41	63.51

The study of table (2) showed that subjects 1,2,3,6,8,9 showed higher mean fundamental frequency in singing. Subjects 5,7,10 showed higher fundamental frequency while singing octave range and subject 3 while reading.

The mean fundamental frequency ranged

1. from 243.00Hz to 284.00Hz in reading

2. from 248.33Hz to 336.66Hz in singing octave range and
3. from 286.66Hz to 373.00Hz in singing song

The mean fundamental frequency of 10 subjects in three conditions were 258.78 with S.D of 31.69 in reading, 307.49 with S.D of 27.41 for singing octave range and 322.75Hz with S.D of 63.51 for singing song.

Mean fundamental frequency was compared for all 10 subjects in all the three conditions using Wilcoxon matched pair test.

The mean difference between reading and singing octave range was significant at 0.009 level and at 0.005 level for reading and singing song. There was no significant difference between singing octave range and singing song. These results are similar to the results of the trained singers group.

Thus the auxilliary hypothesis stating that "there is no significant difference between three conditions when mean fundamental frequencies were compared" was rejected in two conditions:

1. between reading and singing octave range
2. between reading and singing song

But accepted when comparison was made between

3. Octave range and singing song

c) The comparison between trained and untrained singers for three conditions:

The comparison between trained and untrained singers for conditions was made using Mann-Whitney U test.

Significant difference was noticed for reading condition at 0.005 level.

No significance noticed for singing octave range and singing song.

Thus the auxilliary hypothesis stating that "there is no significant difference in reading condition between trained and untrained singers when mean fundamental frequency is compared" was rejected and however with reference to singing in octave range and singing song was accepted.

The results of present study indicate that higher fundamental frequency is noticed during singing song followed by singing octave range and reading respectively among trained and untrained singers thus confirming to the previous studies done by Sheela (1974), Nataraja, Jagadeesh and Kumar (19B5) and Ragini (1986).

The pitch of reference note was higher compared to the pitch used during reading condition in both trained and untrained singers. But the same pattern was also executed by the untrained singers who did not use the reference note as the trained singers. The other reason could be that the range of fundamental frequency was more during singing than reading and the mean fundamental frequency being higher when compared to reading condition. It was also noticed that there was no significant difference between trained and untrained singers except in reading condition. The reasons for this difference between trained and untrained singers is not clear.

2. Freauency Range:

Table (<3) shows the mean frequency range for each trained subject.

Subjects	Reading	Octave Range	Song
1	353	370	395
2	398	408	421
3	283	324	273
4	302	501	366
5	389	346	302
6	305	360	266
7	271	359	365
8	188	359	370
7	334	272	331
10	258	450	448
Mean	308.10	374.90	346.00
S.D	63.50	64.46	50.30

From table (3) it can be noted that subjects 1,2,7,10 showed greater range of fundamental frequency in singing 4 and 6 in octave range, 5 and 9 in reading.

The mean frequency range in all the three conditions were:

l. 308.10 with S.D of 63.50 in reading
2. 374.90 with S.D of 64.46 in singing octave range
3. 346.00 with S.D of 50.30 in singing song

When mean frequency range was compared, the highest mean frequency range was noticed in singing octave range followed by singing song and then reading condition.

The mean frequency range was compared using Wilcoxon matched pair test.

No significant difference was noticed when fundamental fundamental frequency range was compared between the three conditions. So the auxilliary hypothesis stating that "there is no significant difference between the three conditions the mean frequency range is compared" was accepted.

Table (4) shows the mean frequency range for untrained singers in reading, singing octave range and singing the song.

Subjects	Reading	Octave Range	Song
1	279	306	301
2	245	239	175
3	362	404	358
4	333	350	394
5	331	346	310
6	300	334	359
7	355	439	284
a	326	374	344
9	326	336	284
10	347	260	354
Mean	320.40	338.80	316.30
S.D	36.10	60.53	61.56

The above table shows that subjects 4,6,10 used greater frequency range in singing

1,3,4,5,7,8,9 used greater frequency range in singing octave range and subject 2 in reading.

The mean and S.D for 3 conditions for 10 subjects was as follows: .

Reading - 320.40Hz with 36.10 as S.D

Singing octave range - 338.80 and 60.53

Song - 316.30 and 61.56

The mean frequency range for 10 subjects was compared for all the conditions using Wilcoxon matched pair test.

No significant difference was noticed between three conditions among untrained singers. Thus auxilliary hypothesis stating that "there is no significant difference among untrained singers when mean frequency range is compared" was accepted.

Comparison was made for three conditions between trained and untrained singers using Mann - Whitney U test. No significant difference was noticed between the group in all conditions. Thus the null hypothesis is stating that "there is no significant difference between trained and untrained singers when three conditions were compared" was accepted.

