THE ANALYSIS OF DYSPHONIC VOICE BEFORE AND AFTER THERAPY

REG. No.M9510

Prabha Sinha

A dissertation submitted as part fulfilment of Final Year M.Sc.,(Speech and Hearing), Mysore.

All India Institute of Speech and Hearing, Mysore

May 1997

DEDICATION

MY FAMILY

CERTIFICATE

This is to certify that this Dissertation entitled **THE ANALYSIS OF DYSPHONIC VOICE BEFORE AND AFTER THERAPY** is the bonafide work in part fulfilment for the degree of Master of science (Speech and Hearing) of the student with Register No.M9510.

Mysore
May, 1997

Dr.(Miss) S.Nikam
Director
All India Institute of
Speech and Hearing
Mysore 570 006.

CERTIFICATE

This is to certify that this Dissertation entitled **THE ANALYSIS OF DYSPHONIC VOICE BEFORE AND AFTER THERAPY** has been prepared under my supervision and guidance.

Mysore
May, 1997

Dr.N.P. Nataraja
Prof. and HOD
Dept. of Speech Sciences
All India Institute of
Speech and Hearing
Mysore 570 006.

DECLARATION

This Dissertation entitled **THE ANALYSIS OF DYSPHONIC VOICE BEFORE AND AFTER THERAPY** is the result of my own study under the guidance of Dr.N.P. Nataraja, Prof. and HOD, Dept. of Speech Sciences, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other diploma or degree.

Mysore
May, 1997

Reg. No.M9510

ACKNOWLEDGEMENT

I would like to convey my sincere regards to Dr.N.P. Nataraja, HOD, Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore for his invaluable suggstlons, guidance and critical evaluations which enabled me to complete this work succesfully.

I would like to thank Dr. (Miss) S.Nikam, for giving me permission to carryout this study.

I would also like to expres my gratitudes towards N.Sreedevi, Lalitha for their help during data collection and analysis phase.

I would also like to express my deepest gratitude to all my family members for their strong support, love and affection. How can I put in towords "how much I love you?"

Friends are the wonderful gift to mankind. "Dear friends" : whichever country you are in --- all of you are friends beyond compare. Thanks for being there for me.

And finally my deep gratitude to Rajalakshmi Akka for her immense help and efficient services. Akka your efficiency amazes me !!

TABLE OF CONTENTS

h

LIST OF TABLES

Page No.

y

INTRODUCTION

The human vocal mechanism deserves understanding and respect for what it is - a sensitive instrument capable of permitting us to produce a type of sound of distinct quality called voice. Voice has been defined as "the laryngeal modulation of the pulmonary air stream, which is modified by the configuration of the vocal tract {Brackett, 1971) .

Voice plays an important role in speech and language. The production of voice depends upon the various systems like respiratory, phonatory and resonatory. Any anatomical, physological or functional deviation in any of these systems would lead to a voice disorder. Therefore, voice problems must be valuated carefully and therapeutic intervention must proceed after diagnosis of voice problem in order to overcome the problem or to cope up with the problem.

"The treatment of patients suffering from dysphonia depends upon the ability to assess initially the type and degree of voice impairment and also to monitor the patient's subsequent progress throughout treatment" (Kelman, 1981). "Diagnosis is intended to define the parameters of the problem, determining etiology and outline a logical course of action" (Emerick and Hatten, 1979).

The ultimate aim of studies of normality and abnormality of voice assessment and diagnosis of the voice disorder is to enforce procedure which will eventually bring back the voice of an individual to normal or optimal level or will enable the individual to cope up with the problem. There are various means of analyzing voice, developed by different workers (Hirano, 1981; Nataraja, 1986; Rashmi, 1985).

The human ear has remarkable capacity to identify and discriminate varying sound complex. This psychoacoustic evaluation of voice is based on pitch, loudness and quality of voice sample. But due to its subjectivity the perceptual judgement of voice has been considered less useful than the objective measurements. There are objective methods like EGG, stroboscopy, photoglottography, videofluroscopy, expirograph etc. which measure various acoustic and aerodynamic parameters. Presently, computer software programs are available like VAGHMI, aerophone etc. which measure various aerodynamic and acoustic parameters.

Studies have considered in the past the effectiveness of various parameters of voice in differentiating normal from dysphonics (Jayaram, 1975; Nataraja, 1986; Mirano, 1981) and also monitoring pre and post-treatment changes in voices

(Cooper, 1974; Vanderberg and Hocksema, 1980; Wedin and Organ, 1982; Trullinger and Emanual, 1988; Hufnagle and Hufnagle, 1989; Susheela, 1989; Schutte, Kltzung and Akertund, 1993; Menon, 1996). The parameter studied and the kinds of treatment have varied over the studies.

The present study was undertaken to determine the reliability of sixteen acoustic and aerodynamic parameters in normals. The purpose of this study was also to determine those parameters which are usefulin differentiating dysphonics from normals, dysphonics before therapy and after therapy and to compare dysphonics before and after therapy with normals to note the effectiveness of voice therapy.

Hypotheses :

i) There is no significant difference between the values of parameters measured repeatedly (with a gap of one week) in case of normals.

ii) There is no significant difference between normals and dysphonics before voice treatment in terms of different parameters.

iii) There is no significance difference in dysphonics before and after the therapeutic intervention in terms of different parameters.

iv) There is no significant difference between normals and dsyaphonics after treatment in terms of different parameters.

Acoustic Parameters considered for the study were :

i) Mean fundamental frequency for the phonation of /a/,
ii) Maximum fundamental frequency for the phonation of /a/,
iii) Minimum fundamental frequency for the phonation of /a/,
iv) Range of fundamental frequencies for the phonation of /a/,
v) Speed of fluctuations in fundamental frequency for the phonation of /a/,
vi) Extent of fluctuations in fundamental frequency for the phonation of /a/.
vii) Mean intensity for phonation for /a/,
viii) Maximum intensity for phonation for /a/,
ix) Minimum intensity for phonation of /a/.
x) Range of intensities for phonation of /a/.
xi) Speed of fluctuations for phonation of /a/.
xii) extent of fluctuations for phonation of /a/.

Aerodynamic Parameters considered for the study were :

xiii) Vital Capacity

xiv) Mean airflow rate

xv) Maximum phonation duration for /a/,

xvi) S/Z ratio

Brief Methodology :

In the present study 15 normal males and 15 normal females in the age range of 20-25 yers formed the experimental group. 12 acoustic parameters were obtained from computer software program 'VAGHMI[1] and rest 4 aerodynamic parameters were obtained from expirometr. Again after a gap of one week 5 normal males and 5 normal females were evaluated again for the same parameters to check consistency in parameter. Fifteen dysphonic subjects [ten males and five females] were also evaluated for the same parameters and compared with normals, dysphonics before therapy, dysphonics after therapy and dysphonics before and after therapy.

Limitations :

- This study could not be carried out on a large population.
- More parameters could not be studied like spectral analysis, harmonic analysis etc.
- The changes in the dysphonic voice could not be studied time to time during the course of therapy to monitor changes.

REVIEW OF LITERATURE

There is nothing more elemental in all existence than communication. In humans one sees its ultimate expression in describe an event and to establish communication. It took millions of years for human beings to develop this faculty. The onset of humane era is recognized to have started with the acquisition of the ability to communicate using the vocal apparatus for social interaction. No normal person has failed to develop this faculty and no other species is known to have developed this ability.

Speech is the audible manifestation of language. It is one form of communication which people use most effectively in interpersonal relationships. Speech is a complex motor act brought about by sophisticated and fine movements of the components of the vocal tract and their complex interactions with one another. The speech results due to fine organization, co-ordination and modulations between the respiratory, phonatory, resonatory and articulatory systems. With speech people give form to their innermost thoughts, their dreams, ambitions, sorrows and joys, without it they are reduced to animal noises and unintelligible gestures. In the real sense speech is the key to human existence. It bridges the differences and the distances and helps to give meaning and purpose to their lives (Fisher, 1975). According to Boone (1985), "the act of speaking is a very specialized way of using the vocal mechanism, demanding a combination or interaction of respiration, phonation, resonance and articulation".

The voice is the first sign of life. Then, throughout life the voice is a primary means of expression and communication. It is an indicator of health, sickness, emotion and age. The voice provides means to earn living. It may convey great artistic expression through skillful use. The voice has life long importance to normal oral communication and social well-being (Titze, 1994).

Voice is the vehicle of speech. It is the musical sound produced by the vibration of vocal cords in the larynx by air from the lungs. The importance of voice in speech is very well depicted when one considers the cases of voice disorders or laryngectomy. "voice plays the musical accompaniment to speech rendering it tuneful, pleasing, audible and coherent being essential to efficient communication by spoken words" (Green, 1964).

Voice is more than a means of communication of verbal messages clearly. Voice constitutes the matrix of verbal communication in fusing all parameters of human speech and the unique self one presents to the world. Voice has both linguistic and non-linguistic functions in any language. The degree of dependence of language on these functions varies from language to language. For example, tonal languages rely more upon the voice or pitch specifically than other languages.

Perkins (1971) has identified at lest five non-linguistic functions of voice. Voice can reveal speaker identity, i.e. voice can give information regarding sex, age, height and weight of the speaker. Lass, Brong, Ciccolella, Walters and Maxwell (1980) reported several studies which have shown that it was possible to identify the speaker's age, sex, race, socio-economic status, racial features, height and weight based on voice.

It is a prevailing notion that there is a relationship between voice and personality i.e., voice reflects the personality of the individual (Starkweather, 1961; Markel, Meisels and Hauck, 1964; Rousey and Moriarty, 1965; Fairbanks, 1942, 1966; and Hutter, 1967 have concluded from their studies that the voice reflects the emotional conditions reliably. Voice has also been considered to be reflecting the physiological state of an individual, for example, a very weak voice may indicate that the individual may not be keeping good health or a denasal voice may indicate that the speaker has common cold. An attempt has been made by the Russians to find out the physiological conditions of pilots based on voice analysis. Apart from these, it is a well known fact that voice basically reflects the anatomical and physiological conditions of the respiratory, phonatory and resonatory systems, i.e., deviation in any of these systems may lead to voice disorders.

Voice is the carrier of speech; variations in voice in terms of pitch and loudness, provide rhythm and also break the monotony. This function of voice draws attention when there is a disorder of voice.

Voicing (presence of voice) has been found to be a major distinctive feature in almost all languages. Voicing provides more phonemes and makes the language broader. When this function is absent or used abnormally it would lead to a speech disorder.

At the semantic level also voice plays an important role. The use of different pitches, high and low with the same string of phonemes would mean different things. Speech prosody-the tone, the intonation and the stress or the rhythm of language in a function of vocal pitch and loudness as well as phonetic duration.

A recently developed aspect in the area of early identification of disorders is infant cry analysis. It has been found by many investigators (Illionworth, 1981; Indira, 1982; and Venugopal, 1995) that it is possible to identify abnormalities in the neonates by analyzing their cry.

Speaker identification by voice would be of immense value in computer technology (development of machines that will respond to speaker commands). Forensic medicine (Identification of speaker by voice and lie detection) and in defence (availability of classified information).

The quality of voice also becomes important for certain professionals eg. radio/T.V. announcers, actors and singers. Thus voice, has an important role in communication through speech and there is a need for studying voice.

The term voice has been differently defined by different people. The Random House dictionary lists 25 primary and secondary definitions of voice, the first of which, "the sound or sounds uttered through the mouth of the human beings in speaking, shouting, singing, etc. Some definitions of voice restrict the term to the generation of sound at the level of the larynx, while others include the influence of the vocal tract upon the generated tone and still others broadens the definition by including aspects of speech like articulation and prosody. Judson and Weaver (1942) defines voice as "laryngeal vibration (phonation) plus resonance". Further they state that phonation is the production of tone by the laryngeal generator. The equation P=ST has been used by Fant (1960) in which sound 'P' is the product of the source 'S' and the transfer function of the vocal tract 'T'. While discussing the production of speech, it should be noted that the source 'S' of the equation P=ST is an acoustic disturbance, superimposed upon the flow of respiratory air and is caused by a quasiperiodic modulation of the air flow due to opening and closing movement of the vocal folds (Fant, 1960).

Michael and Wendahl (1971), after reviewing various definitions of voice, define voice as "The laryngeal modulation of the pulmonary airstream, which is then further modified by the configuration of the vocal tract.

Though there are varied definitions of voice. It is a difficult task to define normal voice. An attempt has been made by Nataraja and Jayarama (1975) to review the definitions of normal voice critically. They have concluded that each of the available definitions have used subjective terms, which are neither defined nor measurable. They have suggested the possibility of defining good voice operationally as the good voice is one which has optimum frequency as its fundamental (habitual) frequency.

It is apparent that a good voice is a distinct asset and a poor voice, may be a handicap. If a person's voice is deficient enough in some respect, that is, it is not a reasonably adequate vehicle for communication, if it is distracting the listener, then one can consider it as a disorder.

In general the following requirements" can be set to consider a voice as adequate as stated by Iwats and von Leden (1978).

1. The voice must be appropriately loud.

2. Pitch level must be appropriate. The pitch level must be considered in terms of age and sex of the individual. Men and women differ in vocal pitch level.

3. Vocal quality must be reasonably pleasant. This criterion implies the absence of such unpleasant qualities like hoarseness, breathiness, harshness and excessive nasality.

4. Flexibility must be adequate. Flexibility involves the use of pitch and loudness inflection. An adequate voice must have sufficient flexibility to express a range of differences in stress, emphasis and meaning. A voice which has good flexibility is expressive. Flexibility of pitch and flexibility of loudness are not easily separable, rather they tend to vary together to a considerable extent.

Wilson (1962) is of the opinion that good voice should have following characters:

1. Pleasing voice quality.
2. Proper balance of oral and nasal resonance.

3. Appropriate loudness
4. A model frequency level suitable for age and sex of the subject.
5. An appropriate voice inflections involving pitch and loudness.

The production of voice depends on the synchrony, or the coordination between the systems viz. the respiratory, phonatory and resonatory. Voice production involves a complex and precise control by the central nervous system of a series of events in the peripheral phonatory organs. The crucial events essential for voice production is the vibration of the vocal folds. It changes DC airstream to AC airstream converting aerodynamic energy into acoustic energy.

Two major theories have dominated in dealing with voice production. They are - Myoelastic aerodynamic theory (Muller, 1843) - which holds that phonation is the result of balancing of forces of air pressure against tension, elasticity and mass of the vocal folds. Displaced by the air pressure the vocal folds return to a resting state due to combination of factors, the chief ones being the drop in air pressure at the glottis following the valvular opening of vocal folds and the vocal fold mass and elasticity. The function of the vocal folds themselves is in large part passive. As in respiration the final movements of the vocal folds are not under specific conscious control.

Neurochronaxic theory (Husson, 1950) holds that the vocal fold vibration is an active process. Motor impulses to be send are emitted from cortical centres to the muscles of the folds via the recurrent laryngeal nerves. Under the regulation of a 'cochlear recurrential reflex'. Vocal fold stimulation of this kind assumes that the recurrent nerve is capable of transmitting high frequency stimuli i.e. of the order of 1,000 impulse per seconds. However, the experimental evidence is in support of myoclastic-aerodynamic theory. Hence, most commonly acceptd than the other theory.

The crucial event for voice production is the vibration of vocal folds, it changes DC air stream to AC air-stream, converting aerodynamic energy into acoustical energy. From this point of view the parameters involved in the process of phonation can be divided into three major groups.

1. The parameters which regulate the vibratory pattern of the vocal folds.

2. The parameters which specify the vibratory pattern of the vocal folds.

3. The parameters which specify the nature of sound generated (Coiz, 1961).

Hirano (1981) has further elaborated on this by stating that "the parameters which regulate the vibratory pattern of the vocal folds can be divided into two groups:

- Physiological,
- Physical.

The physiological factors are those related to the activity of the respiratory, phonatory and articulatory muscles. The physical factors include the expiratory force, the conditions of the vocal fold and the state of vocal tract.

The vibratory patterns of the vocal folds can be described with respect to various parameters including the fundamental frequency, regularity or periodicity in the successive vibrations, symmetry between two vocal folds; uniformity in the movement of different points within each vocal fold, glottal closure during vibration, contact area between the two vocal folds and so on.

The nature of the sound generated is chiefly determinated by the vibratory pattern of the vocal folds. It can be specified both in acoustic terms and in psychoacoustic terms. The psycho-acoustic parameters are naturally dependent on the acoustic parameters. The acoustic parameters are fundamental frequency, intensity, acoustic spectrum and their time related variations. The psycho-acoustic parameters are pitch, loudness and quality of voice and their time related changes.

Thus, voice serves numerous functions which are varied too and it plays a major role in speech and hence in communication. Therefore, voice needs to be constantly monitored, and in the event of abnormal functioning of voice, an immediate assessment should be undertaken. The production of voice requires synchrony between various systems like respiratory, phonatoryand resonatory. Any deviationin any of these systems wither anatomical or physiological manifests itself by change/deteroration of voice,e.g., in the presence of laryngeal web or vocal nodule excessive muscular tension could be observed in the throat region and vocal quality being hoarse. Severity of the problem difers depending on the extent of structural deviation. The therapist has to assemble all such relevant information and form a cohesive whole with other psychological and physical factors which will influence the assessment. This assessment will lead to the diagnosis which not only identifies the voice disorders, but also acts as an indicator for the treatment and the management to be followed. Subjective and instrumental assesment results form the baseline uponwhich progress can be evaluated.

CLINICAL EVALUATION OF VOICE IS MEANT

1. to diagnose the etiological disease (s),
2. to determine the degree and extent of etiological disease(s), .
3. to evaluate the degree and nature of dysphonia,
4. to determine the prognosis, and
5. to monitor changes.

The ultimate aim of studies on normality and abnormality of voice assessment and diagnosis of the voice disorder is to enforce the procedure which will eventually bring back the voice of an individual to normal or optimum level. With the advances in technology, the perspectives of assessment and treatment of voice disorders have changed. Suggestions to view the function of voice production as related to various systems (Perkins, 1971) and to describe voice with reference to different positions of vocal tract (Lever and Hansan, 1981) have been made. Further a number of attempts have been made to analyze voice using various methods like glottography, x-ray, electroacoustic measurements and aerodynamic measurements (Hirano, 1981).

Lasiua et al. (1986) have developed a compact voice evaluation system, primarily aiming at its application to voice screening for early detection of laryngeal pathology. The system employs multiple acoustic parameters which are associated with

1. Perturbation in pitch period and amplitude sequences.
2. Amount of noise in voice signals.
3. Frequency characteristics of both harmonic and noise component in voice signal.
4. Spectral variations of the waveforms from period to period.
5. Some other statistical parameters relevant to pitch periods and amplitudes.

In order to develop an assessment system of voice, acoustical correlates of pathological voice qualities were investigated for 98 samples using GRBAS scale which consists of 'grade of hoarseness', 'rough', 'breathy', 'asthenic' and 'strained'. Several acoustic parameters were extracted from the voice which were -

1. Modulation indices representing periodical variations in the pitch period, in the amplitude and in the waveform.
2. Pitch perturbation quotient.
3. Amplitude perturbation quotient.
4. Distortion factor representing richness of harmonics.
5. Additive noise level (Imaizumi, 1988).

In order to provide an objective analysis of the function of whole vocal tract (Berry, Epstein, Fourcin, Freeman, MacCurtain and Noscoe, 1982) combined techniques of xeroraduography and electro-laryngography. It was found that 'at rest' and habitual /i/ gestures were the most useful for detecting aberrant muscle patterning.

Voice disorders related to occupational demand requires not only the investigation of their vocal capacities but also knowledge about their vocal load. For an objective measurement of vocal load, a voice accumulator has been developed. This portable instrument records total speaking time and sound level over a period of several hours. With this, it is possible to monitor vocal ability or disability during vocal rehabilitation (Buebers, Bierens, Kingma, Marres, 1995).

Michael and Wendahl (1971) considers voice as a multidimensional series of measurable events. Implying that a single phonation can be assessed in different ways. They present a tentative list of 12 parameters of voice, "most of which can be measured and correlated with specific perceptions while others were elusive and difficult to talk about in more than ordinal terms". The twelve parameters listed by them are -

1. Vital capacity
2. Maximum duration of controlled, sustained blouring.
3. Modal frequency range.
4. Maximum frequency range.
5. Maximum duration of sustained phonation.
6. Volume/velocity airflow during phonation.
7. Glottal waveform.
8. Sound pressure level.
9. Jitter of the vocal signal.
10. Shimmer of the vocal signal.
11. Effort level.
12. Transfer function of the vocal tract.

But still as Hirano (1981) points out there is no agreement on the terms used and the methods used in assessing voice disorders. This problem is again because of the fact that the voice is being described by different people from different points of view.

AERODYNAMIC MEASUREMENTS deals with aerodynamic factors including measurements of the various airflows and air volumes*.X'*

The human ear has a remarkable capacity to identify and discriminate varying sound complex. One can identify the speaker, simply by listening to the voice. Well-trained voice clinicians are frequently able to determine the causative pathologies of voice (Takhashi, 1974 and Hirano, 1975) just by listening tovoice of patients i.e. by psychoacoustic evaluation of voice.

The term phonatory abilities refers to the measurements of maximum duration of sustained phonation (Lass and Michel, 1969; Placek and Sander, 1963; Van Riper, 1954; Fairbanks, 1960; and Ladesetals, 1968), maximum frequency range (Hiller and Michael, 1968), dynamic range of vocal intensity, glottal efficiency and others. Measurements that can reflected the normal physiology and pathophysiology of abnormal behaviour are highly desirable. Since phonatory dysfunction usually manifests as a result of abnormal oscillatory movements, the measurement and analysis of vibratory patterns of vocal folds has the potential to provide detailed information on pathophysiology of the vocal folds during phonation (Hanson et al. 1983). The study of vibratory movements has drawn a lot of attention of researches recently. Several methods have been developed with the objective of visualizing the rapid movements of the vocal folds.

The vocal fold vibrate in the frequency range of 100-300 Hz during normal conversation and even at higher levels during singing. Observation of such vibrations require special methods. The following are some of the methods to study vocal fold vibrations.

1. Stroboscopy
2. Ultra sound glollography/electrography
3. Ultra speed photography
4. Inverse filtering
5. Photoelectric glottography (PGG)
6. Electroglottography (PGG)

These techniques are invasive and have their own draw-backs.

THE ACOUSTIC ANALYSIS OF VOICE

These have been considered as much simpler technique when compared to the above tools in the investigation of voice disorders. It has been considered vital in the diagnosis and management of patients with voice disorders. Hirano (1981) has pointed that acoustic analysis of voice signals may be one of the most attractive methods for assessing phonatory function or laryngeal pathology because it is non-invasive and provides objective and quantitative data - Many voice tests, are in fact unnecessary for the diagnosis of the etiological disease. They are, however, useful and necessary for other purposes. Some of the tests including acoustic analysis might be useful for the purpose of screening.

Further, a clinician will not really know what to expect with a medical diagnosis having complete physical description of larynx together with some adjectives like hoarse or rough until they actually see the case (Michael and Wendhl, 1971). On the other hand if the clinician receives a report which includes measures of frequency ranges, respiratory functions, jitter, shimmer the irrelated variations, noise and harmonic components, etc. in the form of a voice profile, the clinician can then compare these values the norms for each one of the parameters and thus have a relatively good idea as how to proceed, with.

AERODYNAMIC PARAMETERS

1. Vital capacity
2. Mean airflow rate
3. Phonation Quotient
4. Vocal velocity index
5. Maximum phonation duration
6. S/Z ratio.

ACOUSTIC PARAMETERS

7. Fundamental frequency in phonation
8. Fundamental frequency in speech.
9. Optimum frequency.
10. Extent of fluctuation in fundamental frequency in phonation.
11. Speed of fluctuation in fundamental frequency in phonation.
12. Extent of fluctuation in intensity.
13. Speed of fluctuation in intensity.
14. Frequency range in phonation.
15. Frequency range in speech.
16. Intensity range in speech.

17. Intensity range in phonation.
18. Rising time in phonation.
19. Falling time in phonation.
20. Ratio of intensities between 0-1 KHz and above 1-5 KHz.
21. Ratio of intensities of harmonics and the noise in 2-3 KHz.
22. Frequency of the first formant.

Measurement of fluctuations in fundamental frequency and Intensity has been found to be useful in differential diagnosis.

Presence of small perturbations or irregularities of glottal vibration in normal voice has been known long (Moore and Von Leden, 1958; Moore and Tincke, 1960). Relatively few attempts have been made to note the perturbations in fundamental frequency and intensity, although such a measure may have value in describing the stability of laryngeal control (Liberman, 1963). The cycle to cycle variation in period that occurs when an individual is attempting to sustain phonation at a constant frequency, has been termed as 'jitter'.

While considering the neurophysiologicalcal significance of jitter (Heiberger and Horii, 1981) state that physiological interpretation of jitter in sustained phonation should probably include both physical and structural variations and myoneurological variations during phonation. A number of high speed laryngoscopic motion picture have revealed that the laryngeal structures (the two vocal cords) are not totally symmetric. Different amounts of mucas accumulate on the surface of the folds during vibration. In addition turbulent airflow at the glottis also causes some. Limitations of laryngeal servo mechanism through the articular myolitic and mucosal reflex systems (Gold and Okumura, 1974; Wyke, 1967) may also introduce small perturbations in the laryngeal muscle tones. Even without the consideration of the reflex mechanisms, the laryngeal muscle tones have inherent perturbation due to time staggered activities of motor units that exist in any voluntary muscle contractions (Baer, 1980).

Heiberger and Horii (1982) while considering the perceptual significance of jitter state that even though these acoustic measures have been considered as some of the physical correlates of rough voice quality, there is discrepancy between the findings of earlier synthesis studies (Coleman, 1969; Cakeman and Wendahl, 1967; Wendhal, 1963, 1966a, 1966b) and the more recent human voice studies (Horii, 1979; Ludlow, et al. 1979). The synthesis studies found near perfect correlations between jitter and perceived roughness. The human voice studies, on the other hand showed low, non-significant correlations between the magnitude of jitter and perceived roughness level.

Iwata (1972) tested the voice of 20 normal subjects and 27 patients with various laryngeal diseases for pitch perturbations. The results showed that the correlograms were useful in differentiating normal and abnormal voices and different types within the abnormal group. Studies have shown that the intensity, the fundamental frequency level and the type of phonatory initiation and termination are the factors which affect the jitter magnitude in sustained phonation (Moore and VonLeden, 1958; Jacob, 1968; Koike, 1973; Hollien et al. 1973).

Shimmer refers to cycle to cycle variations in amplitude. Jitter and Shimmer have been applied to the early detection of laryngeal pathology. Liberman (1961, 1963) states that pitch perturbation factor might be a useful index in detecting a number of laryngeal diseases. Crystal and Jackson (1970) measured both the fundamental frequency and amplitude perturbation of voice in persons with varying laryngeal conditions and concluded that several purely statistical measures of the data they extracted might be useful as guidelines in detecting laryngeal dysfunction. Shipp and Huntington (1965) recorded the voice of 15 subjects while each had acute laryngitis and when their voice returned to normal. The recordings of laryngitis and post-laryngitis voice were subjected to a number of perceptual evaluations and to fundamental frequency measurements. The results indicated that the laryngitis condition received higher hoarseness ratings than did the normal condition. Laryngitic voices had significantly smaller ranges of frequency than did the post laryngitic voice and small number of frequency breaks were also observed in the laryngitic voice.

Kim et al. (1982) have analyzed the vowel /e/ using the spectrograph in ten voices of patients with recurrent laryngeal nerve palsy and ten normals to obtain the following parameters.

1. Extent of fundamental frequency fluctuations.
2. Speed of fundamental frequency fluctuations.
3. Extent of amplitude fluctuations.
4. Speed of amplitude fluctuations.

The results of the study indicated that among the parameters as described by Kim et al. (1982) had significant differences among normals and patients with recurrent laryngeal nerve paralysis.

It is a Known fact that aerodynamic and acoustic parameters vary with age and sex. Rashmi (1985) did a study comprising of 220 children in age range of 4-15 yers (10 males and 10 females were included in each of the 11 groups with one year interval to investigate developmental changes in aerodynamics and acoustics of voice by taking following 13 parameters:

i) The maximum duration of phonation of vowels.
ii) The maximum durtion of /s/,/z/ and the s/z ratio.
iii) The fo of phonation
iv) Speaking fo
v) Fuctuations in the frequency of phonation
vi) Fluctuations in intensity of phonation
vii) Frequency range in phonation
vii) Frequency range in speech
ix) Intensity range in phonation
x) Intensity range in speech
xi) Harmonics
xii) Rise and fall time of phonation and
xiii) Vowel duration

Following are the conclusions

1. The fluctuations in frequency of the initial and final segments of phonation of /a/, /i/ and /u/ showed a decreasing trend with age in males.
2. The 14-15 years old group showed an increase in the range of fluctuations for all the vowels.
3. In females there was a decrease in the range of fluctuations in frequency of the initial and final segments is upto the age of 9 years; an increase in the range of fluctuations in the 9-11 year old females which again shops down till the age of 15 years.
4. The medial segment of phonation, for both males and females, were quite steady.
5. No difference in the ranges of fluctuations in frequency between males and females were obtained in the younger age group.
6. The males consistently showed greater fluctuations in frequency in the phonation of /a/, /i/ and/u/ than the females of 14-15 year old group.
7. The fluctuations in the initial and final segments of phonation for all the three vowels was greater than the fluctuation in the medial segment, for both males and females.

8. The fluctuations in intensity did not show any systematic trend for any vowels both in males and females. However, the initial segment of phonation showed a significantly larger fluctuation in intensity in the above 12 years old; in the case of males for all three vowels /a/, /i/ and /u/.

In computer based techniques, there are many programs which are designed to extract different parameters of voice. However, the software program MDVP acquirs, analyses and displays 33 voice parameters from a single vocalization. Arun Biran (1995) estrablished normative value using MDVP in the age range of 5-15 years for both males and females.

SPECTRAL ANALYSIS OF VOICE has been used to note The possibilities of diagnosing voice problems. According to Fant (1959) voice is a function of both the source and the jitter that is the laryngeal vibrator and the source tract. While vibrating, the vocal folds provide a wide spectrum of quasiperiodic modulations of the air stream accounting for various tonal qualities, reflecting the different ways the vibrator behaves (Brackett, 1971). This according to Fant (1959) consists of frequencies approximately ranging from 80 Hz to 8 KHz and includes fundamentals and harmonics.

In voice production, as in the production of /a/some of the harmonics get emphasized or amplified as they pass through vocal tract or the supraglottal resonators because of resonant characteristics of the vocal tract. The overtones with greater energy are called formants. This amplification or modification of certain components of sounds from the laryngeal source permits one to distinguish one vowel from the other, uttered by the same speaker. There are also proponents of the view that the supraglottal structures act in such a way as to allow individuals to be distinguished from each other on this basis i.e., based on the quality of voice. Quality of voice has been defined, 'the hearer's impression of the complex sound wave, its harmonic and nonharmonic partials and the relative intensity, number and duration of these components'. Therefore the study of spectra is essential to understand the basis of different types of qualities, normal and abnormal.

A number of spectrum analyzers are available now for the analysis of speech and voice. The long term average spectrum (LTAS), provides information on the spectral distribution of the speech signal over a period of time. Spectral analysis of glottal waveform reveals that the harmonics tend to decline in amplitude at a rate of approximately 10-12 dB per octave (Flenegan, 1958; and Gattin and Sundberg, 1977) found long term average spectrum correlation between LPTS features and perceptual factors, such as over tight, breathy and hypokinetic obtained in a study by Fritzell et al. (1977) based on long term average spectrum (LTAS). Their long term average spectrum (LTAS) features were decibel energies in the 0-2 KHz, 2-5 KHz and 5-8 KHz bands and decibel energy differed among the bands.

Wendles, Doherty and Hollien (1980) have made an attempt at voice classification by means of long term average speech spectra. They have tried to differentiate objectively among four classes of voices according to auditive judgements (normal, mild, moderate and severe degree of hoarseness). In addition, attempts have been made to differentiate between certain degree of roughness and breathiness as well as to carryout differential diagnosis based on acoustical analysis. They conclude that, these results which were obtained from a rather small group of subjects, are very encouraging.

Rashmi (1985) made an attempt to study the ratio of intensities below and above 1 KHz; in the spectra of vowel /i/. She concluded that-

1. The energy level above 1 KHz has less than the energy level below 1 KHz.

2. The parameters showed no significant difference till the age of 9 years in both males and females. The female group in the age range of 9-14 years and the male group ranging from 9-15 year showed some changes.

3. No significant group differences between males and females has been found. The age group above 9 years of age showed a change in the voice quality both in the case of males and females as reflected by the changes in ratio. The mean value ranged from 0.78 - 0.92.

Wendler et al. (1980) made an attempt to classify normal voice from abnormal voice and different types of voice disorders based on long term average spectrum (LTAS). They concluded that the results were encouraging. Kim et al. (1982) have measured level of harmonic components, relative level of noise and the first formant frequency in cases of recurrent laryngeal nerve paralysis. The relative level of higher harmonic components was defined as the ratio of the intensity level between 3 and 4 KHz to that below 1 KHz. Relative level of noise was defined as the ratio of the noise level to the harmonic component in the frequency range of 2-3 KHz. They have reported that the relative level of higher harmonic components was significantly greater in dysphonic group than in normals. Similarly it was found that the relative level of noise and the first formant frequency were different in dysphonic group than in normals.

The earliest method used to rate hoarseness was bsed on spectrograms. Yanagihara (1967) was the first person to use spectrograms to objectively quantify hoarseness. He classified 4 types of spectrograms based on the amount and location of noise. It ranged for type I having slight hoarseness to type IV with severe hoarseness.

Nataraja and Veena (1981) from their study concluded that spectrograms of hoarseness voice indicated the presence of aperiodic variation of the vocal cords, presence of noise components, variation in frequency and amplitude as contributing to hoarseness of voice. Kim et al. (1982) investigated the significance of acoustic parameters extracted from sound spectrographs in evaluating the voice of patients of recurrent laryngeal paralysis. This is undertaken as they found that the previous studies, with the use of a computer system suggested that the acoustic evaluation is quite promising for differentiating some causative conditions diseases of voice disorders (Hiki, et al. 1976 and Kakita et al. 1980). Imaizumi et al. (1980) found the acoustic parameters obtained from sound spectrographs as useful in differentiating pathological voices from normal voice. Kim et al. (1982) also analyzed the vowel using the spectrograph in 10 voices of recurrent laryngeal nerve paralysis and 10 normals to obtain nine acoustic parameters. Significant differences were found between the control and diseased groups in terms of fluctuation of fundamental frequency, relative level of higher harmonic component, relative level of noise and first formant frequency.

Yoon et al. (1984) studied the voice of patients with glottical carcinomas using the same procedure and parameters. Significant difference were found between the normals and patients with advanced carcinomas in terms of extent of frequency fluctuation, speed of fluctuation, extent of amplitude fluctuation, speed of amplitude fluctuation and relative level of noise. Thus results were similar to the results obtained by Kim et al. (1982) with the cases of recurrent laryngeal nerve paralysis.

The measurement of harmonic to noise ratio to quantify hoarseness is very practical and objective method. Deliyski (1990) presented an acoustic model of pathological voice production which described the non-linear effects occurring in the acoustic wave form of disordered voice. The noise components such as fundamental frequency and amplitude irregularities and variations, sub-harmonic components, turbulent noise and voice breaks are formally expressed as a result of random time function influence on the excitation function and the glottal jitter. Quantitative evaluation of these random functions was done by computation of their statistical characteristics which can be used in assessing voice in clinical practice. The set of parameters which correspond to the model, allows a multi dimensional voice quality assessment. Any single acoustic parameter does not sufficiently demonstrate the entire spectrum of vocal function or of laryngeal pathology, multidimensional analysis using multiple acoustic parameters.

One of the computer based programmes which extracts several parameters of voice is the multidimensional voice programme (MDVP). This programme options acquires, analyzes and displays 31 voice parameters from a single vocalization. The 33 extracted parameters are available as numerical file or they can be displayed graphically in comparison to a data base. These 31 parameters can be grouped into 8 groups of analysis.

1. Fo related measurements
2. Long and short term frequency perturbation
3. Long and short term amplitude perturbation.
4. Voice break related measurements.
5. Noise related measurements.
6. Tremor related measurements.
7. Sub-harmonic component measurements.
8. Voice irregularities.

Management of voice disorders is through either medical, surgical or therapeutic intervention in that order. Even if medical and surgical intervention have taken place, therapeutic intervention is done if the voice problem persists or to correct the undesirable habits in producing voice. Voice therapy has truely become a blend oi art with science. Voice therapy refers to the training or re-training of the following parameters of voice.

1. Pitch
2. Tone locus
3. Quality volume
4. Breath support
5. Rate

Voice therapy may take many different forms. The kind of therapy given to people who simply want to improve their voice might vary markedly from that given to a patient with a paralyzed vocal cord. Voice therapy is highly individualized according to the physical problem, length of its existence, voice and the patients feeling quality. In general a four point programme (Boone, 1993) is being followed with both children and adults with voice problems.

1. Identify abuse or misuse.
2. Reduce its occurrence
3. Use of diagnostic probe
4. Practice facilitating approaches

Several studies have been undertaken in the past regarding the effectiveness of acoustic analysis as a tool to monitor pre and post-treatment changes in voice. Due to the advent of several sophisticated analysis techniques it has been possible to evaluate the effectiveness of a particular therapy technique, to more for changes following treatment i.e. either medical or surgical and also to select an appropriate approach/technique for management. The parameters studied and the kinds of treatment have varied over the studies.

A study was undertaken by Fiitzell, Sundberg and Anders-Strange-Ebbeson to determine the pitch changes following surgery for oedematous vocal folds for 12 patients with vocal fold edema and having a major symptom of low pitched voice. They were analyzed preoperatively to determine the mean fundamental frequency and the same was done after stripping the vocal folds. The results showed that in all the patients there was an upward shift of fundamental frequency as a result of the operation. In one patient it was very small and insignificant. However, musically this increase in pitch ranged from 2-5 semitones to an octave. This study indicated that measurement of fundamental frequency is a simple method to monitor postoperative changes in voice.

Susheela (1989) undertook a study to draw a conclusion regarding the usefulness of aerodynamic and acoustic measurements in cases of laryngeal lesions. The aerodynamic parameters considered were vital capacity, mean air flow rate, phonation quotient and vocal velocity index and the acoustic parameters considered were fundamental frequency and phonation duration. Twelve cases of the age range of 21-56 years having various laryngeal lesions like vocalpolyp, vocal nodule, laryngeal papilloma, and laryngeal web were taken for the study. Pre-operatively, they were subjected to aerodynamic and acoustic measurements following which microlaryngeal surgery was periormod to relieve the abnormal of voice symptoms. The results showed significant differences in fundamental frequency, phonation duration mean airflow rate and vocal velocity index, between pre and post operative measures i.e., out of the six parameters four showed significant differences.

Cooper (1974) analyzed spectrographically the fundamental frequency and hoarseness before and after vocal rehabilitation. He found significant increase in the fundamental frequency and decrease in hoarseness post therapeutically. He found that out of the 155 subjects studied pre-therapeutically 150 of them were using too low pitch. Thus he concluded, that "a pitch level that is below the optimal or natural level is a major factor in initiating, maintaining or contributing to most types of dysphonia. Thus he said that pitch adjustments should be a vital part of voice therapy in almost all cases. Hufnagle and Hufnagle (1984) investigated the relationship between speaking fundamental frequency and vocal quality improvement. This study was undertaken because there was always discrepancy in literature pertaining to the relationship between hoarseness and speaking fundamental frequency. Some investigators state that hoarseness results in a pitch level that is below 'optimal' (Fisher and Logernan, 1970; Cooper, 1974) while others contend and that the consequence of hoarsenss is a pitch higher than 'optimal' (Van Riper and Irwin, 1958). There was also an evidence suggesting that no relationship between the speaking fundamental frequency and hoarseness (Murry, 1978; Shipp and Huntington, 1965; Hacker and Kruel, 1971). This particular study used listener judgements to assess vocal quality improvement. Results showed no significant change in the speaking fundamental frequency accompanying vocal quality improvement. Therefore, the results of this study supported previous investigation by Shipp and Huntington (1965), Hecker and Kruel (1978) and Murry (1978).

Wedin and Orgen (1982) analyzed the fundamental frequency of voice and its frequency distribution before and after a voice training programs, three groups of subjects were studied. One group consisted of professional singers, one of normal untrained voices and a third group consisted of test subjects with more or less pronounced phonasthenic symptoms. Fundamental frequency and average variation of the spectrum was determined following which a five day voice training programme was given. The results indicated that all three groups showed an increase in fundamental frequency after training. The difference between the normal and the professional groups were about 16 Hz on an average. The difference for the phonesthenic group was larger i.e., 24 Hz. The results were as expected as the phonasthenic voice tended to decrease in intensity because of fatigue which lowered the pitch of the voice. Generally this training programme seemed to be effective in bringing the pitch to its optimum range. In terms of spectrum most of the subjects got an increase in frequency components above 1000 Hz. The change was greater for professional and the normal groups than for phonasthenic group. It was also seen that the group with the smallest increase in fundamental frequency had the biggest change in the alpha value, and it was concluded that using the alpha value it is possible to decide whether training is successful or not.

Wedin, Leanderson and Wedin (1978) evaluated improvement after voice training, using a combination of spectral analysis and listener judgement. Ten professional singers were trained intensively for one week. Before and after training, the voice were recorded under four conditions.

1. Speech voice at normal level.
2. Speech voice at 10 dB stronger
3. Singing voice with piano (low intensity)
4. Singing voice forte (high intensity)

The parameters considered for the comparison was alpha ratio where

$$\text{Alpha ratio} = \frac{\text{Intensity above 1000 Hz.}}{\text{Intensity below 1000 Hz.}}$$

long term average spectrum (LTAS) showed positive values post-therapeutically. Trulliner, Emanuel and Skenas (1988) studied the effectiveness of spectral noise level measurements to track the voice improvement. A single subject with vocal nodules and rough voice was taken. Vocal spectral noise level and fundamental voice frequency measurements were acquired for five sustained vowels produced by one patient having bilateral vocal nodules. The measurements were obtained at specific intervals while the patient underwent voice therapy. Clinically observed changes over the course of therapy include an improvement in perceived voice quality, a general reduction in vowel spectral noise level, and an increase in vocal fundamental frequency. These observations were accompanied by usually detected laryngeal tissue changes. These results suggest that acoustic spectral measurements can be employed clinically to verify and support perceptual judgement of voice quality.

Schutte, Vanden, Berg and Hocksema (1980) determined the vocal efficiency values in 47 patients before and after surgical and/or voice treatment. The efficiency values were compared by means of reference regression lines which was obtained in efficiency measurements in normal subjects. Since, comparison took place at the same intensity values, essentially a comparison was made of the supplied subglottic power. Thus, the relative efficiency values (E ref) could be expressed in decibel. The change of efficiency was computed as the difference between E. ref. of measurements before and after treatment. The patients were divided into three groups.

1. Having organic disturbances.
2. Having normal vocal folds with slight adduction disturbances (often called as functional voice disorders).
3. Having normal vocal folds but with unilateral or bilateral laryngeal paralysis.

A significant improvement was found in 33% of the patients in group one and two. Three out of the four patients in group three with bilateral laryngeal paralysis underwent glottic widening operation, because of breathing difficulties. In these cases a decrease in efficiency might be expected. However, this was not always the case.