In the present study, it was noticed that greater frequency range was used during singing octave range followed by song and reading. The possible reason could be that of the instructions given by the experimental since they were instructed to sing the octave range with the highest and lowest possible notes they could sing (i.e., the maximum vocal range) which was not used during singing song and reading.

The result of present study contradicts the results of Sheela's study (1974) where there was significant difference between trained and untrained singers when frequency range was compared.

3. Transition:

Transition is the change noticed in fundamental frequency between two adjacent notes in an octave range.

Table - 5 showing an example of transition between two adjacent notes in trained and untrained singers:

Untrained		Trained	
Sa-Ri - 226 223 267 274	Pa-Ma - 334 314 313	Sa-Ri - 157 170 219 242	Ga-Ri - 540 481 479
Ri-Ga - 272 276 288	Ma-Ga - 307 299	Ri-Ga - 240 243	Ri-Sa - 421 417 377

The similarities noticed between trained and untrained singers in the present study were

1. A gradual transition from one note to another
2. A reduction in frequency at the termination of one note followed by an increase in frequency for both

the ascending and descending glissandoes (Sliding), of the octave range.

The differences observed included

1. A longer time of transition period among trained singers when compared with the untrained singers.
2. Lesser pauses noticed between notes among trained singers as against the untrained singers.

Thus the present study indicated a good breath control among trained singers which might be due to the training factor.

Studies by Proctor (1770), Boone (1771) and Luchsinger (1765) indicate that trained singers possess longer phonation time when compared to the untrained singers and that a trained singer is capable of maintaining phonation for atleast 20-30 secs.

According to Luchsinger (1765), Boone (1771) and Greene (1772), in order to maintain phonation, expiratory power is necessary which depends on vital capacity.

Luchsinger and Arnold (1765) state that "the longer the available air lasts the more can be said or sung.

Thus the above results of present study can be explained either in terms of

the greater vital capacity observed among trained singers OR

the ability of trained singers to maintain the phonation for longer time.

4. Alpha ratio:

Alpha ratio is the energy concentration above and below 1 KHz region.

$$\text{i.e., Alpha} = \frac{\text{Energy above 1 KHz}}{\text{Energy below 1 KHz}}$$

Table-6 shows the alpha ratio for trained and untrained singers.

Subjects	Trained singers	Untrained singers
1	1.20	0.73
2	0.88	0.81
3	1.32	0.86
4	1.27	0.87
5	0.74	0.71
6	0.84	0.82
7	0.77	1.37
8	0.85	0.73
9	0.71	0.88
10	0.70	0.87

The above table shows that the alpha ratio exceeds one only in three subjects, that is, 1,3,4 in trained singers group and subject 7 in untrained singers group. Rest of the subjects showed alpha ratio which is less than one thus the energy concentration below 1 KHz region was more compare to that above 1 KHz region.

The alpha ratio ranged from a minimum of 0.84 to 1.32 in trained singers and 0.81 to 1.37 in untrained singers.

Mean alpha ratio was compared between the trained and untrained singers using Mann - Whitney U test.

No significant difference was noticed. Thus the hypothesis stating "there is no significant difference between trained and untrained singers for alpha ratio" was accepted. It may also be stated that there was not much difference between the two groups in terms of quality, when the groups are considered as a whole.

5. Energy concentration below and above 1KHz region:

Subjects	Trained		Untrained	
	Below 1KHz	Above 1KHz	Below 1KHz	Above 1KHz
1	77.07	121.75	107.22	101.24
2	102.46	70.48	101.52	82.26
3	75.87	126.75	106.78	72.20
4	102.07	127.20	105.70	73.67
5	78.54	73.07	110.45	100.53
6	103.83	87.14	103.37	84.30
7	103.86	100.80	72.18	126.22
8	78.76	84.24	102.30	87.73
7	74.46	85.27	115.84	107.27
10	74.46	85.27	106.13	74.47

The energy concentration above 1 KHz was more for subjects 1,3,4 and rest of the subject showed more energy below 1 KHz. Among untrained singers only one subject that is, No.l showed more energy concentration above 1 KHz.

When comparison was made between energy conceptration above and below 1 KHz in trained singers using Wilcoxon matched pair test, no significant difference was found out. Same result was noticed among untrained singers.

When comparison was made between trained and untrained singers using Mann-Whitney U test, no significant difference was noticed. Thus the auxilliary hypothesis stating there is no significant difference between trained and untrained singers when mean energy concentration below and above 1 KHz region is compared" was accepted.

The result of present study concerning the alpha ratio and energy concentration below and above 1 KHz region did not show significant difference between trained and untrained singers since both the groups showed similar research. That is, most of the trained and untrained singers showed more energy concentration below 1 KHz when spectral analysis was done except for three subjects among trained singers and one subject among untrained singers, thus contradicting the results of previous studies indicating alpha ratio being more than one in trained singers and more energy concentration above 1 KHz region when compared to untrained singers.