Kitzung and Akerlumd (1993) made an attempt to determine long term average spectrograms of dysphonic voices before and after therapy. Tape recordings of 174 subjects with nonorganic voice disorders (functional dysphonia) was done before and after successful voice therapy. This was analyzed by long term average spectrograms (long term average spectrum (LTAS)). In females as well as in males there was a statistically significant increase in the level of first formant region of the spectra. In the female voice there were also an increase in level in the region of fundamental frequency. The long term average spectrum (LTAS) was compared withtheresults of perceptual evaluation of the voice qualities by a small group of expert listeners. There was no significant change of the long term average spectrum (long term average spectrum (LTAS)) invoices with negligible amelioration after therapy. In the voice where the change after therapy was perceptually rated to be considerable, the long term average spectrum (long term average spectrum (LTAS)) showed only an increase in intensity, but the general configuration of the spectral envelop remain unchanged. There was only weak positive correlation between the quality rating and parameters of the spectra.

Divya Menon (1996) did a study on dysphonic population to analyze the voice samples before and after therapy. She had undertaken following 16 paameters.

i) Mean fo

ii) Maximum fo

iii) Minimum fo

iv) To range

v) Speed of fo fluctuations

vi) Extent of fo fluctuations

vii) Mean intensity

vii) Maximum intensity

ix) Minimum intensity

x) Intensity range

xi) Speed of intensity fluctuation

xii) Extent of intensity fluctuation

xiii) Vital Capacity

xiv) Mean Air Flow Rate

xv) Maximum Phonation Duration

xvi) s/z ratio

Out of the 16 parameters studied most parameters showed significant differences between the dysphonics before and after treatment capable of differentiating between normal and dysphonic voices.

Generally, variations in normals are also observed, when repeated measures of the same parameter is carried out. In the present study it is proposed to whether there is any statistical difference between repeated measured of parameters (with a qap of one week in normals). Also these parameters will compared with dysphonics before therapy and after therapy and before and after therapy with normals to note the changes in these parameters and to note the effectiveness of therapy.

METHODOLOGY

The purpose of the study was to -

i) Determine the reliability of sixteen acoustic and aerodynamic parameters in normals on repeated measures.

ii) Compare the normal and dysphonics in terms of these acoustic and aerodynamic parameters.

iii) Compare the acoustic and aerodynamic parameters is the voice of dysphonics before and after therapeutic intervention.

iv) Compare between normals and dysphonics after treatment in terms of acoustic and aerodynamic parameters of voice.

It was decided to consider the following 16 acoustic and aerodynamic parameters with the aim (a) to determine the reliability of these parameters in normals on repeated measures, and which of these would show differences between normals and dysphonics, (b) before and after therapeutic intervention, (c) dysphonics to degree of change in these parameters following therapy. These parameters have been used as the earlier investigators had shown that these parameters have been useful in differentiating dysphonics from normals (Nataraja, 1984; Jayarama, 1975; Divya, 1996) and as these were easily measurable ina clinical setup.

i) Mean fundamental frequency in phonation
ii) Maximum fundamental frequency in phonation
iii) Minimum fundamental frequency in phonation
iv) Range of fundamental frequency in phonation
v) Speed of fluctuations in Fo in phonation
vi) Extent of fluctuations in Fo in phonation
vii) Mean intensity in phonation
viii) Maximum intensity in phonation
ix) Minimum intensity in phonation
x) Range of intensity in phonation
xi) Speed of fluctiations in intensity in phonation
xii) Extent of fluctuations in intensity in phonation
xiii) Vital capacity
xiv) Mean airflow rate
xv) Maximum phonation duration
xvi) S/Z ratio

SUBJECTS

Normal subjects

30 normal subjects (15 males and 15 females) in the age range of 20-25 years were part of the present study. These subjects had no apparent speech, hearing or ENT problems.

For the above mentioned 16 parameters, recording of phonation of sample /a/ for acoustic measurements and aerodynamic measurements were obtained three times with a gap of 2-3 minutes after each recording and reading respectively for 30 normals (15 males and 15 females). Again after a gap of one week same steps were repeated two times for 10 normals (5 males and 5 females).

Dysphonic group

15 dysphonics who visited All India Institute of Speech and Hearing, Mysore with a complaint of voice problem were considered for the study. 10 males in the age range of 20-45 years and 5 females in the age range of 30-50 years formed the experimental group. These cases had been diagnosed as cases of voice disorder after routine otolaryngological, speech and audiological evaluation. They underwent voice therapy at AIISH, Mysore as recommendd by Speech Pathologist and Otolaryngologist. The number of sessions being twenty on an average.

Table-1: Showing the age, sex, diagnosis and treatment of the dysphonic subjects.

S.No.	Age	Sex	Diagnosis	Treatment
1	25	F	High pitched voice	Voice therapy
2	26	M	Mild hoarse voice	Voice therapy
3	30	F	Mild hoarse voice	Voice therapy
4	41	F	low pitched hoarse voice	Voice therapy
5	26	M	High pitched voice	Voice therapy
6	21	M	Mild-moderte hoarse voice	Voice therapy
7	22	M	High pitched voice	Voice therapy
8	31	M	High pitched hoarse voice	Voice therapy
9	50	F	High pitched hoarse voice	Voice therapy
10	28	M	High pitched hoarse voice	Voice therapy
11	44	M	Severe hoarse voice	Voice therapy
12	28	M	High pitched voice	Voice therapy
13	27	M	Mild hoarse voice	Voice therapy
14	42	F	Low pitched mild hoarse voice	Voice therapy
15	39	M	Moderate hoarse voice	Voice therapy

Data Collection

Measurements were carried out at the Phoniatrics Laboratory of the Department of Speech Sciences, AIISH, Mysore, which has very low noise level.

Measurements of Acoustic Parameters :

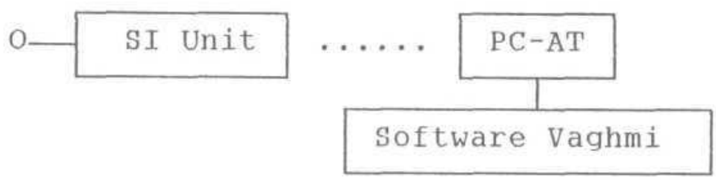
All the acoustic parameters were obtained in the following manner.

Instrumentation : The following instruments were used for recording and for obtaining acoustic and aerodynamic parametrs for all subjects.

1. Dynamic Microphone (AI1UJA AUD-5354)
2. Speech Interface Unit } Voice and Speech
3. PC-AT (486 DX) Vaghmi Software) Systems, Bangalore

Block diagram of the instrumentation set-up

Fig.



4. Expirograph.

Voice sample:

i) Recording of voice sample :

The subjects were seated comfortably. A dynamic mic (Ahuja AVD. 5354) was kept in front of subject's mouth at **a** distance of about 15 cm. They were instructed to take a deep breath and say /a/ as long as they could sustained the phonation. They were asked to maintain a constant pitch and intensity at a comfortable level as far as possible (the recorded voice was stored *on* the hard disk of the computer). Recording of the signal was done using VAGHMI 'Utilities' - record program with 'Analog-to-digital-converter' of the computer (PC 486 AT with DSP board of 12 bit) at a sampling rate of 16,000 Hz.

Thus the sample of /a/ was recorded for each subject of both the groups and again for normals on a second occasion after a gap of one week from the Ist recording the phonation of vowel /a/ was recorded using the procedure described above, for all subjects..

ii) Analysis of the signal

The voice signal stored on the hard disk of the computer was subjected for analysis. The 'VSS-Vaghmi Inton Program' analysesthevoicesignalusingautocorrection.techniqueandprovide the following parameters in digital form as which can be displayed on the monitor. Thus each voice signal was analyzed using inton program and the values for each parameter were noted down. Thus three recordings of each subject was analysed and resutls were obtained. The voice samples of all the subjects of both the groups were analyzed using the same procedure.

Aerodynamic Parameters Measurements

xiii) **Vital capacity**

Vital capacity has been defined as the amount of air an individual can expire after a deep inspiration. A wot expirograph was used to measure the vital capacity.

Each subject was given the following instructions. "Now we are trying to find out the amount of air that you can blow. Please take a deep breath and blow into this mouth piece as much as you can and please see that no air escapes from the mouth piece". Demonstration was given by the experimenter. The vital capacity was directly read from the verticle trace of the pinter on the graph. The subject was asked to repeat the whole process thrice with a rest of 2-3 minutes between the trials. The subjects were encouraged to increase the volume of blowing as much as possible. Thus these findings of VC were taken. The maximum among the three readings was considered the VC of the subject.

xiv) **Mean Air-Flow Rate (MAFR)**

MAFR has been defined as the amount of air collected in one second during the phonation at a given frequency and intensity.

$$MAFR = \frac{\text{Total volume of air collected during phonation (in cc)}}{\text{Total duration of phonation (in sec)}}$$

For the purpose of measuring the MAFR an expirograph and a stopwatch were used. The subjects were instructed as follows:

"Now take a deep breath and say /a/ into this mouth piece as long as you can. You please say /a/ at your comfortable pitch and loudness i.e., with a voice that you usually use for speaking. Please see that no variations occur in voice while saying /a/ and please see that no air leaks out from your nose or mouth piece". The process was demonstrated. Then from the performance of the subject, the duration of phonation was measured using the stopwatch and the volume of air collected was directly read from the markings of expirograph. The mean air flow rate was determined by dividing the volume of air collected during phonation by the duration of phonation.

The whole experiment was repeated three times for each subject with a rest of 2-3 minutes between each trial. Thus the MAFR was measured 3 times for each subject. The mean of the three readings was taken as MAFR for that subject.

xv) Maximum Phonation Duration (MPD)

MPD has been defined as the duration for which an individual can sustain phonation. The subject was instructed as follows:

"Take a deep breath and then say /a/ as long as you can, with the voice you usually use. Please try to maintain your voice a constant level". The procedure was demonstrated. Then each subject phonated as long as possible. Using a stop watch the duration of /a/ was measured. The subject was asked to repeat the whole process thrice with 2-3 minute gap between trials. The longest duration of the three trials was considered the maximum phonation duration for that subject.

xvi) S/Z ratio

S/Z ratio was defined as the ratio of the durations for which the fricatives /s/ and /z/ were produced by the subject.

$$\text{S/Z Ratio} = \frac{\text{Maximum duration of sustained /s/}}{\text{Minimum duration of sustained /z/}}$$

The subject was instructed as follows:

"Take a deep breath and then say /s/ as long as you can, with the voice you usually use, please try to maintain your voice at a constant level. Similarly same instructions were given for the phonation of /z/". The procedure was demonstrated to the subject. Then the subject produced /s/ and /z/ as long as possible. Using a stop watch duration of /s/ and /z/ were measured. The subject was asked to repeat the whole process three times with 2-3 minutes gap between trials. The average of three ratios was considered as the S/Z ratio.

Thus for each subject of the dysphonic groups and twice for subjects of normal group the values for acoustic as well as aerodynamic parameters were obtained three times each. The average of values were taken for which the highest values were considered except for Vital Capacity and Maximum Phonation Duration.

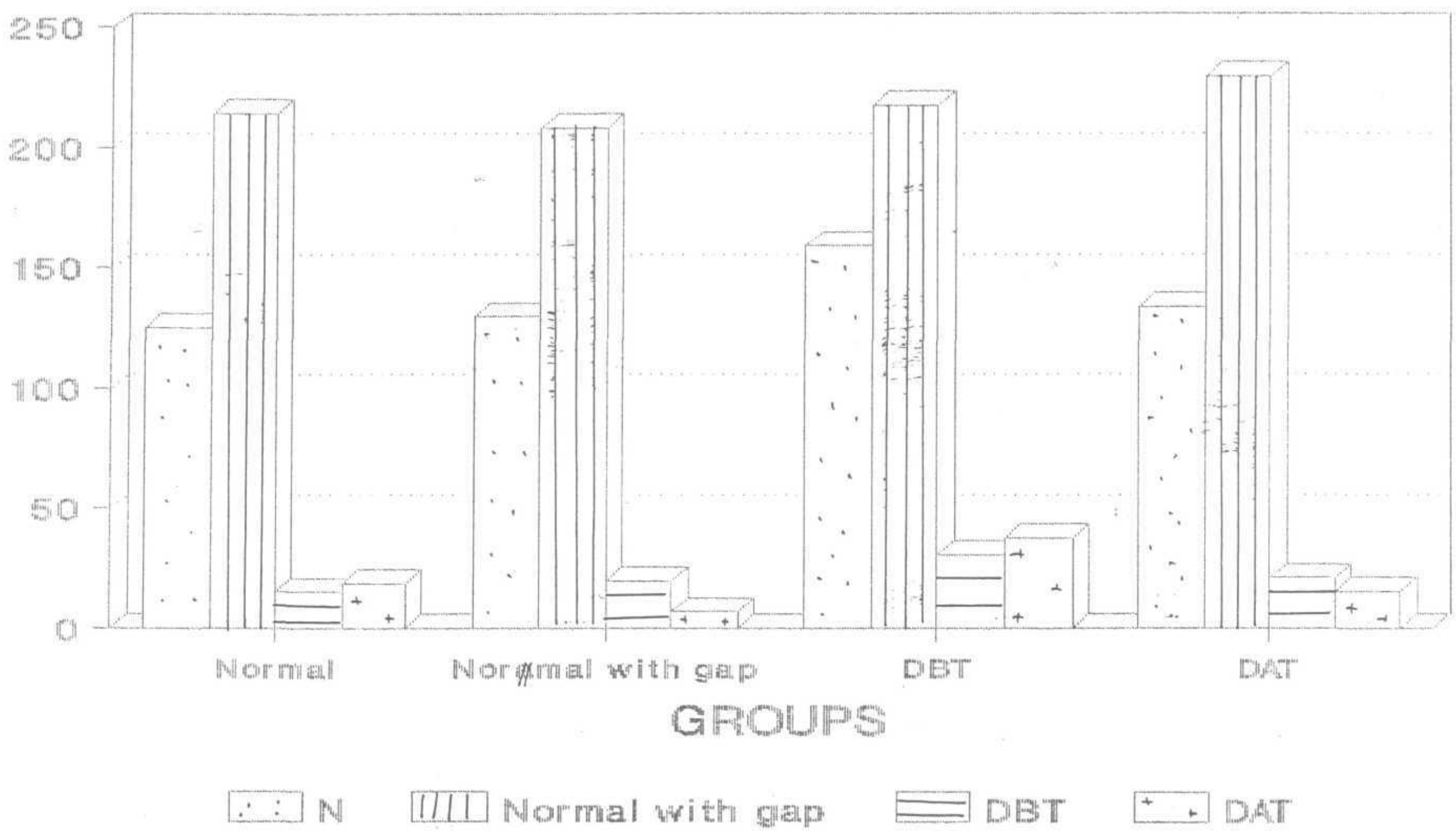
RESULTS AND DISCUSSION

It was aim to see the consistency of values of the parameters on repeated measures in case of normals. The purpose of this study was also to determine the parameters which could differentiate normal and abnormal voice and to determine the sensitivity of vairous parameters following therapeutic intervention in order to detect subtle changes in voice in case of dysphonics. Therefore it was necessary to (a) compare repeated measure s in case of normals (b) dysphonics before tretment with normals (c) dysphonics after treatment with normals (d) dysphonics after treatment with normals.

Sixteen parameters were measured and analyzed using different procedures. These parameters were (1) acoustic and (2) aerodynamic.

The results of the performance of different parametrs have been discussed after analysis using an appropriate test.

Gr.1: Mean Fundamental Frequency



1) **Mean fundamental frequency for the phonation of /a/ :**

The study of Table 1 and Graph 1 showed that the mean Fo for males was 125.03 Hz on the first measurement and 129.89 Hz with ranges of 116.79 to 133.31 and 105.32 to 154.45 Hz on first and second measure respectively. Similarly for females the mean Fo was 214 Hz with a range of 203 Hz to 224 Hz and SD of 14.44 on first measure and 208.15 Hz was the mean to with a range of 199.66 to 216.62 Hz and SD of 16.82 on the second measure. These values were within the vicinity of the values reported by other investigators like Nataraja (1984), Jayaram (1975), Gopal (1986).

Groups		Mean	S.D.	Range
N	M	125.03	14.96	116.74 - 133.31
	F	214.23	18.44	203.01 - 224.44
N with gap	M	129.89	19.78	105.32 - 154.45
	F	208.15	6.82	199.66 - 216.62
DBT	M	159.36	30.77	137.34 - 181.37
	F	217.70	37.69	170.89 - 264.50
DAT	M	133.94	21.1	118.84 - 149.03
	F	229.42	15.18	210.56 - 248.27

N = Normal; DBT = Dysphonics before therapy, DAT = Dysphonics after therapy

Table-1 : The mean Fo in phonation S.D and Range for normals, normals with a gap of one week dysphonics before treatment (DBT), and dysphonics after treatment (DAT)

	Group	Z	P	Significance
N vs DBT	M	-1.3760	0.1688	+ve
	F	-0.4045	0.6858	-ve
N vs N	M	-0.6742	0.5002	+ve
	F	-0.4045	0.6858	-ve
N vs DAT	M	-2.8031	0.0051	+ve
	F	-0.4045	0.6858	-ve
D (DBT vs DAT)	M	-2.6656	0.0077	+ve
	F	-0.7303	0.4652	+ve

Table-2 : Comparison of normals vs. pretherapy dysphonics (N Vs. DVT), normals normals with a gap of one week (N vs. N). in post therapy dysphonics (N vs. DAT), dysphonic before and after therapy (DBT vs. DAT) in terms of Fo in phonation.

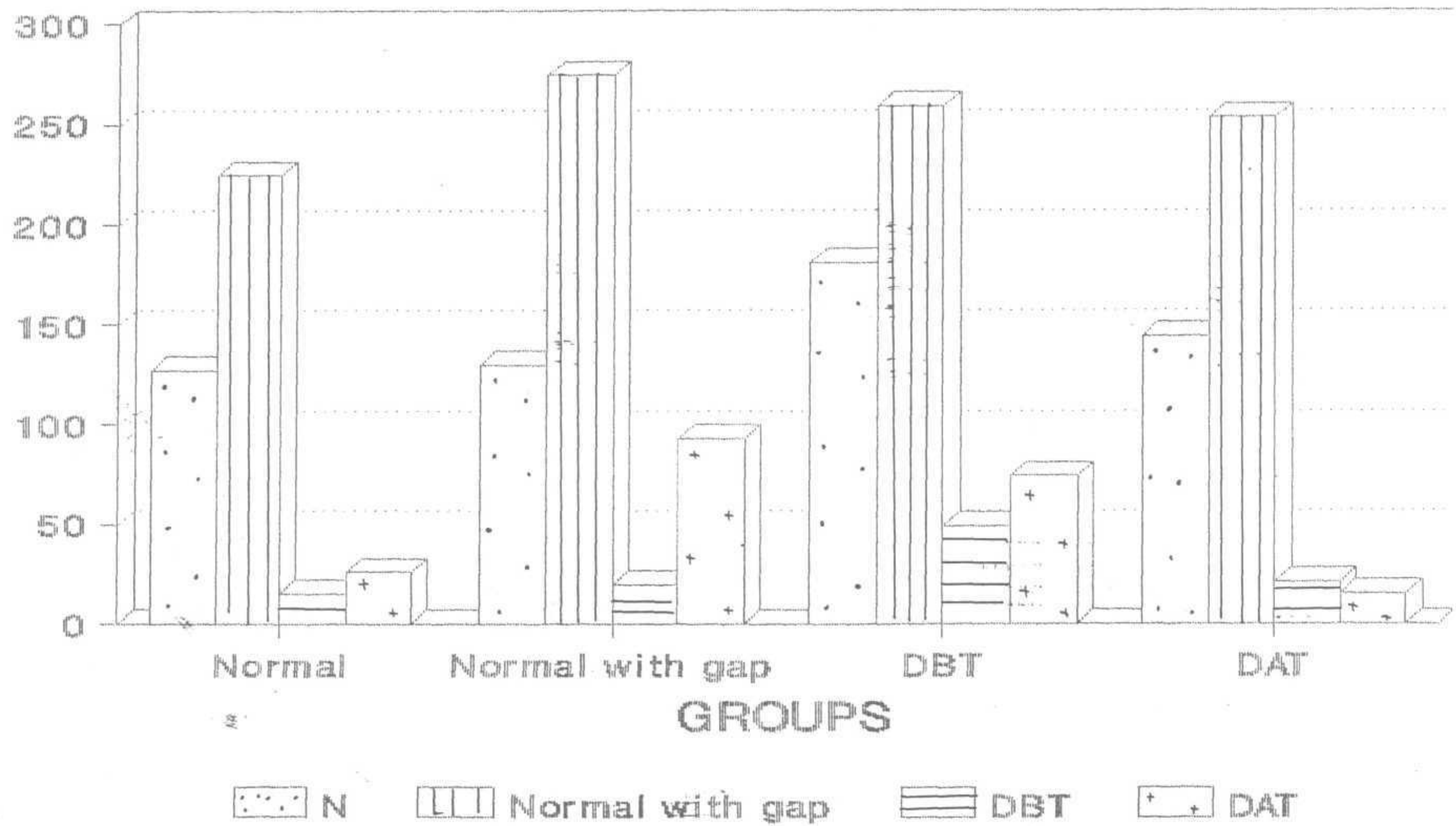
The values obtained on two different occasions for normals i.e. for the land II measures were compared. As it could be seen from Table 1 and Graph 1 not much difference between 1st and 2nd measurements in both males and females. The difference was 5.86 Hz in males and 6.08 Hz in females for mean Fo on between two measurements. The statistical test of significance showed that the mean Fo were significantly different on two occasions for males, but the differences were not significant for females. It could be concluded that the repeated measurements of mean Fo in case of males varied significantly. Whereas females did not show such variation. Thus hypothesis stating that there is no significant differences between I and II measures in case of normals was rejected and accepted in case of normal females with refernce to the mean, fundamental frequency.

Further scrutiny of Table 1 and Graph 1 showed that there was difference between normal males and dysphonic males in terms of Fo in phonation, with the value of Fo of the dysphonic on the higher side, i.e. mean was 159 Hz with a range of 137.34 to 181.37 Hz with SD of 30.77. This variability of Fo in dysphonic group was much higher compared to the normal male group. The difference was found to be statistically significant also. Female dysphonic group showed a mean Fo of 217.70 Hz with a range of 170.89 - 264.50 Hz with SD of 37.69. The Fo values of dysphonic females were similar to that of normal female group which had a mean Fo of 208.15 Hz and 214.23 Hz land II measure respectively. However, the variability was greater in dysphonic female group than normal female group. There was no statistically significant difference between the two groups. Thus the hypothesis stating that there is no significant between differences between dysphonics and normals was accepted with refrerence tomean, fundamental frequency

Table 1 and Graph 1 also revealed difference between Fo of dysphonics after therapy for dysphonic males and normal males. The Fo for dysphonics after treatment was 133.94 Hz with a range of 187.84 to 149.03 Hz with SD of 31.18 which is slightly on the higher than normal values. The test of significance showed that even after treatment the voices of dysphonic males were significantly different from normal males. For females the mean Fo after therapy was 229.49 Hz with a range of 210.56 - 248.27 Hz with a SD of 15-19 which were quite close to the range of normal females. The test of significance also revealed that there was no differences between the Fo of treated female voice and normal female voice. Thus the hypothesis stating that no significant differences between normals and treated dysphonics was accepted.

When a comparison was made between dysphonic males and females before and after therapy, (Table 1 and Graph 1) reduction in Fo for males and increase in Fo of females were found. The variability was also reduced in both groups with lowering of SD. Test of significance also revealed significant differences between the voices before and after therapy as reported by Nataraja (1984), Jayarama (1975), Divya (1996). Thus the hypothesis stating that no

Gr.2: Maximum Fundamental Frequency



significant differences between dysphonics before and after therapy was rejected.

ii) Maximum fundamental frequency in phonation :

Table 3 and Graph 2 indicate that maximum Fo for the phonation by normal males was 127.12 Hz with a range of 118.80 to 135.43 Hz and SD of 15.01 and 129.89 with the range of 105.32 to 154.45 Hz and the SD of 19.78 on first and second measures respectively. Similarly for normal females the maximum Fo was 224.72 Hz and a range of 210.29 to 239.14 Hz with SD of 26.04 and 274.38 Hz and a range of 58.7 to 290.05 Hz with a SD of 93.16 on first and second measures respectively. These values were similar to the maximum values reported by other researches like Nataraja (1984), Jayaram (1975), Gopal (1986), Divya (1996). Values obtained for maximum Fo by normal males and females on two different occasions were compared using the statistical test of significance which revealed no significant difference. Thus it be concluded that maximum Fo for normal males and females does not vary on repeated measure. Thus the null hypothesis stating that there was no significant difference for normal males and females for maximum Fo was accepted.

Groups		Mean	S.D.	Range
N	M	127.12	15.01	118.80- 135.43
	F	224.72	26.04	210.29 - 239.14
N with gap	M	129.89	19.78	105.32 - 154.45
	F	274.38	93.16	58.7 - 290.05
DBT	M	180.89	49.16	145.71 - 216.05
	F	259.20	74.55	166.63 - 351.76
DAT	M	144.16	21.09	129.06 - 159.24
	F	253.52	15.09	234.77 - 272.26

Table-3 : The mean of maximum for frequency in phonation, SD, range of in normals, normals with a gap of one week, dysphonics before therapy, and dysphonics after therapy.

	Group	Z	P	Significance
N vs N	M	-0.4045	0.6858	-ve
	F	-0.1348	0.8927	-ve
N vs DBT	M	-2.5992	0.0093	+ve
	F	-0.9439	0.3452	+ve
N vs DAT	M	-1.5799	0.1141	+ve
	F	-2.0226	0.0431	+ve
D (DBT vs DAT)	M	-2.5471	0.0109	+ve
	F	-0.4045	0.6858	-ve

Table-4 : Comparison of normals with dysphonics before therapy, normals with a gap of one weeks (N vs. N) normals with dysphonics after therapy (N vs. DAT), and dysphonics before and after therapy (DBT vs. DAT) in terms of maximum Fo phonation.

The mean of maximum Fo for dysphonics males before therapy was found to be 180.89 Hz with a range of 145.71 to 216.05 Hz and a SD of 49.16 while for female dysphonics the mean of maximum Fo was 259.20 Hz with a range of 16.63 to 351.76 Hz and SD of 79.56 Hz which could be deduced from Table 3 and Graph 2 both male and female dysphonics maximum Fo were much higher than normal group. On further analysis for the test of significance, (Table 4) there were statistically significant differences both the groups i.e. male and female dysphonics when compared with normals. Thus the hypothesis stating there were no significant differences between the voices of normals (males and females) and dysphonics (males and females) regarding maximum Fo was rejected.

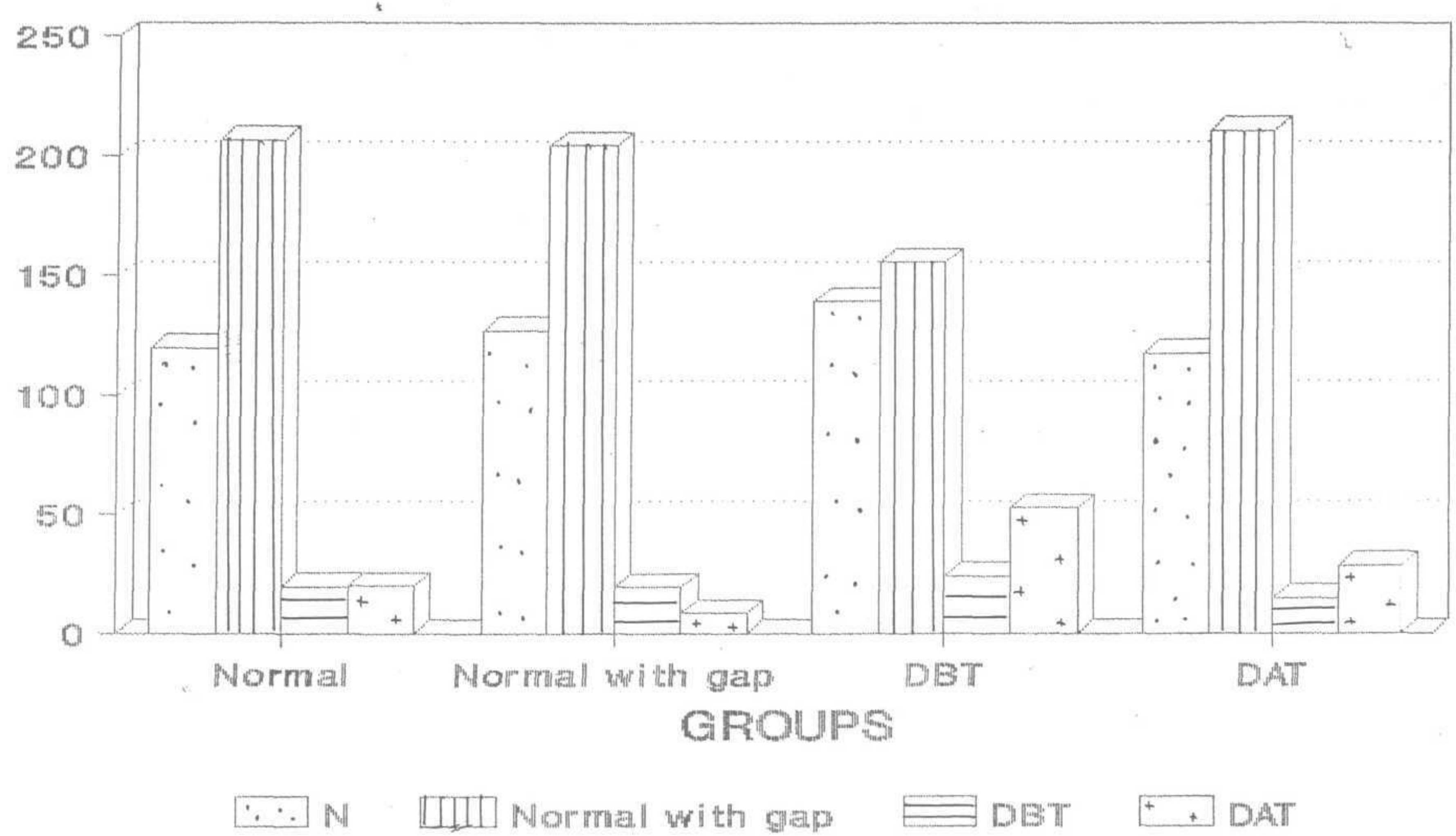
Study of Table 3 indicated that maximum Fo after threapy for dysphonic male was 144.16 Hz and range of 129.06 to 159.24 Hz with a SD of 21.09 whereas for female dysphonics it was 253.52 Hz and range of 234.77 to 272.26 Hz and SD of 15.09. Though the values for maximum Fo for dysphonics had reduced in the direction towards normal range still the test of significance revealed statistically significant difference between normals and dysphonics (males and females) for the parameter of maximum Fo which could be easily inferred from Table 4. Thus as stated in the hypothesis that no significant difference inmaximum Fo between normal and dysphonics after therapy was rejected.

Scrutiny of Table 4 indicated that there was significant differences between the voice of dysphonics before and after therapy for dysphonic males but not for female dysphonics Thus the hypothesis that no significant differences before and after therapy for maximum Fo parameter was accepted for male dysphonics and was rejected for female dysphonic groups for the parameter maximum Fo.

iii) **Minimum Fo** :

Minimum Fo for normal males was 119.70 with a range of 108.76 to 130.64 Hz with SD of 19.75, and 126.70 Hz with a range of 102.59 to 150.8 Hz and SD of 19.41 on the first and second occasions of measurement respectively. While for females measurement on first occasion showed a mean of 206.79 Hz with a range of 195.70 to 217.88 Hz and SD of 20.02 while on the second occasion mean of 204.18 Hz with a range of 193.71 - 214.63 Hz and SD of 8.42. These values were comparable to other studies reported on, normalcy by other researchers. But the test of significance revealed statistically significant differences in case of both normal

Gr.3: Minimum Fundamental Frequency



males and females between the first and second measurements. Thus the hypothesis stated earlier that minimum Fo does not change significantly on repeated measurements was rejected as indicated in Table 5 and 6 and Graph 3.

Groups		Mean	S.D.	Range
N	M	119.70	19.75	108.76 - 130.64
	F	206.79	20.02	195.70 - 217.88
N with gap	M	126.70	19.41	102.59 - 150.8
	F	204.18	8.42	193.71 -214.63
DBT	M	139.05	23.97	121.89 - 156.20
	F	155.40	52.78	89.85 - 220.94
DAT	M	117.41	14.70	106.89 - 127.92
	F	201.32	28.54	165.87 - 236.76

Table-5 : The mean of minimum fOin phonation, SD and range of frequency for normals, normals with a gap of one week, dysphonics before therapy, and dysphonics after therapy.

	Group	Z	P	Significance
N vs N	M	-0.6742	0.5002	+ve
	F	-0.6748	0.5002	+ve
N vs DBT	M	-1.5990	0.1141	+ve
	F	-1.4832	0.1380	+ve
N vs DAT	M	-0.3568	0.7213	-ve
	F	-0.6742	0.5002	+ve
DBT vs DAT	M	-2.6656	0.0077	+ve
	F	-2.0226	0.0431	+ve

Table-6 : Comparison of normals with a gap of one week, normals with dysphonics before therapy, normals with dysphonics after therapy, dysphonics before and after therapy in terms of minium fO in phonation.

Dysphonic males before therapy had a mean of 139.05 Hz with a range of 121.89 - 156.20 Hz and SD of 23.97 where as dysphonic females had mean of 155.40 Hz with a range of 89.85 - 220.99 Hz and SD of 52.78 as indicated in Table 5. These values deviated from normal values. Table 6 indicates the comparison between normal voice and dysphonic voice for the parameter of minimum fO which showed no statistically significant differences in dysphonic males did not stastistically significant in female dysphonics .Thus the hypothesis stating that no significant differences between normal and dysphonic voices was accepted for male dysphonics but for female dysphonics it was rejected.

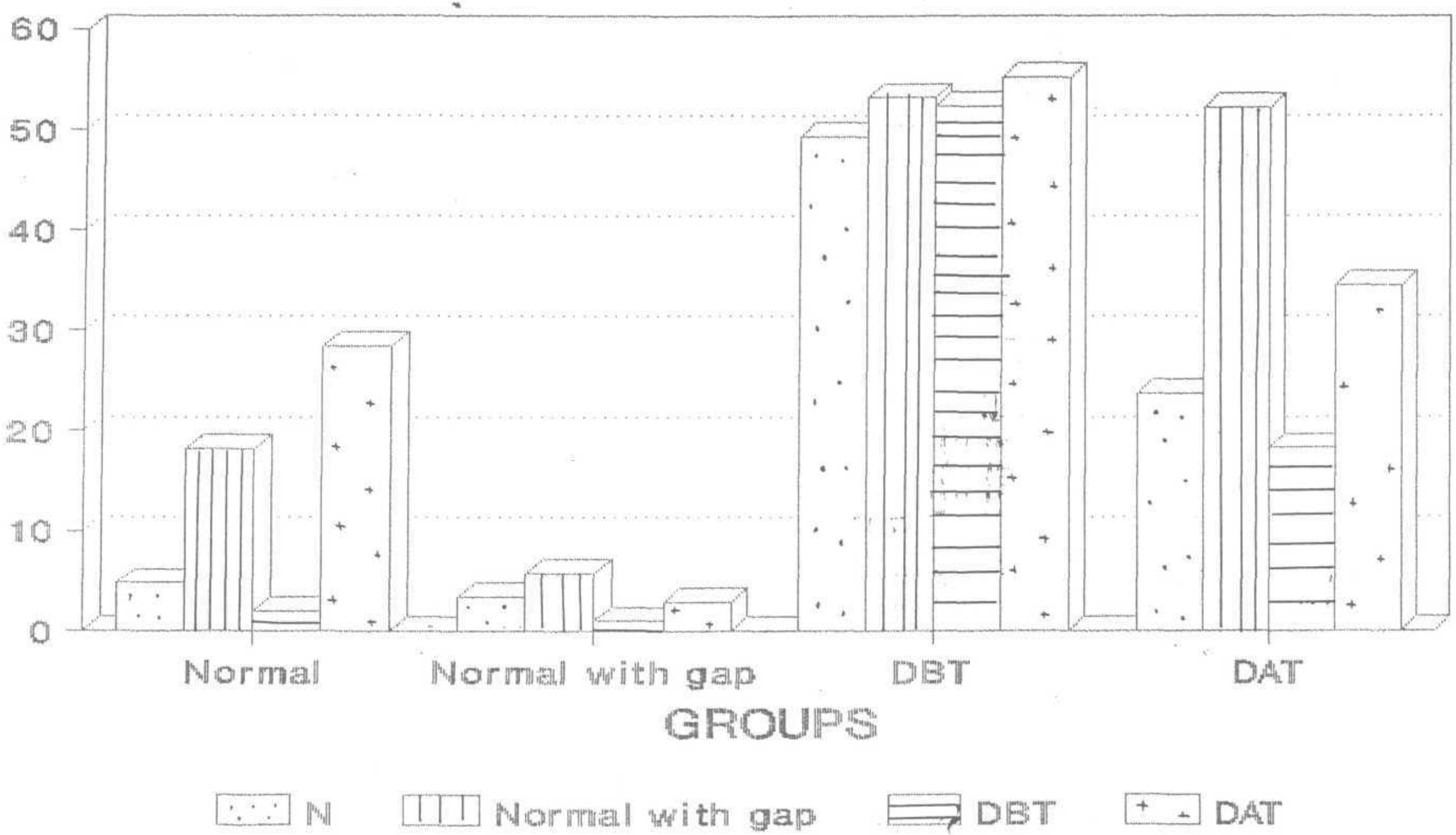
Scrutiny of Table 5 and Graph 3 indicate the mean of minimum fO in phonation,after therapy , as 11 7.41 Hz and range 106.89 to 127.92 with SD of 14.70 for male dysphonics and whereas female dysphonics mean of 201.32Hz with a range of 165.87 to 236.76 Hz and SD of 28.54 Hz .Further test of significance revealed significant difference between normal and dysphonic males after therapy but no statistically significant difference between normal females and treated dysphonic females (Table 6). The hypothesis which stated no significant diference between normals and dysphonics after therapy was accepted for dysphonic males but rejected in case of dysphonic females.

Table 6 also indicates significant changes after institution of voice therapy for both males and females as reported by other researchers like Nataraja (1986) and Jayaram (1975). Then the hypothesis stating that no significant differencebetween dysphonics before and after therapy was rejected.

iv) **Range of Fo** :

Table 7 and Graph 4 revealed range of Fo with a mean of 4.78 Hz with range of 3 .72 - 5.83 Hz and SD of 1.9 for males on first occasion while on second occasion 3.49 Hz as mean with a range of 2.27 to 4.70 Hz and SD of 0.98 on second measure. Where as for normal females on first occasion they showed a mean of 18.21 Hz with a range of 2.45 -33.96 Hz and SD of 28.45. While on second occasion they showed a mean of 5.74 Hz with a range of 2.19 -9.28 Hz and SD of 2.85. Test of significance revealed s tatistical significant difference on repeated measures. Table 8. Thus the hypothesis which was stating that there is no statistical difference for repeated measures in case of normals was rejected.

Gr.4: Range of Fundamental Frequency



Groups		Mean	S.D.	Range
N	M	4.78	1.9	3.72 - 5.83
	F	18.21	28.45	2.45 - 33.96
N with gap	M	3.49	0.98	2.27 - 4.70
	F	5.74	2.85	2.19 - 9.28
DBT	M	49.33	52.39	11.85 - 86.81
	F	53.20	55.29	-15.46 - 121.86
DAT	M	23.76	18.30	10.67 - 36.85
	F	52.20	34.54	9.31 - 95.09

Table-7 : The mean, SD and range for normals, normals with a gap of one week, dysphonics before therapy, and dysphonics after therapy for the phonation of /a/ for range of fundamental frequencies in phonation.

	Group	Z	P	Significance
N vs N	M	-0.9439	0.3452	+ve
	F	-1.2136	0.2249	+ve
N vs DBT	M	-2.4973	0.0125	+ve
	F	-2.0226	0.0431	+ve
N vs DAT	M	-2.2934	0.0218	+ve
	F	-2.0226	0.0431	+ve
DBT vs DAT	M	-1.5993	0.1097	+ve
	F	-0.1348	0.8927	-ve

Table-8: Comparison of normals with a gap of one week, normals with dysphonics before therapy, normals with dysphonics after therapy, dysphonics before and after therapy for the parameter range of Fo.

Inspection of Table 7 indicates the range of Fo for dysphonic males before therapy with a mean of 49.33 Hz with a range of 11.85 - 05.81 Hz and SD of 52.39 whereas for dysphonic females mean of 53.20 Hz with a range of -15.46 - 121.86 Hz and SD of 55.29 which are very wide and high compared to normals. Table 8 indicated that there were significant differences between normal and dysphonic before therapy thus rejecting the hypothesis stated no significant differences between normal and dysphonic voice before therapy in both groups males and females.

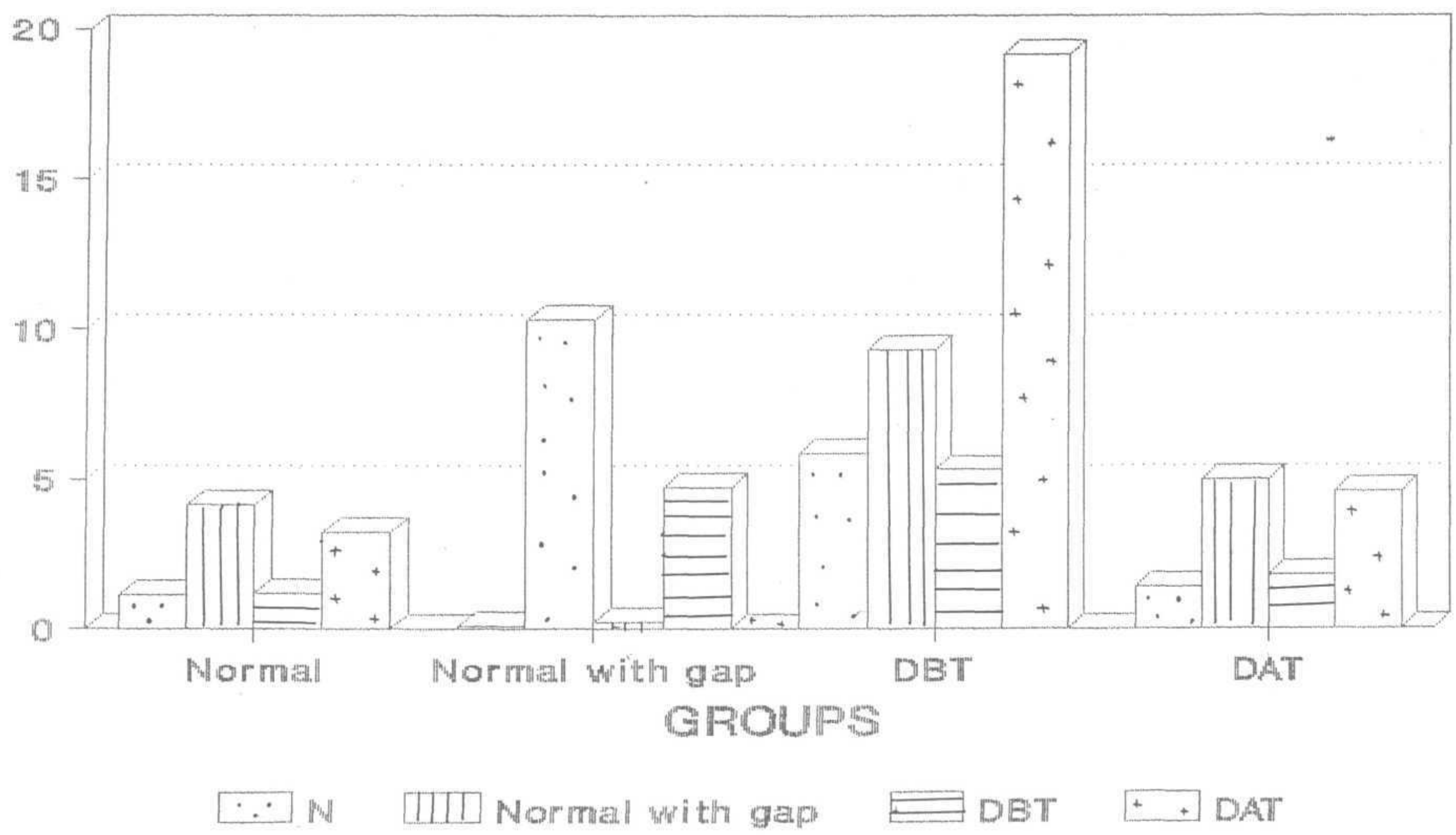
After voice therapy the mean was 23.76 Hz with a range of 10.67 - 36.85 Hz and SD of 18.30 for dysphonic male where as for dysphonic females mean was 52.20 with a range of 9.31 - 95.09 and SD of 34.54 as reported on the Table 7. It could be inferred from the Table 7 that the range was reduced but did not come to normal range following voice therapy which has also supported by test of significance. Thus the hypothesis stating no significant difference between normals and dysphonics after therapy was accepted.