It may also be stated that there was not much difference between the two groups in terms of quality when the groups are considered as a whole.

6. Frequency at which maximum energy concentration is noticed from 2-3 KHz region:

Table-8 shows the frequency at which maximum concentration of energy is noticed around 2-3 KHz region

Subject	Trained	Untrained
1	2484, 2531	2578, 2609, 2594
2	2344	2297
3	2953	2141, 2156
4	2969	2328
5	2281	2328
6	2500, 2516, 2531, 2547	2125
7	2359, 2516	2313, 2344, 2672
B	2547, 2563, 2281, 2297	2078
*	2375	2328
10	2500	2313

From table the interpretation is that most of the trained singers have maximum concentration of energy around 2500 - 2969 Hz region except for subjects No.1,2,5,9, where energy concentration is more around 2300 Hz region. Where as among untrained singers the maximum concentration of energy is noticed around 2300 - 2500 Hz region.

Most of the trained and untrained singers who showed more energy concentration below 1 KHz showed maximum energy concentration around 250 - 350 Hz region where as, subjects who showed more energy concentration above 1 KHz remain showed maximum energy concentration around 1700 Hz region when compared with the subjects showing more energy concentration below 1 KHz region.

The study done by Hollien etal (1978) showed maximum concentration of energy around 2850 - 3150 Hz range among trained singers.

The result of present study confirms to the study done by Hollien etal (1978). That is, maximum energy concentration around 2500-2950 KHz region was noticed.

Among the untrained singers the maximum energy concentration was around 2300 - 2500 Hz region which was at lower level when compared to the trained singers eventhough, significant difference was not noticed.

CHAPTER - V

SUMMARY AND CONCLUSION

The review of literature on differences between trained and untrained singers reveal a significant difference between acoustic and aerodynamic factors,namely fundamental frequency and its range, vital capacity, mean airflow rate

The present study was conducted to determined the acoustic and aerodynamic factors among singers and compare them among trained and untrained singers as also across the two groups.

The following were the acoustic and aerodynamic factors studied:

Acoustic parameters:

1. Fundamental frequency and frequency range in reading, singing octave range and singing the song.
2. Transition from one register to the other in an octave range.
3. The ratio of energy concentration above and below 1 KHZ (Alpha ratio) and the frequency at which there was maximum concentration of energy around 1-3 KHz region.

Aerodynamic factors:

1. Vital capacity
2. Mean airflow rate during phonation at low, mid and high pitches.

Procedure:

10 trained and 10 untrained singers with the mean age of 21.6 years and 20.3 years respectively served as subjects. All of them reported of no hearing problem or vocal pathology at the time of recording. Sample of reading passage, singing octave range and singing a piece of song were audio recorded. The passage included the Kannada voiced passage. The above sample was analysed for acoustic parameters of fundamental frequency, frequency range, transition, alpha ratio and energy concentration around 1-3 KHz region using PCXT and PM 100. Aerodynamic factors were measured using a wet expirograph. The results were compared among the trained and untrained singers and across the two groups using Mann-Whitney U test and Wilcoxon matched pair test procedures.

Conclusions:

The following conclusions were drawn from the present study.

1. Significant differences have been noticed among trained singers when fundamental frequency in reading, singing octave range and singing song were compared.
2. Significant differences have been noticed among untrained singers when fundamental frequency in reading, singing octave range and singing song were compared.
3. No significant difference was noticed in singing octave range and song among trained and untrained singers when fundamental frequency was compared.
4. No significant difference was compared when trained and untrained singers were compared except for fundamental frequency in reading condition.
5. No significant difference was noticed among and between trained and untrained singers when frequency range in reading, singing octave range and song were compared.
6. Significant difference was noticed between trained and untrained singers when vital capacity was compared.
7. No significant difference was noticed between trained and untrained singers when mean airflow rate was compared during phonation at low, mid and high pitches.

B. No significant difference was noticed when alpha ratio was compared between trained and untrained singers.

9. No significant difference was noticed during transition except that trained singers consumed longer time for transition and lesser number of pauses were observed in between the swaras (notes).
10. Maximum energy concentration was around 2500-2900 Hz region for trained singers and 2300-2500 Hz region for untrained singers.
11. Maximum concentration of energy below 1 KHz was around 250-350 Hz region for singers who had alpha ratio less than one and around 1700 Hz region for those singers who had alpha ratio more than one.

Recommendations:

These results need to be confirmed using

1. Larger sample,
2. Across amount of training,
3. Across various styles of music.

Limitations:

1. Sample was limited to 10 +10 subjects only,
2. Years of training was not considered as a factor.

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