Table 8 also indicated statistically significant differences between dysphonic males before therapy and after therapy but it was not so in dysphonic female group. Thus the hypothesis stated no statistical significant differences between dysphonics before therapy and dysphonic after therapy was accepted for females but rejected for males.

v) **Speed for fluctuations for Fo** :

Study of Table 9 indicated a mean of 1.12 with range of 0.46 - 1.78 and SD of 1.19 and mean of 0.1 with a range of 0.17 to 0.37 and SD of 0.21 for males on first and second measures respectively. For females mean was 4.14 with a range of 2.35 - 5.92 and SD of 3.22 on first measure and on second measure mean of 10.33 with a range of 4.45 -16.21 and SD of 4.73 was observed. Table 10 indicated significant differences for normals on repeated measures thus the hypothesis that there are no significant differences between repeated measure on normals interms of speed of fluctuations F0 was accepted with reference to both males and females .

Gr.5: Speed of Fluctuation for Fo



Groups		Mean	S.D.	Range
N	M	1.12	1.19	0.46 - 1.78
	F	4.14	3.22	2.35 - 5.92
N with gap	M	0.10	0.21	0.17 - 0.37
	F	10.33	4.73	4.45 - 16.21
DBT	M	5.86	5.31	2.05 - 9.66
	F	9.31	9.17	-2.08 - 20.69
DAT	M	1.39	1.8	0.09 - 2.68
	F	4.99	4.66	-0.08 - 10.78

Table-9 : The mean, SD and range of speed of fluctuations in fundamental frequency while phonating /a/ by normals, normals with a gap of one week, dysphonics before treatment, and dysphonics after treatment.

	Group	Z	P	Significance
N vs N	M	-1.8257	0.0679	+ve
	F	-0.9439	0.3452	+ve
N vs DBT	M	-1.9876	0.0469	+ve
	F	-1.2136	0.2249	+ve
N vs DAT	M	-0.0592	0.9528	-ve
	F	-0.4045	0.6858	-ve
D (DBT vs DAT)	M	-2.5330	0.0113	+ve
	F	-1.3416	0.1797	+ve

Table-10 : The results of comparison between normals with a gap of one week ,normals with dysphonic before treatment, normals with dysphonics after treatment, and dysphonics before and after therapy in terms of speed of fluctuations in F0 of phonation.

Male dysphonics prior to therapy had a mean of 5.36 with a range of 2.05 - 9.66 and SD of 5.31 while female dysphonics had a mean of 9.31 with a range of -2.08 to 20.69 and SD of 9.17. These values were significantly higher in both males and females of dysphonic group when compared with normals which was also supported by the test of significance as indicated in Table 10. Thus the hypothesis stating no statistical difference between dysphonics and normals for the parameter of speed of fluctuations in Fo was rejected.

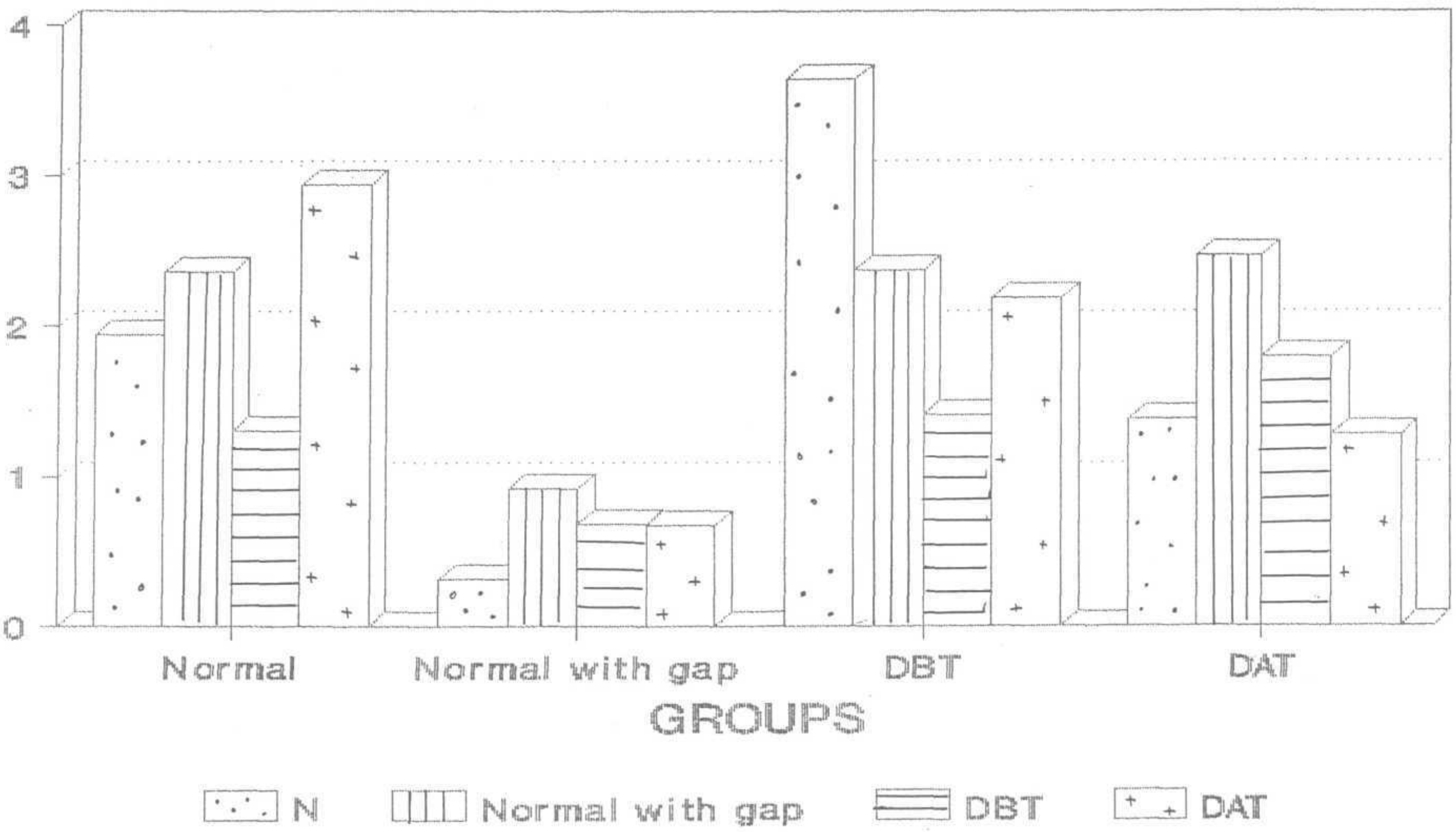
Table 9 revealed a mean of 1.39 with a range of 0.09 -2.68 and SD of 1.8 in dysphonic males after receiving therapy while in females after therapy showed a mean of 4.99 with a range of -0.08 to 10.78 and SD of 4.66. These values were quite comparable to normal values indicating significant changes following therapy which was also supported by test of significance (Table 10) i.e. there were no significant differences between normals and dysphonics after therapy (bothmales and females) in terms of speed of fluctuations in Fo in phonation. Thus the hypothesis stating that there is no statistical significant difference between normals and dysphonics (both males and females) after therapy in terms of fluctuations in Fo in phonation was accepted.

Table 10 also made it clear that there was significant changes between dysphonics before and after therapy i.e., the speed of fluctuations were reduced after therapy. Further the statistical test also revealed significant differences between before and after therapy conditions both in case of males and females. It was concluded that this parameter was very strong and accurate to indicate changes following treatment of dysphonic patients. Thus the hypothesis stated previously that there is no significant differences between pretherapy and post therapy was rejected in case of males and females for the parameter speed of fluctuations in Fo.

vi) **Extent of fluctuations**

The inspection of Table 11 and Graph 6 revealed mean of 1.94 with a range of 1.21 - 2.65 and SD of 2.3 for normal males on first occasion and on second occasion a mean of 0.31 with a range of -0.54 to 1.16 with a SD of 0.68 was noticed. Whereas for normal females a mean of 2.36 with a range of 1.3 -3.42 and SD of 2.94 and mean of 0.92 with a range of 0.08 -1.76 and SD of 0.67 were observed on first and second measures respectively. Test of significance (Table 12) indicated significant difference between first and second measures both in males and females. Thus rejecting the hypothesis stating that there is no statistical

Gr.6: Extent of Fluctuation for Fo



significant differences between repeated measures for normals for the parameter of speed of fluctuations.

Groups		Mean	S.D.	Range
N	M	1.94	1.30	1.21 - 2.65
	F	2.36	2.94	1.30 - 3.42
N with gap	M	0.31	0.68	-0.54 - 1.16
	F	0.92	0.67	0.08 - 1.76
DBT	M	3.64	1.41	2.63 - 4.65
	F	2.37	2.19	-0.35 - 4.65
DAT	M	1.38	1.79	0.09 - 2.66
	F	2.47	1.28	-0.36 - 5.31

Table-11 : The mean, SD and range of extent of fluctuations in fundamental frequency while phonating /a/ by normals, normals with a gap of one week dysphonics before therapy dysphonics after therapy.

	Group	Z	P	Significance
N vs N	M	-1.8257	0.0679	+ve
	F	-0.6742	0.5002	+ve
N vs DBT	M	-1.9876	0.0469	-ve
	F	-0.4045	0.6858	+ve
N vs DAT	M	-0.8885	0.3743	+ve
	F	-0.4045	0.6858	-ve
DBT vs DAT	M	-2.5236	0.0116	+ve
	F	-1.0000	0.3173	+ve

Table-12: The results of comparison normals with the gap of one week, between normals with dysphonics before Therapy, normals and dysphonics after therapy, and dysphonics before and after therapy in terms of extent of fluctuations in Fo.

Dysphonic males prior to therapy showed a mean of 3.64 with a range of 0.09 -2.66 and SD of 1.79 whereas female dysphonics showed mean of 2.47 with a range of -0.35 to 4.65 and SD of 2.19. The values of dysphonic males were higher than normal males but the values for dysphonic females whne compared tonomral females were quite close which were also strengthened by test of significance (Table 12). Thus the hypothesis stated previously no significant difference between dysphonics and normals for this particular parameter was accepted for males but rejected for female dysphonics.

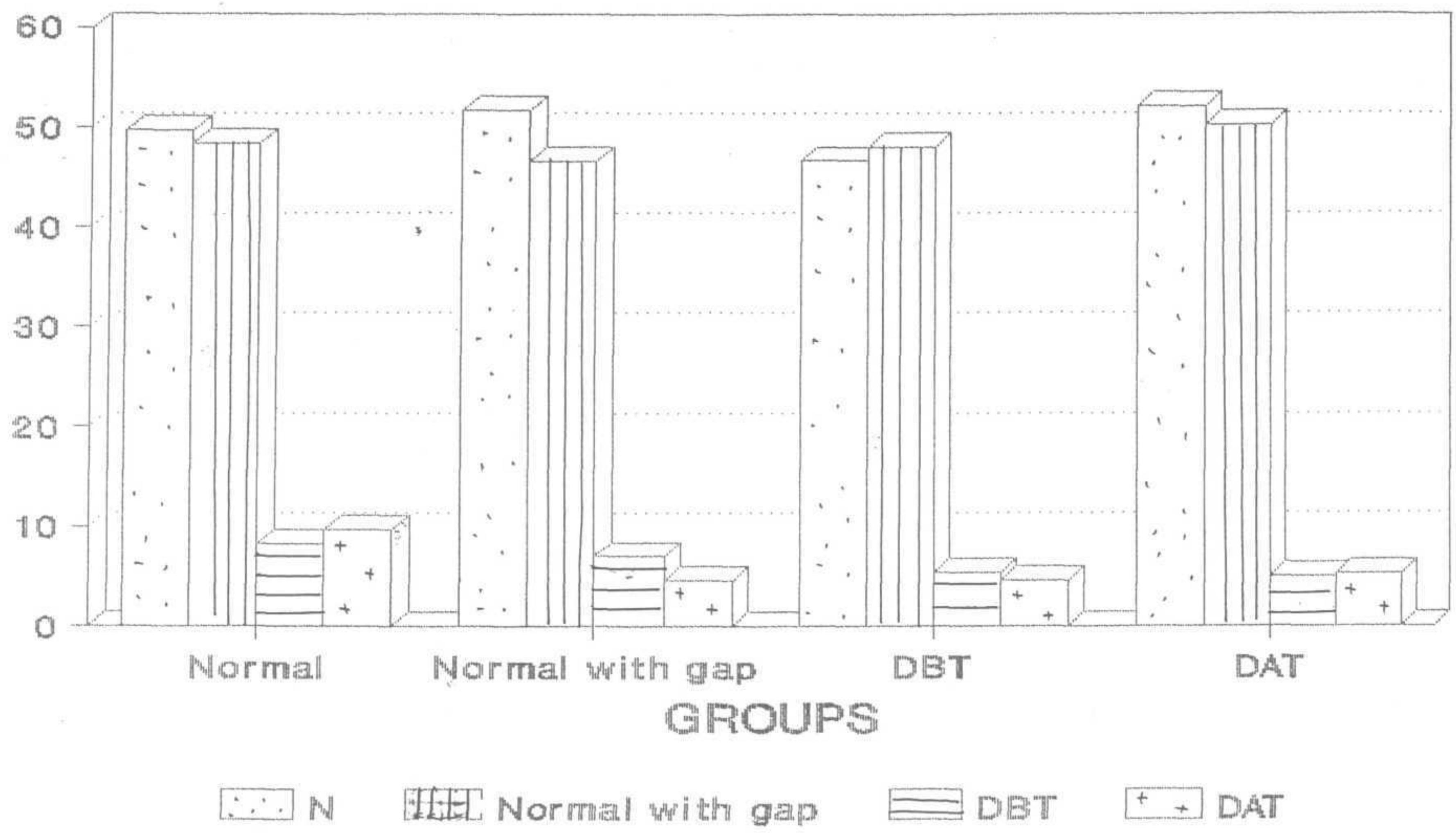
After receiving therapy the mean of dysphonic male group was 1.38 with a range of 0.09 - 2.66 and SD of 1.79 whereas in dysphonic female group the mean was 2.47 with range of -0.36 - 5.31 and SD of 1.28. Further, test of significance revealed statistically significant differences betwen males of normal group and dysphonics after therapy but not in normal females and dysphonics after therapy. Thus the hypothesis not statistically significant differences between normal and dysphonics after therapy interms of extent of fluctuation in Fo of phonation was rejected for males but accepted for females.

Table 11, 12 also revealed significant reduction in the value of extent of fluctuations in Fo following therapeutic intervention. The mean and SD of dysphonics were much higher than normals suggesting irregular vocal fold movements Imaizumi et al. (1980), Kim et al. (1982), Yoon, et al. (1984), Nataraja (1989), Divya (1996) have found similar results. Thus the hypothesis stating that not statistically significant differences between pretherapy and posttherapy values of extent of fluctuations in Fo in phonation both in case of males and females was rejected.

vii) **Mean Intensity**

Table 13 and Graph 7 revealed mean of mean intensity 49.73 dB with a range of 45.18 to 54.27 dB and SD of 8.20 in case of normal males on first occasion while on second occasion the mean was 51.74 dB with a range of 43.02 - 60.44 and SD of 7.01. Similarly in case of normal females the mean was 48.44 dB with a range of 43.08 - 53.78 dB and SD of 9.65 on first occasion while on second occasion mean was 46.55 dB with a range of 40.89 - 82.21 dB and SD of 4.56. Test of significance revealed not statistically significant differences for normal males on repeated measures but statistically significant in case of females for repeated measures (Table 14). Thus the hypothesis stating earlier that not statistically significant differences in normals on

Gr.7: Mean intensity



repeated measures was accepted for males but rejected for females.

Groups		Mean	S.D.	Range
N	M	49.73	8.20	45.18 - 54.27
	F	48.44	9.65	43.08 - 53.78
N with gap	M	51.74	7.01	43.02 - 60.44
	F	46.55	4.56	40.89 - 52.21
DBT	M	46.64	5.39	42.78 - 50.50
	F	48.02	4.54	42.38 - 53.66
DAT	M	52.12	4.96	48.56 - 55.67
	F	50.3	5.24	43.78 - 56.82

Table-13 : The mean, SD and range of normals, normal with the gap of one week, dysphonics before therapy, and dysphonics after therapy for mean intensity of /a/ during phonation.

	Group	z	P	Significance
N vs N	M	-1.2136	0.6858	-ve
	F	-0.4045	0.2249	+ve
N vs DBT	M	-0.1529	0.8785	-ve
	F	-0.6742	0.5002	+ve
N vs DAT	M	-0.8885	0.3743	+ve
	F	-0.4045	0.6858	-ve
D (DBT vs DAT)	M	-2.1917	0.0284	+ve
	F	-1.4606	0.1441	+ve

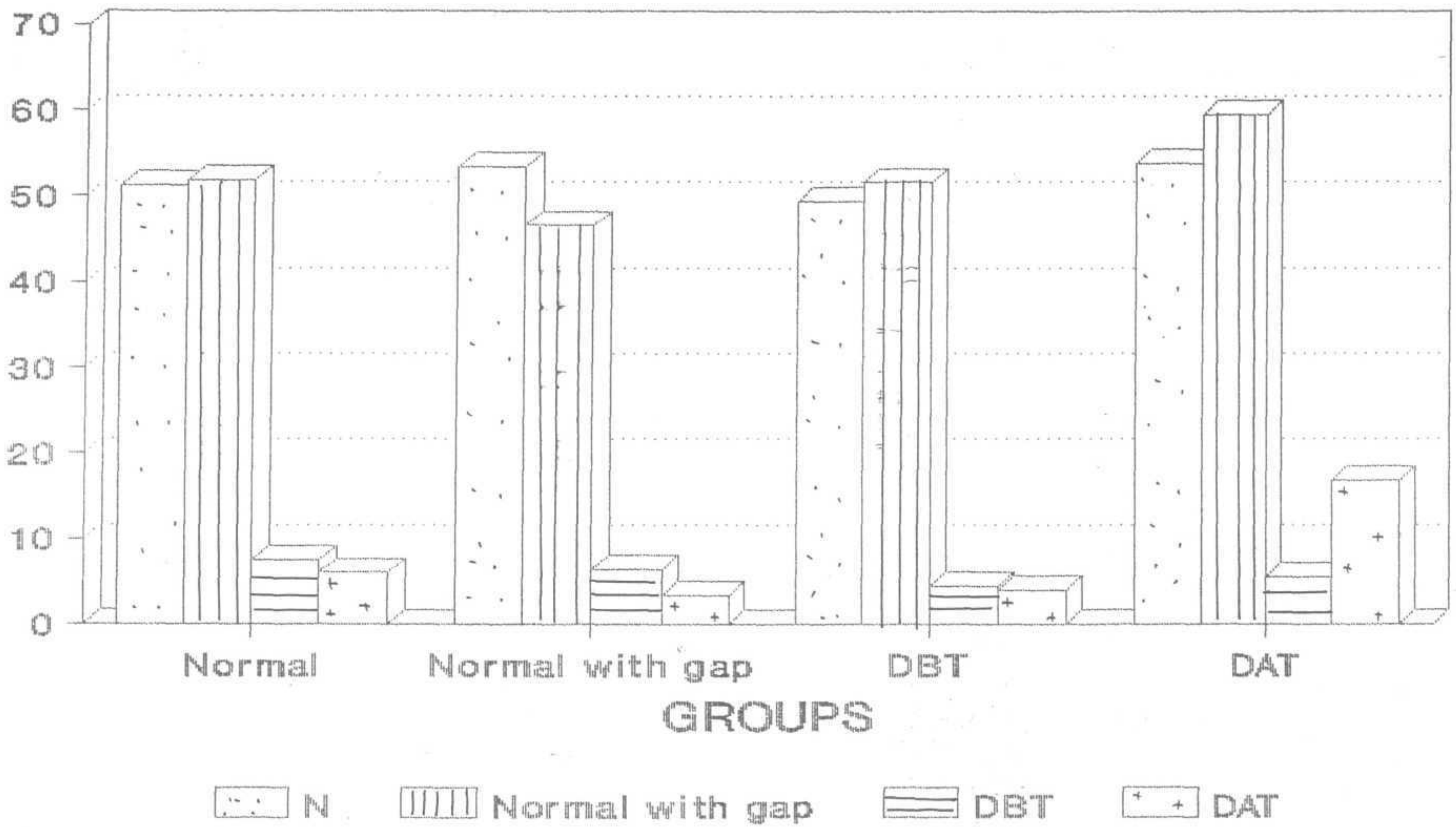
Table-14 : The results of comparison between normals with a gap of one week, normals and dysphonics before therapy, normal and dysphonics after therapy, and dysphonics before and after therapy in terms of mean intensity.

A Comparison of between the values of dysphonics before and after therapy showed statistically significant difference indicating improvement after institution of voice therapy. It was a strong parameter to differentiate pretherapy voice from post therapy voice. Thus the null hypothesis stating not statistically significant differnece between dysphonics before therapy and after therapy in terms of mean intensity in phonation for both in males and females was rejected.

viii) **Maximum Intensity**

Table 15 and Graph 8 indicated that the mean for maximum intensity for normal males as 51.27 dB with a range of 47.15 - 55.38 dB and SD of 7.43 and mean of 53.42 dB with a range of 45.42 - 61.41 dB and SD of 6.43 on first and second occasions respectively. Similarly for normal females on Ist occasion mean was 51.85 dB with the range of 48.51 to 55.18 dB and SD of 6.02 and on next occasion mean was 46.62 dB with a range of 42.51 - 50.72 dB and SD of 3.39. Further analysis, revealed that in case of normal males voice changed significantly on repeated measure but in case of normal females it was not significant (Table 16). Thus the hypothesis stating that not statistically significant

Gr.8: Maximum intensity



difference between repeated measures on normals was rejected for males but was accepted in case of females.

Groups		Mean	S.D.	Range
N	M	51.27	7.43	47.15 - 55.38
	F	51.85	6.02	48.51 - 55.18
N with gap	M	53.42	6.43	45.42 - 61.41
	F	46.62	3.30	42.51 - 50.72
DBT	M	49.50	4.49	46.28 - 52.71
	F	51.66	3.97	46.72 - 56.59
DAT	M	53.83	5.14	50.83 - 57.5
	F	59.5	16.77	38.67 - 80.32

Table-15 : The mean, SD and Range for the maximum intensity in phonation /a/ by normals, normals with a gap of one week, dysphonics before treatment, and dysphonics after therapy.

	Group	Z	P	Significance
N vs N	M	-1.2136	0.2249	+ve
	F	-0.6742	0.5002	-ve
N vs DBT	M	-0.0510	0.9594	-ve
	F	-0.6742	0.5002	+ve
N vs DAT	M	-1.4780	0.1394	+ve
	F	-1.7529	0.0796	+ve
D (DBT vs DAT)	M	-2.1936	0.0283	+ve
	F	-2.1936	0.0283	+ve

Table-16 : The results of comparison between normals with a gap of one week, between normals and dysphonics before therapy, normals with dysphonics after therapy, and dysphonics before and after therapy in terms of maximum intensity in phonation.

The dysphonic males prior to therapy had a mean of 49.80 dB with a range of 46.28 - 52.71 dB and SD of 4.49 whereas female dysphonics had mean of 51.66 dB with a range of 46.72 - 56.59 dB and SD of 3.97 as indicated in Table 15. Table 16 reveales showed test of significance when compared with normal values which for normal males and dysphonie males but statistically stating that the differences between normal females and dysphonic females in terms of maximum intensity in phonation. Thus the hypothesis stating no statistical significant differences between normal and dysphonie before therapy was accepted for males but rejected for females in terms of maximum intensity in phonation.

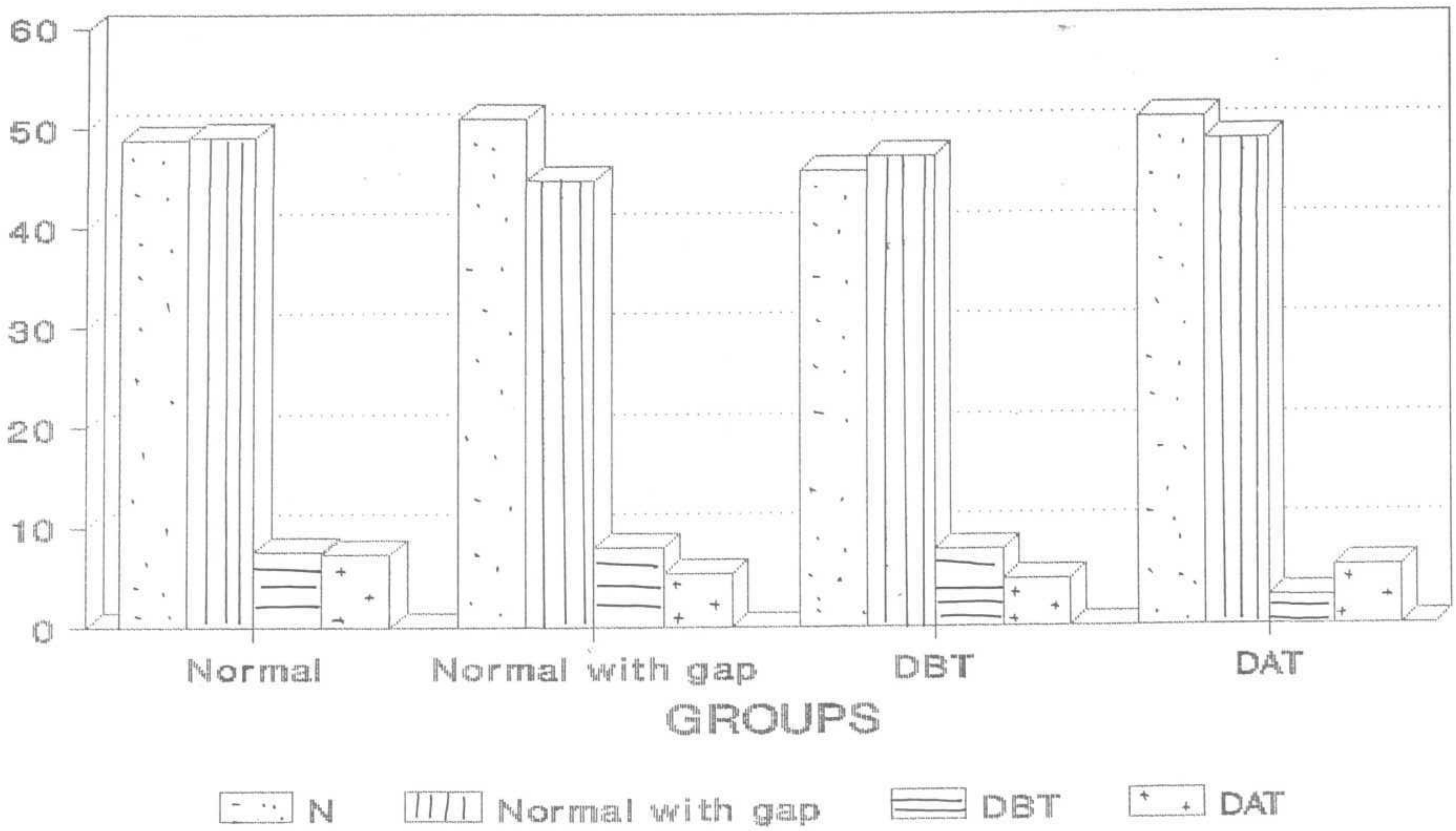
After therapeutic intervention dysphonie males obtained a mean of 53.83 dB with a range of 50.83 - 57.5 dB and SD of 5.14 whereas dysphonie females obtained mean of 59.5 dB with a range of 38.67 - 80.32 and SD of 6.77 as reported in Table 15. These values were compared with normal values as indicated in Table 16 which revealed statistically significant differences between normal voice and treated voice of dysphonics in terms of maximum intensity. Thus it could be safely concluded that even after therapeutic intervention voice did not come back to normal value for this particular parameter. The hypothesis stating that there is no significant differences between normal and treated dyspbonics in terms of maximum intensity was rejected both in case of males and females.

Table 16 shows comparision between between pre and post therapy voice sample swhich indicated statistically significant differences for both males and females in terms of maximum intensity. Though following voice therapy voice moved towards the normalcy it was not totally normal. So this paramter could be useful while monitoring post therapeutic changes. Thus the hypothesis, i.e. not statistically significant difference between pre and post therapeutic voices in terms of maximum intensity was rejected.

ix) **Minimum Intensity**

Study of Table 17 Graph 9 the mean value for normal males as 48.83 dB with a range of 44.59 to 53.96 dB and SD of 7.64 and mean of 50.87 dB with a range of 40.68 - 61.05 dB and SD of 8.02 on Ist and 2nd measure respectively while normal females had mean of 44.08 dB with a range of 45.69 - 53.15 dB and SD of 7.35 and mean of 44.70 dB with range of 31.96 -51.42 dB and SD of 7.35 on first and 5.41 on second occasion respectively. Table 18 indicates not statistically significant difference between normals for repeated measure for the parameter minimum intensity thus accepting the

Gr.9: Minimum intensity



hypothesis no significant difference between normals on repeated measures for minimum intensity thus accepting the hypothesis stating that there is not statistically significant difference between normals on repeatred measures of minimum intensity in phonation.

Groups		Mean	S.D.	Range
N	M	40.83	7.64	44.59 - 53.06
	F	49.00	7.35	45.04 - 53.15
N with gap	M	50.87	8.02	40.68 - 61.05
	F	44.70	5.41	31.96 - 51.42
DBT	M	45.65	7.69	40.15 - 51.15
	F	47.12	4.66	41.33 - 52.91
DAT	M	50.95	2.89	48.88 - 53.01
	F	40.64	5.05	41.36 - 55.91

Table-17 : The mean, SD and range for normals, normals with a gap of one week, dysphonics before treatment, and dysphonics following therapy (DAT) for the minimum intensity.

	Group	Z	P	Significance
N vs N	M	-1.2136	0.2249	+ve
	F	-0.4045	0.6850	-ve
N vs DBT	M	-0.2548	0.7989	-ve
	F	-0.4045	0.6858	-ve
N vs DAT	M	-1.3760	0.1688	+ve
	F	-0.4045	0.6858	-ve
D (DDT vs DAT)	M	-1.9540	0.0506	+ve
	F	-0.0000	1.0000	-ve

Table-18 : The showing comparison between normals with a gap of one week, between normals and dysphonic before treatment, after treatment and dysphonic before and after treatment in terms of minimum intensity.

While study the values for male dysphonics before therapy revealed a mean of 45.65 dB with a range of 40.15 - 51.15 dB and SD of 7.69 while for dysphonic females it was 47.12 dB as mean with range of 41.33 - 52.91 dB and SD of 4.66 as seen in Table 17. When these values were compared with normal values dysphonic males showed significant difference but dysphonics females did not. Thus the hypothesis stated previously nsd between normal and dysphonics before therapy held true for female dysphonics. Thus accepting the hypothesis for female dysphonics but was rejected for males dysphonics.

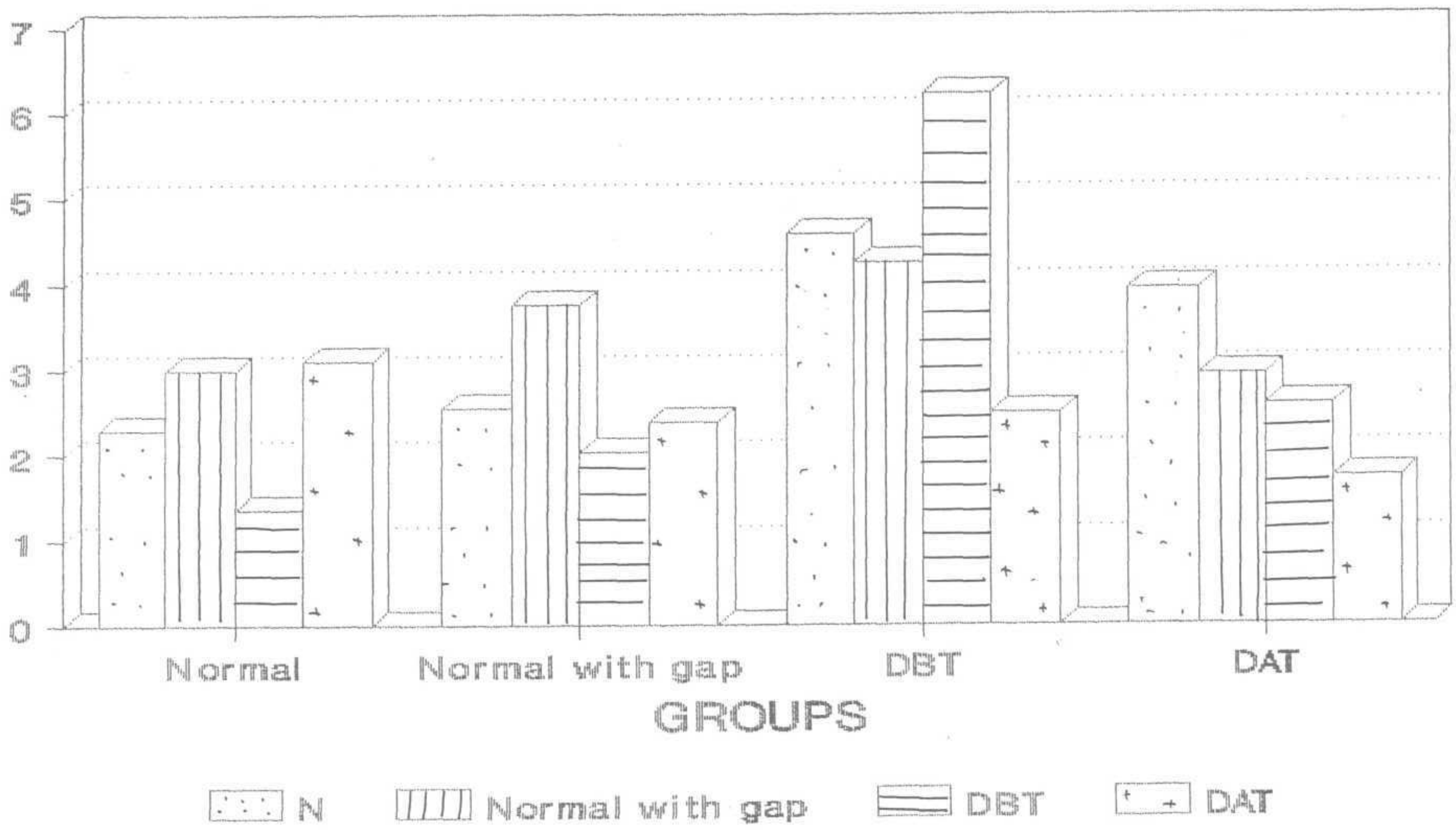
After therapeutic intervention mean value for dysphonic male was 50.95 dB with a range of 48.38 - 53.01 dB and SD of 2.89 while female dysphonic after treatment has been of 48.64 dB with range of 41.36 - 55.91 dB and SD of 5.85 dB reported in Table 17. Table 10 reveals that when these values are compared against normal values, dysphonic males after treatment significantly differed from normals males but dysphonics females did not differ from normal females. Thus the hypothesis stating that there is not statistically significant difference between normal and treated dysphonics in terms of minimum intensity in phonation was accepted in females but not in males.

Table 18 also reveals not statistically significant difference in case of females but statistically significant in case of dysphonic males before and after therapy in terms of minimum intensity. Thus according to this study minimum intensity appears to be not changing significantly in females after therapy. Thus the hypothesis i.e., stating that there is no statistically significant difference between dysphonics before and after therapy was true for females but was accepted for females but was rejected for males.

x) Range of Intensity

Mean value for range of intensity was 2.29 dB with a range of 1.53 - 3.04 dB and SD of 1.36 for males on first occasion while on second occasion the mean value was 2.55 with a range of 0.02 - 5.0 dB and SD of 2.03. Whereas in normal females mean was 3.00 dB with range of 1.27 - 4.72 dB and SD of 3.11 and mean of 3.76 dB with a range of 0.84 -6.68 dB and SD of 2.39 on first and second occasions respectively as indicated in Table 19. When these values were tested for significance of difference results indicated significant changes on during repeated measures thus rejecting the hypothesis stating no statistically significant difference between normals on repeated measures of range of intensity in phonation (Table 19 and 20) .

Gr.10:Range of intensity



Groups		Mean	S.D.	Range
N	M	2.29	1.36	1.53 - 3.04
	F	3.00	3.11	1.27 - 4.72
N with gap	M	2.55	2.03	0.02 - 5.0
	F	3.76	2.39	0.84 - 6.68
DBT	M	4.59	6.23	0.13 - 9.05
	F	4.25	2.5	0.27 - 8.22
DAT	M	3.95	2.58	2.1 - 5.79
	F	2.94	1.73	1.35 - 3.97

Table-19 : The mean, SD and range for normals, normals witha gap of one week, dysphonics before therapy, and dysphonics after therapy for range of intensity.

	Group	Z	P	Significance
N vs N	M	-0.9439	0.3452	+ve
	F	-0.9439	0.3452	+ve
N vs DBT	M	-0.4587	0.6465	-ve
	F	-1.8257	0.0679	+ve
N vs DAT	M	-1.6818	0.0926	+ve
	F	-1.7529	0.0796	+ve
DBT vs DAT	M	-0.4146	0.6784	-ve
	F	-1.6036	0.1088	+ve

Table-20 : The results of comparison of normal with a gap of one week, normals with dysphonics before treatment, normals with dysphonics after treatment, and for the range of intensities.

The mean value for dysphonic males before therapy was 4.59 dB with a range of 0.13 - 9.05 dB and SD of 6.23 while for dysphonic females it was 4.25 dB as mean with a range of 0.27 - 8.22 dB and SD of 2.5 (Table 19). When compared to normal values with the values of dysphonic males it was found that they were similar but dysphonic females differed significantly from normal females (Table 20). Thus the hypothesis stating that there is no statistically significant differences between normal and dysphonic before treatment in terms of range of intensity.

Table 19 reveals the values of dysphonic males after therapy where the mean was 3.95 dB with a range of 2.1 - 5.79 dB anda SD of 2.58 where as dysphonic females had mean of 2.94 dB with a range of 1.35 - 3.97 dB and SD of 1.73. These values were higher than normal values which was also indicated supported by the results of test of signfiicance (Table 20). Thus the hypothesis stating that there is no statistically significant differences between normals and treated dysphonics regarding the range of intensity in phonation was rejected.

Test of significance between pre and post therapy revealed (Table 20) that in case of dysphonic males had no significant differences but in case of dysphonic females showed statistically significant differneces. Thus the hypothesis stating no statistically significant differences between pre and post therapeutic voices of dysphonics in terms of range of intensity was accepted for males but rejected for females.

xi) Speed of Fluctuations

The normal male showed a mean of 0.22 with a range of -0.07 to 0.51 with sd of 0.52 on first occasion whereas on the IInd occasion mean was 0.3 with range of -0.52 to 1.11 with a sd of 0.66. Similarly for normal females mean was 0.88 with a range of -0.07 - 1.83 with SD of 1.72 and mean of 0.71 with range of -1.25 to 2.67 with a sd of 1.58 on Ist and 2nd occasion respectively (Table 21). When test values were tested for test of significance test ( ) revealed nsd for both males and females thus accepting the hypothesis stated earlier nsd repeated measures on normals.

Groups		Mean	S.D.	Range
N	M	0.22	0.52	-0.07 - 0.51
	F	0.88	1.72	-0.07 - 1.83
N with gap	M	0.3	0.66	-0.52 - 1.11
	F	0.71	1.58	-1.25 - 2.67
DBT	M	1.00	2.22	-0.58 - 2.57
	F	0.20	0.4	-0.35 - 2.74
DAT	M	0.00	0.00	0.00
	F	0.00	0.00	0.00

Table-21 : Mean, SD and range normals, with a gap of one week, dysphonics before treatment, and dysphonics after treatment for the parameter speed of fluctuations in intensity while phonating /a/.

	Group	Z	P	Significance
N vs N	M	-0.5345	0.5930	-ve
	F	-0.5345	0.5930	-ve
N vs DBT	M	-1.8411	0.0656	+ve
	F	-1.3416	0.1797	+ve
N vs DAT	M	-0.4472	0.6002	-ve
	F	-0.4472	0.6547	-ve
DBT vs DAT	M	-1.6036	0.1088	+ve
	F	-1.0000	0.3173	+v

Table-22 : The results of comparison between normals with a gap of one week, normals with dysphonics before therapy, normals with dysphonics after therapy, and dysphonics before and after therapy for the parameters speed of fluctuations in intensity.

Before therapeutic intervention dysphonic males had a mean of 1.00 with a range of -0.07 to 0.51 and 8D of 2.22. While dysphonic females had a mean of 0.2 with range of -0.35 -2.74 SD of 0.4 (Table 21). When these values were compared with normals it was found that there was a significant differences as the values in dysphonic group were higher. This parameter was regarded to provide information regarding conditions and functioning of the vocal folds. This has been cited in literature by Yoon et al. (1984), Nataraja (1989). Thus the hypothesis stating no statistically significant differences between normal and dysphonic voices in terms of speech fluctuations in intensity in phonation before therapy was rejected.

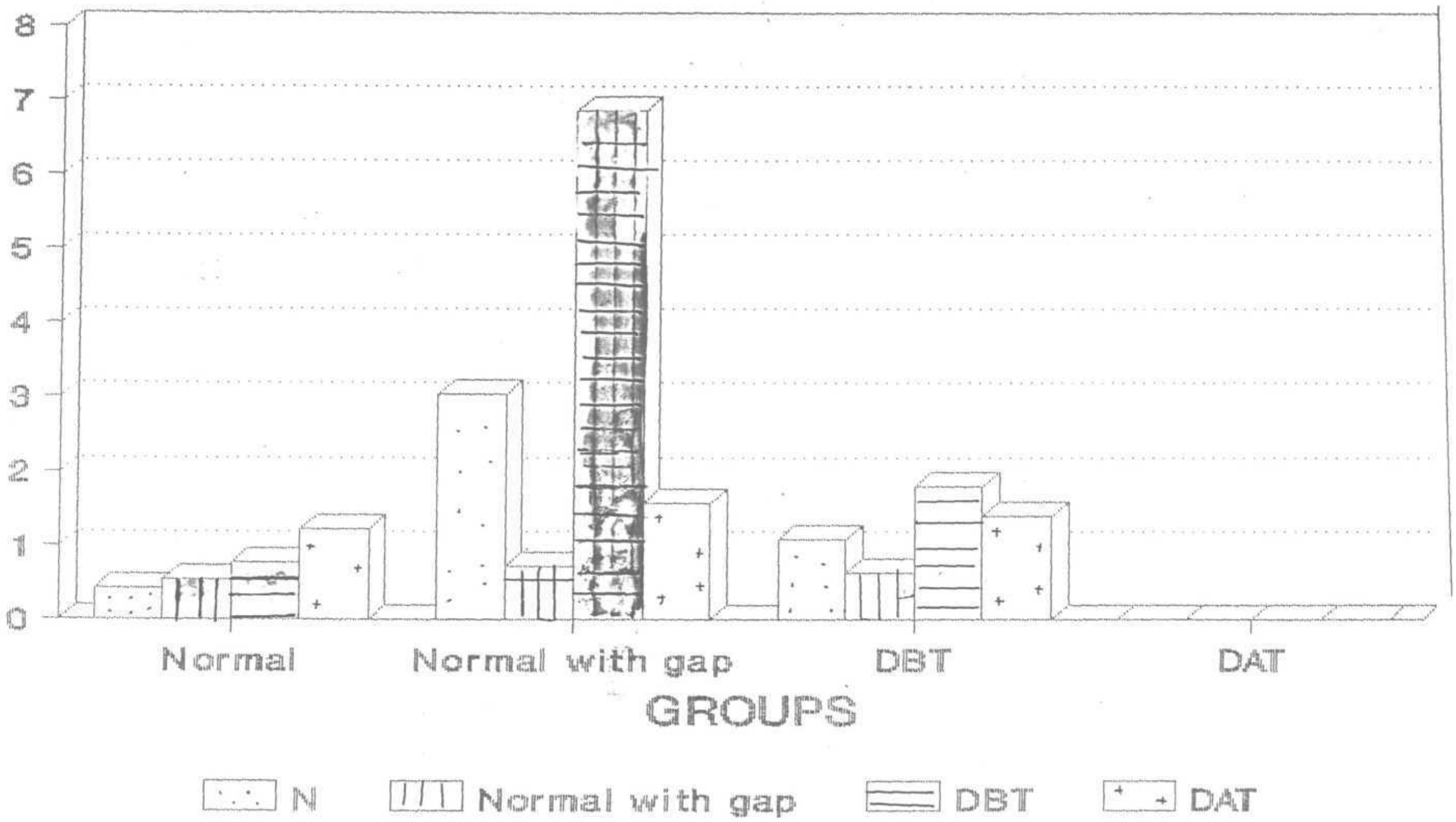
Table 21 also revealed values of treated dysphonics which were negligible after therapy. This was further supported by test of significance (Table 22). Thus the hypothesis stating that there is no statistically significant differences between normal and treated dysphonics in terms of speed of fluctuations in intensity in phonation for both males and females was accepted.

Inspection of Table 22 showed significant differences between dysphonics before and after therapy. The number of fluctuations reduced to 0 after therapy. Therefore this parameter in useful in monitoring changes in voice.

xii) **Extent of fluctuations in intensity**

The normal male obtained a mean value of 0.42 with a range of -0.008 - 0.83 and SD of 0.76 on Ist measure. While on IInd occasion mean of 3.05 with a range of -0.54 -11.59 and SD of 6.86. For normal females, the mean was 0.54 with -0.13 to 1.22 and SD of 1.22 and mean of 0.71 with the range of -1.25 to 2.67 and SD of 1.58 as reported in Table 23. When these values were compared using test of significance on repeated measures it indicated no statistically significant differences. Thus accepting the hypothesis stating that the is no significant differences between repeated measures in terms of extent of fluctuations in intensity both in case of males and females was accepted.

Gr.12:Extent of fluctuations in intensity



Groups		Mean	S.D.	Range
N	M	0.42	0.76	-0.008 - 0.83
	F	0.54	1.22	-0.13 - 1.22
N with gap	M	3.05	6.86	-0.54 - 11.59
	F	0.71	1.58	-1.25 - 2.67
DBT	M	1.09	1.8	-0.20 - 2.38
	F	0.62	1.39	-1.10 - 2.34
DAT	M	0.00	0.00	0.00
	F	0.00	0.00	0.00

Table-23 : The mean, SD and range normals, normals after a gap of one week, dysphonics before therapy, and dysphonics after therapy, for the parameter extent of fluctuations intensity for /a/.

	Group	Z	P	Significance
N vs N	M	-0.0000	1.0000	-ve
	F	-0.4472	0.6547	-ve
N vs DBT	M	-0.9435	0.3454	+ve
	F	-1.0000	0.3173	+ve
N vs DAT	M	-1.8257	0.0679	+ve
	F	-1.0000	0.3173	+ve
DBT vs DAT	M	-1.6036	0.1088	+ve
	F	-1.0000	0.3173	+ve

Table-24 : The results of comparison between normals with a gap of one week, normals with dysphonics before therapy, Normals with dysphonics after therapy, and dysphonics before and after therapy and normals for the parameters extent of fluctuations in intensity.

Table 23 also reveals values for dysphonic males before enrolling into management program with a mean of 1.09 with the range of -0.2 - 2.38 and SD of 1.8. Whereas dysphonic females had a mean of 0.62 with a range of -1.10 to 2.34 and SD of 1.39. When these values were compared against normal values it was found that there was significance differences. Thus null hypothesis stating that there is no statistically significant differences between normals and dysphonics before therapy in terms of extent of fluctuations in intensity for both males and females was rejected.

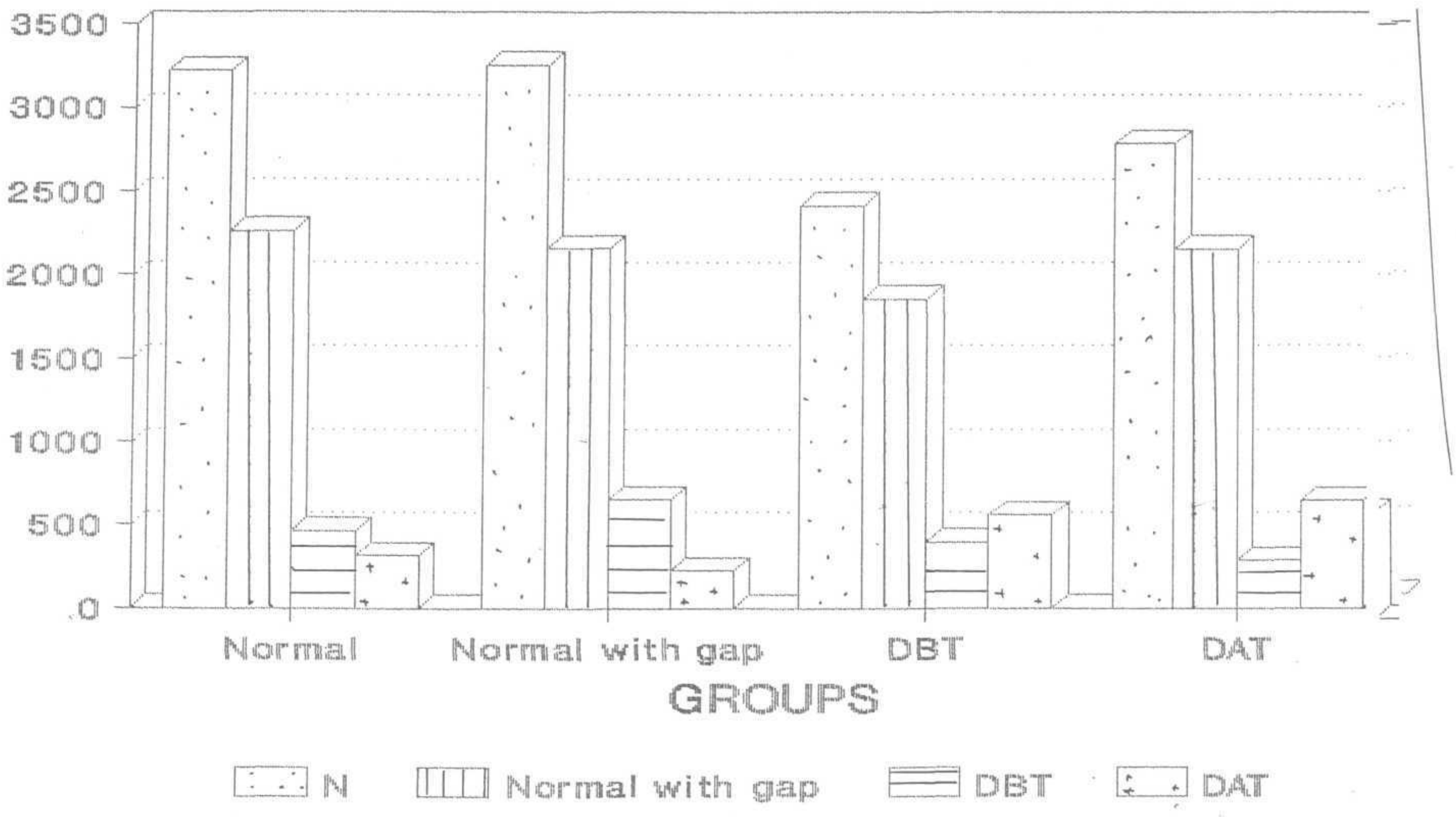
When dysphonics attended therapy the values of extent of fluctuations in intensity became zero. Test of significance also reveals no statistically significant differences between normal and dysphonic voices. Thus accepting the hypothesis stating that there is no significant differneces between normals and treated dysphonics for the parameters extent of fluctuations in intensity both in case of males and females.

Table 24 reveals the results of comparison between dysphonics before and after therapy which indicates significant improvement in voice in terms of extent of fluctuation in intensity following therapy. Thus it could be concluded that this parameter is useful in monitoring changes in voices. Thus the hypothesis stating that no significant difference between dysphonics before and after therapy in terms of extent of fluctuations in intensity was rejected.

xiii) **Vital Capacity**

The normal males had a mean of 3226.67 cc with a range of 2968.42 to 3884.90 cc and SD of 466.31 on Ist occasion while on IInd occasion normal males had a mean of 3260 cc and SD of 654.21 and range of 2487.68 - 4092.31. Similarly normal females on Ist measurement showed mean of 2265.56 with a range of 2088.31 - 2442.79 cc and SD of 320.06 and on IInd measurement mean of 2160.00 cc, with the range of 1877.53 to 2442.46 cc and SD of 227.48. These values are within range of normal values as reported by other investigators like Nataraja (1989), Jayaram (1975). When test of significance was carried out (Table 26) revealed normal males varied significantly over repeated measures whereas normal females performed similarly on repeated measure. Thus the hypothesis stating earlier that no significant differences between normals on repeated measure of vital capacity was accepted for normal females but not for normal males.

Gr.13:Vital Capacity



Groups		Mean	S.D.	Range
N	M	3226.67	466.31	2968.42 - 3884.90
	F	2265.56	320.06	2088.31 - 2442.79
N with gap	M	3260.00	654.21	2447.68 - 4072.31
	F	2160.00	227.48	1877.53 - 2442.46
DBT	M	2417.00	397.21	2132.85 - 2701.15
	F	1858.2	563.3	1158.76 - 2557.63
DAT	M	2790.00	288.48	2583.62 - 2996.36
	F	2158.00	654.65	1345.14 - 2970.85

Table-25 : Mean, SD and range for vital capacity for normals, normals with the gap of one week, dysphonics before therapy, and dysphonics after therapy for the parameter vital capacity.

	Group	Z	P	Significance
N vs N	M	-1.4604	0.1441	+ve
	F	-0.4064	0.6845	-ve
N vs DBT	M	-2.8044	0.0050	+ve
	F	-0.6742	0.5002	+ve
N vs DAT	M	-2.8122	0.0049	-ve
	F	-0.3651	0.7150	+ve
D (DBT vs DAT)	M	-2.2075	0.0273	+ve
	F	-1.8411	0.0656	+ve

Table-26 : The results of comparisons between normals with a gap of one week, normals with dysphonic before therapy, normals with dysphonics after therapy, and dysphonics before and after therapy and normals for the parameters vital capacity.

Table 25 also gives values for dysphonics before starting therapy. For dysphonic males the mean was 2417.00

with a range of 2132.05 - 2701.15 and SD of 397.21 while in case of dysphonic females it was 1858.2 with a range of 1158.76 -2557.63 and SD of 563.3. The values of vital capacity were lower in dysphonic group when compared to normal group. Similar findings have been reported by Nataraja (1986) and Jayaram (1975). Thus the hypothesis stating that there are no significant differences between normal and dysphonics before therapy in terms of vital capacity was rejected both in case of males and females.

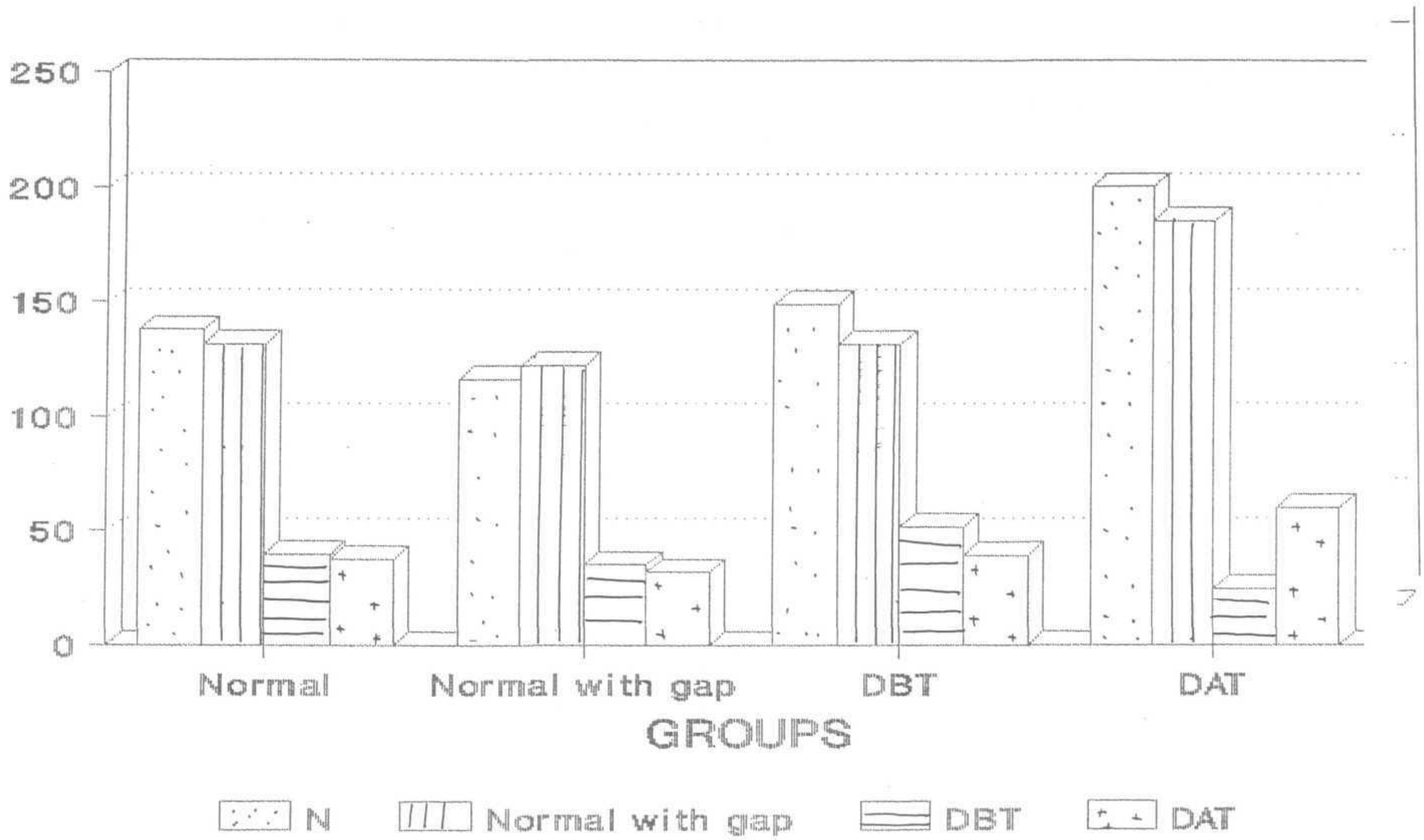
After voice therapy, the dysphonic males had a mean vital of 2790.00 cc and a range of 2583.62 - 2996.36 and SD of 288.48 whereas dysphonic females had a mean of 2158.00, with a range of 1345.14 - 2970;85 and SD of 654.65 as reported in the Table 23. When these values were compared against normal values it showed statistically significant difference for males but no significant differences for females (Table 26). Thus the hypothesis stated no significant differences between normals and dysphonic after therapy held was accepted for females but not for females

Table 26 also provides information regarding significant improvement following therapy as the test of significance revealed statistical differences between the performance before and after therapy. Thus the null hypothesis stating that there is no significnt differences between dysphonics before and after therapy in terms of vital capacity was rejected.

xiv) **Mean Air Flow Rate**

Table 27 illustrated the values of normal males as a mean of 137.96 with a range of 115.85 - 160.07 and SD of 39.92 on Ist occasion and on II occasion mean was 116.28 with a range of 72.36 - 160.19 and SD of 35.36. Similarly in case of normal females the values for Ist and 2nd measure were respectively 131.81 as mean, 110.91 - 152.70 as range and SD of 37.73 and mean of 122.51, range 82.71 - 162.30 and SD 32.09. These values are similar to values obtained by researchers like Jayaram (1975), Nataraja (1989). When these, values were further analyzed by test of significance . It reveals the differences in performance by females on I and II occasions but males had no significant differences for repeated measures. Thus the hypothesis stating there is no significnt differences between normals on repeated measure of mean air flow rate was rejected on case of males but accepted in case of females.

Gr.14:Mean airflow rate



Groups		Mean	S.D.	Range
N	M	137.96	39.92	115.85 - 160.07
	F	131.81	37.73	110.91 - 152.70
N with gap	M	116.28	35.36	72.36 - 160.19
	F	122.51	32.04	82.71 - 162.30
DBT	M	149.30	51.97	112.11 - 186.48
	F	131.60	39.37	82.71 - 180.48
DAT	M	200.3	24.74	182.6 - 218.00
	F	185.20	60.19	110.45 - 259.94

Table-27 : Showing mean, SD and range of MAFR normals, normals with a gap of one week, dysphonics before therapy, and dysphonics after therapy for the mean air flow rate.

	Group	Z	P	Significance
N vs N	M	-0.4045	0.6858	-ve
	F	-1.2136	0.2249	+ve
N vs DBT	M	-0.4587	0.6465	-ve
	F	-0.9439	0.3452	+ve
N vs DAT	M	-2.7011	0.0069	+ve
	F	-1.4832	0.1380	+ve
D (DBT vs DAT)	M	-2.6656	0.0077	+ve
	F	-1.8257	0.0679	+ve

Table-28 : The results of comparison between normals with a gap of week, normals with dysphonics before therapy, normals and dysphonics after therapy, and dysphonics before and after therapy for the parameter Mean Air Flow Rate.

The male dysphonic group, prior to therapy, had a mean of 149.30 with range of 112.11 - 186.48 and a SD of 51.97 while dysphonic females had mean value of 131.60 and range of 82.71 -180.48 with SD of 39.37 (Table 27). When compared with normal values (Table 28), the differences were not significant for males but were statistically significant for females. Thus the hypothesis stating that there is no significant differences between normals and dysphonics before therapy in terms of mean air flow was accepted for males ut rejected in case of females.

After therapeutic intervention, the dysphonic males had mean of 200.30 with range of 182.6 - 218.00 and SD of 24.74 while dysphonic females had a mean of 185.20 with a range of 110.45 to 259.94 and SD of 60.19 (Table 27).

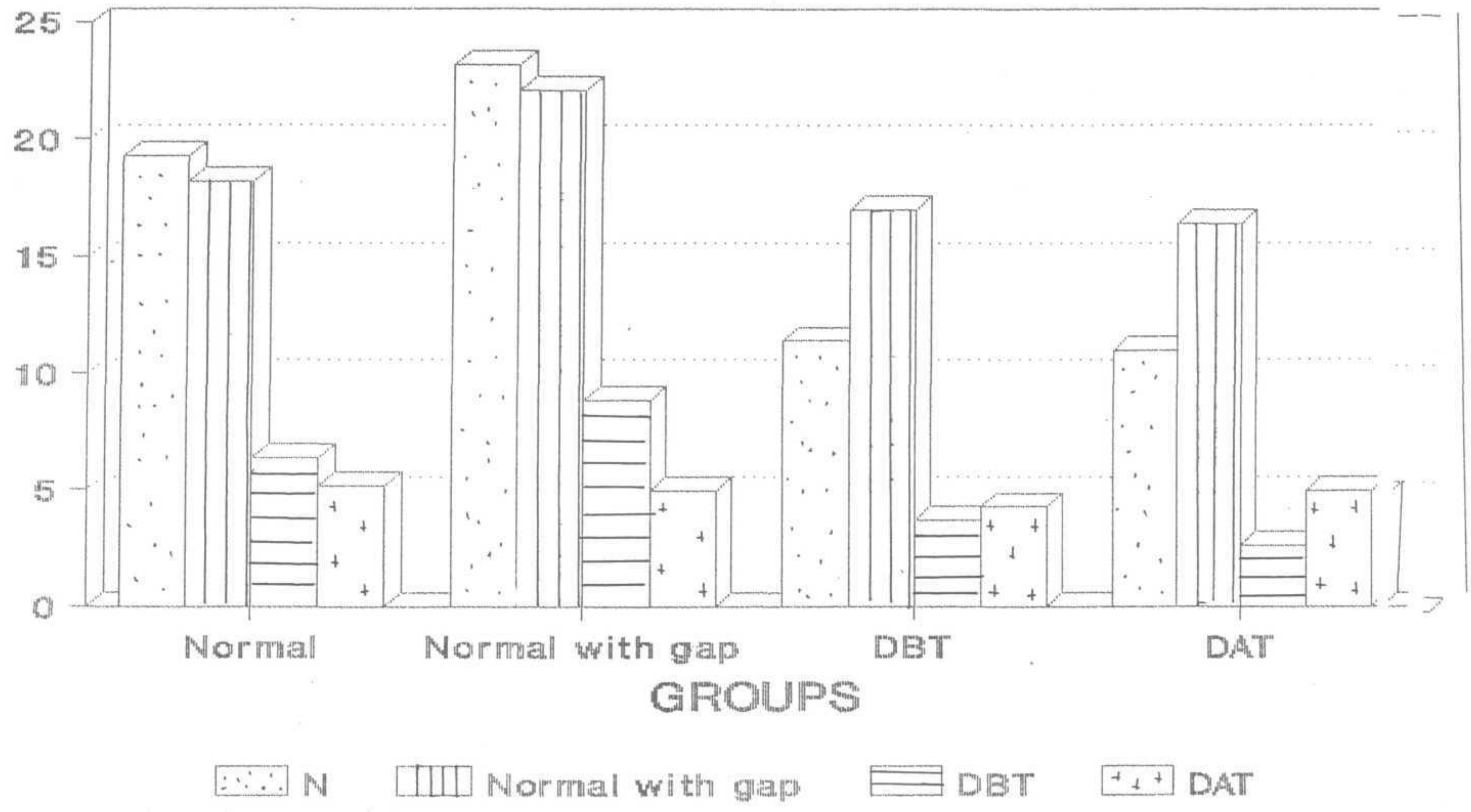
After therapy the air flow was reduced. When compared with normals however differed significantly both in case of males and females (Table 28). Thus the hypothesis stating that there is was no significant differences between normals and dysphonics after therapy in terms of mean air flow rate was rejected both in case of males and females.

Table 28 also provides information regarding significant differences between dysphonics before and after therapy. A comparision of before and after therapy conditions interms of meanair flow rate in dysphonics shared there was significant difference between the two conditions both in males and females. Thus rejecting the hypothesis stating that there is no significant difference between and after therapy interms of meanairflow rate in both males and females. The dysphonics showed much higher mean air flow rate and much greater variability than the normals. The same finding were also cited by Issihiki and Van Ledon (1964), Hirano et al. (1968), Yoshioke et al. (1977), Shigimori (1977), Jayaram (1975). This is a very useful parameter for monitoring dysphonic cases post therapeutically (Susheela, 1989). The hypothesis stated previously nsd between dysphonics before and after therapy was rejected.

xv) **Maximum Phonation Duration**

Table 29 and Graph 15 illustrates the values maximum phonation for normal males having a mean of 19.31 with range of 15.49 - 21.12 and SD of 6.39 on Ist measures. While a mean of 23.20 with a range of 12.18 -34.21 and SD of 8.87 on2nd occasion. Similarly normal females obtained a mean value of 18.20 with a range of 15.31 - 21.08 and SD of 5.21 and mean of 22.10 with a range of 15.91 - 28.30 and SD of

Gr.15:Maximum phonation duration



4.98 on I and II occasion respectively. These values were in accordance to normal values reported by investigators like Hirono et al. (1968), Jayaram (1975), Shegemori (1977), Nataraja (1989) for normal males and females. When analyzed for test of significance it showed that there was no significant differences for repeated measure accepting the hypothesis stating no significant differences between normals on repeated measure in terms of maximum phonation duration.

Groups		Mean	S.D.	Range
N	M	19.31	6.39	15.49 - 21.12
	F	18.20	5.21	15.31 - 21.08
N with gap	M	23.20	8.87	12.18 - 34.21
	F	22.10	4.98	15.91 - 28.30
DBT	M	11.40	3.71	8.74 - 14.06
	F	17.00	4.29	13.92 - 20.07
DAT	M	11.00	2.64	7.71 - 14.28
	F	16.40	4.98	10.21 - 22.58

Table-29 : Mean, SD and range for maximum phonation duration for normals, with a gap of one week, dysphonics before therapy, and dysphonics after therapy for the parameter maximum phonation durtion

	Group	Z	P	Significance
N vs N	M	-1.4064	0.6845	-ve
	F	-2.0226	0.0431	-ve
N vs DBT	M	-2.8031	0.0051	+ve
	F	-2.0226	0.0431	+ve
N vs DAT	M	-0.5103	0.6098	-ve
	F	-0.1348	0.8927	-ve
DBT vs DAT	M	-2.5236	0.0116	+ve
	F	-1.8257	0.0679	+ve

Table-30 : The results of comparison between normals with a gap of one week, normals with dysphonic before treatment, normals with dysphonics after treatment, and dysphonics before and after treatment for the parameters maximum phonation duration

The male dysphonic group showed a mean of 11.40 and SD of 3.71 and range of 8.74 - 14.06 and dysphonic females had a mean of 17.00 with a range of 13.92 - 20.07 and SD of 4.29 (Table 29). Thus dysphonic group had lower MPD compared to normals which has been reported by other authors like Nataraja (1984); Jayarama (1975). When compared with normal values dysphonics were significantly different (Table 30). Thus rejeteing the null hypothesis stating that there is no significant differences between normal and dysphonics before therapy for the parameter maximum phonation duration in both the groups males and females..

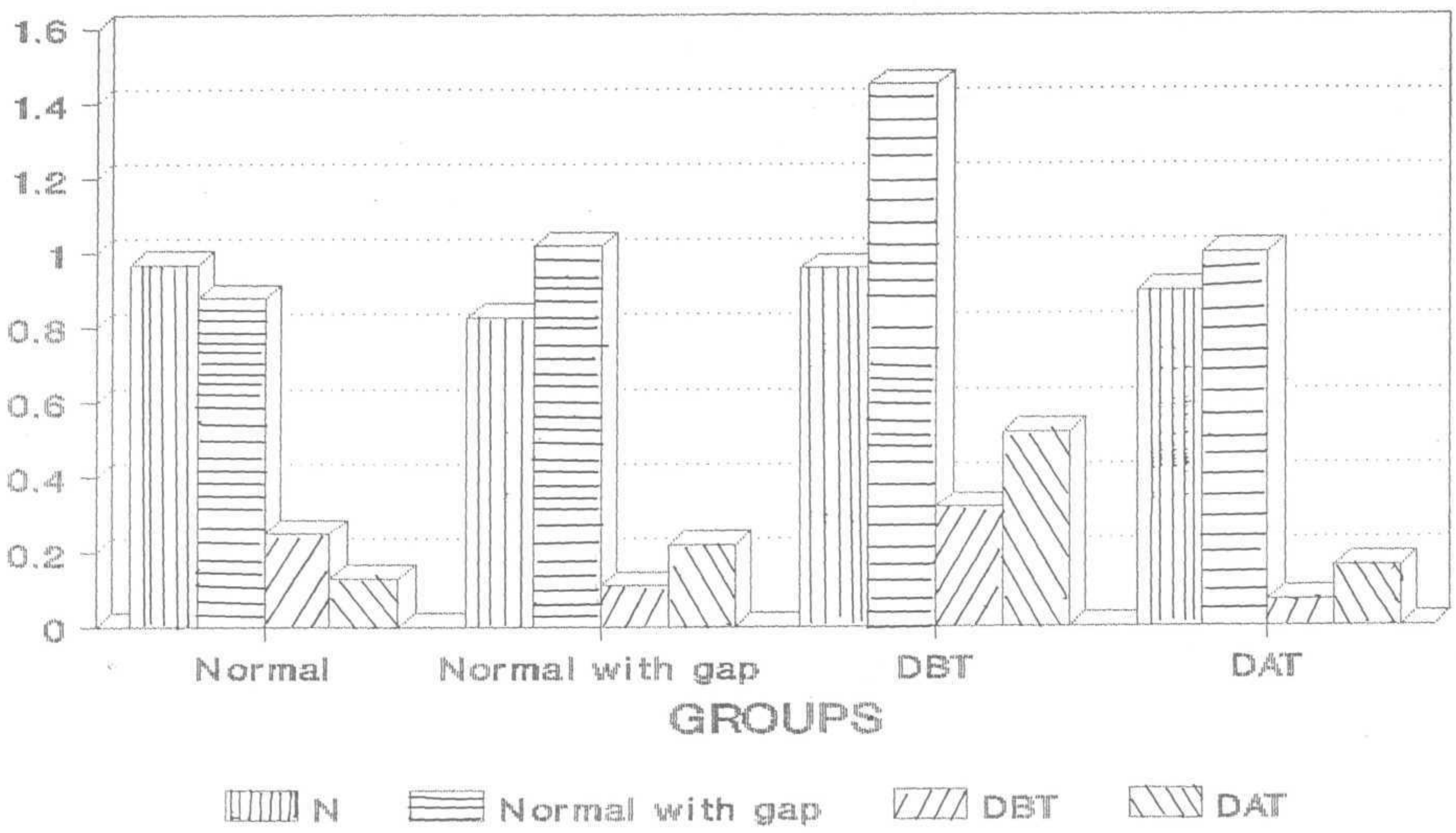
After therapeutic intervention, the dysphonic males had a mean of 11.00 with a range of 7.71 - 14.28 and SD of 2.64 while dysphonic females showed a mean of 16.40 with range of 10.21 - 22.58 and in terms of maximum phonation duration SD of 4.98 (Table 29). When compared with normals it was found that there was no significant differences between normals and treated dysphonics in terms of maximum phonation duration. Thus normalcy was achieved which made to reject the hypothesis stating that there is no significant differences between normals and treated dysphonics in terms of phonation duration both in case of males and females.

Table 30 also reveals statistically significant differences between the untreated and treated dysphonics which indicated that the lagged system function moves toward optimum following therapy. It could be concluded that therapy had resulted in favourable changes towards normalcy, thus the hypothesis stating that there is no significant difference between dysphonics before and after therapy was rejected in case of males and females.

xvi) **S/Z Ratio**

The mean value for normal male was 0.97 with a range of 0.63 - 1.11 and SD of 0.25 on Ist occasion while on IInd

Gr.16:S/Z ratio



measure the mean value was 0.83 with a range of 0.69 - 0.96 and SD of 0.11. Similarly, normal females showed a mean value of 0.88 with a range of 0.8 - 0.95 and SD of 0.13 and mean of 1.02 with range of 0.74 - 1.3 and SD of 0.22 on Ist and IInd measure respectively (Table 31). Test of significance (Table 32) revealed significant differences for males but not for females between Ist and IInd measures. Thus the hypothesis stating there is no significant differences between normals for repeated measure was accepted for females but not for males in terms of s/z ratio.

Groups		Mean	S.D.	Range
N	M	0.97	0.25	0.83 - 1.11
	F	0.88	0.13	0.8 - 0.95
N with gap	M	0.83	0.11	0.69 - 0.96
	F	1.02	0.22	0.74 - 1.30
DBT	M	0.96	0.32	0.73 - 1.19
	F	1.45	0.52	0.79 - 2.1
DAT	M	0.9	0.07	0.84 - 0.95
	F	1	0.16	0.78 - 1.20

Table-31 : Mean, SD and ratio for S/Z ratio for normals, normals with a gap of one week, dysphonics before therapy, and dysphonics after therapy for the parameters s/z ratio.

	Group	Z	P	Significance
N vs DBT	M	-0.1530	0.8784	-ve
	F	-2.0226	0.0431	+ve
N vs DAT	M	-0.3062	0.7595	ve
	F	-0.6742	0.5002	+ve
DBT vs DAT	M	-0.1400	0.8886	-ve
	F	-2.0226	0.0431	+ve
N vs N	M	-1.2136	0.2249	+ve
	F	-0.6742	0.5002	-ve

Table-32 : The results of comparison between normals with a gapof one week, normals and dysphonics before Therapy, normals and dysphonics after treatment, and dysphonics before and after treatment for the parameter S/Z ratio.

The mean value for dysphonic males before therapy was 0.96 with the range of 0.73 - 1.19 and SD of 0.32 while in case of females mean value was 1.45 with range of 0.79 -2.1 and SD of 0.52 (Table 31). When test of significance was carried out dysphonic males showed nosignificant differences when compared to normal males but dysphonic females showed significant differnces. Boone (1971) and Gekle and Boone (1980) reported that there was difference in therapeutic between dysphonics and normals which holds true only in case of dysphonic females in the present study but not in case of males. Thus hypothesis stating that there is no statistical significant difference between normals and dysphonic before therapy awas accepted for males but rejected for females for s/z ratio.

The male dysphonics after therapy showed a mean of 0.9 with range of 0.89 - 0.95 and SD of 0.07 while dysphonic females showed a mean of 1 with range of 0.78 - 1.20 and SD of 0.16 (Table 31). When these values were compared with normals males no significant differences but dysphonic females showed significant differences when compared to normal females. Thus the hypothesis stating no significant differences between normals and dysphonic after therapy was accepted for males and rejected for females for s/z ratio.

Further, Table 32 provides information regarding pre and post therapy condition in case of males and females. S/Z ratio did not differ significantly from pre and post therapy voices in case of males dysphonics but in case of females there was significant differences between the two. Thus accepting the hypothesis stating no significant differences in S/Z ratio between pre and post therapy condition for males but rejecting for females.

5.1

SUMMARY AND CONCLUSIONS

The main aim of the study was to determine the consistency of values in normals for 16 acoustic and aerodynamic parameters. It was also aimed at determining the parameters which could differentiate between normal and dysphonic voice and to identify those parameters which show significant differences after therapeutic intervention in case of dysphonics.

In this study the following sixteen parameters were considered to determine which of these would dysphonics before and after therapy and normals with a gap of one week.

i) Mean Fundamental Frequency
ii) Maximum Fundamental Frequency
iii) Minimum Fundamental Frequency
vi) Range of Fundamental Frequency
v) Speed of Fundamental Frequency fluctuations
vi) Extent of Fundamental Frequency fluctuations
vii) Mean intensity
viii) Maximum intensity
ix) Minimum intensity
x) Range of intensity
xi) Speed of intensity fluctuations
xii) Extent of intensity fluctuations

Aerodynamic parameters

xiii) Vital capacity

xiv) Mean Air Flow Rate

xv) Maximum Phonation Duration,

xvi) S/Z Ratio

All these 16 parameters were measured in normals (15 males and 15 females), it was measured for 10 normals (10 males and 5 females) after a gap of one week and 15 dysphonics (10 males and 5 females) before and after therapy. Results were subjected to statistical analysis using SPSS package. Here four different comparisons were made in terms of all the parameters.

a) Between normals with a gap of one week.

b) Between normals and dysphonics before therapy.

c) Between normals and dysphonics after therapy.

d) Between dysphonics before and after therapy.

The statistical test used was the Wilcoxon non-parametric test and descriptive statistics which led to following conclusions.

CONCLUSIONS

(1) In normals most of the parameters showed variations when measured after a gap of theweek. parameters which remained consistent inboth males and females were

- maximum fundamental frequency
- speed of fluctuations for intensity
- extent of fluctuations for intensity
- maximum phonation duration

Parameters which consistently varied over time in both normal males and females were

- minimum fundamental frequency,
- speed of fluctuations for frequency
- extent of fluctuations for freuency
- range of intensity

Other parameters were quite variable and nothing could be concluded sfely. This conclusion is put-forward with a small group of population. Further, it shuld be carried out on more number of subjects.

2) Out of 16 parameters studied 11 parameters showed

significant differences between the dysphonics (both males and females) before and after treatment. These were

a) Mean Fo
b) Range of Fo
c) Speed of Fo fluctuations
d) Extent of Fo fluctuations
e) Mean intensity
f) Maximum intensity
g) Speed of intensity fluctuations
h) Extent of intensity fluctuations
i) Vital capacity
j) MAFR
k) MPD.

3) These above mentioned parameters could also differentiated normal from dysphonics before therapy.

4) Following therapy 6 parameters were still significantly different from normals which gives the insight into though the voice of dysphonics is quite as 'par with' normals but it still needs further stabilization in those significantly different parameters.

IMPLICATIONS OF THE STUDY

1. It gives an insight into that in normals also many parameters show significantly different values over a period of time.

2. This study gives an understanding into the various parameters which could differentiate between normal voice and dysphonics.

3. This study gives idea of the various parameters that are expected to undergo significant changes after voice therapy.

4. It permits shorts terms monitoring of even subtle changes following therapy.

5. It gives direction to treatment and the parameters could be used to determine efficiency of various therapy programmes.

FURTHER RECOMMENDATION

1) These parameters could be studied for more number of subjects.

2) More parameters could be studied eq. spectral analysis, hormonic analysis etc.

3) These parameters could be studied from time to time-during the course of therapy (say after five sessions) to monitor progressive changes during the course of therapy.

4) In case of normals, more number of subjects should be undertaken and evaluated more number of times in order to achieve at normative value for all these parameters This will make the process easier of differentiating normal and pathological voice.

BIBLIOGRAPHY

Alexej, N., Jan, V. (1995). Acoustic parameters for the evaluation of voice of future voice professionals. Folia Phoniatrics, 47, 279-285.

Antikinson, J. (1978). Correlation analysis of the physiological factors controlling fundamental voice frequency. Journal of Acoustical Society of America, 63, 211-222.

Arnold, V. (1942). Training the speaking voice. Oxford University, N.Y.

Arnold, G.E. (1955). Vocal rehabilitation of pulalytic dysphonica II. Acoustic analysis of vocal fold function. Archives of Otolaryngoloy, 62, 593-601.

Berry, R.J., Epstein, R., Fourcin, A.J., Freeman, H., MacCurtain, F., and Noscoe, N. (1982-83). An objective analysis of voice disorders Part-I. British Journal of Disorders of Communication, 17-18, 67-76.

Berry, R.J., Epstein, R., Fourcin, A.J., Freeman, H., MacCurtain, F., and Noscoe, N. (1982-83). An objective analysis of voice disorders. Part II. British Journal of Disorders of Communication, 17-18, 77-83.

Boone, D.E. (1983). The voice and voice therapy (1st Ed.). Prentice-hall Inc, Englewood Cliffs, N.J.

Borden, G.J., and Harris, K.S. (1980). Speech primer : Physiology, acoustics and perception of speech. The Williams and Wilkins company, Baltimore.

Bowler, N.W. (1964). A fundamental frequency analysis of harsh vocal quality. Speech Monograph, 31, 128-134.

Brackett, I.P. (1971). Parameters of voice quality in Travis, L.E. (1971) Handbook of speech pathology and audiology. Appleton Century-Crofts, N.Y.

Briess, F. (1957). Voice therapy. Part I. Identification of specific laryngeal muscle dysfunction by voice testing. Archieves of Otolaryngology, 66, 375-301.

Britto, A.I., Doyle, P.C. (1990). Social environment and incidence of voice disturbances in children. Folia Phonetrica, 46, 134-138.

Britto, A.I., Doyle, P.C. (1990). A comparison of habitual and derived optimal voice funamental frequency values in normal young adult speaker. Journal of Speech and Hearing Disorders, 55, 416-484.

Broad, D. (1979). The new theories of vocal fold vibration in speech and language : Advances in basic research and practice, Vol.2. N.J. Lass, New York, Academic Press, Pp. 203-256.

Brodnitz, F.S. (1959). Vocal rehabilitation. Rochester, Minn. Whiting Press.

Buekens, R., Bierens, E., Kingma, H., Mawes, S.H.M.A. (1995). Vocal load as measured by voice accumulator. Folia Phoniatrica, 47, 252-261.

Bunch, M. (1982). Dynamics of singing voice. Springerverg, N.Y.

Casper, J.K., Brewer, D.W., Conture, E.G. (1986). Use of flexible fiber optic langyngoscope in documenting therapeutic efficacy. Folia Phoniatrics, 38, 288.

Chan, S.H., Chang, S.V., Fu, S.W., Chang, P. (1986). A survey on voice disorders of junior high school teachers in Taipai. Folia Phoniatrics, 38,290.

Cooper, M. (1979). Spectrographic analysis of Fo and hoarseness before and after vocal rehabilitation. Journal of Speech and Hearing Disorders, 39, 286-297.

Davis, S.B. (1976). Computer evaluation of laryngeal pathology based on inverse filtering of speech. SCRL Monograph, 13, Caif.

Davis, S.B. (1979). Acoustic characteristics of normal and pathological voice. In N.J. Lass, Speech and Language : Advances in basic research and practice, Vol.1. Academic Press, N.Y.

Drake, O. (1937). Towards an improved vocal quality. Quarterly Journal of Speech, 23, 620-626.

Dreher, J., and Bragg, V. (1953). Evaluation of voice normality. Speech Monograph, 20, 74-78.

Emerick, L. , and Hatten, J. (1979). Diagnosis and evaluation in speech pathology. New Jersy, Prentice-Hall, Englewood Cliffs.

Esbenozi, L., Childers, D.G., Hilbs, D.M. (1990). Acoustic correlates of voice quality. Journal of Speech and Hearing Research, 32, 298-306.

Fairbanks, G. (1979). Recent experimental investigations of vocal pitch in speech. Journal of Acoustical Society of America, 11, 457-466.

Fant, G. (1970). Acoustic theory of speech production (2 Edn.). Mouton, The Hague.

Fitch, J.L., Holbrook, A., Tallahasser (1970). Modal vocal fundamental frequency of young adults. Archieves of Otolaryngology, 92, 379-382.

Fox, D. (1978). Evaluation of voice problems. S. Sing, and J. Lynch, Diagnostic procedures in hearing, speech and language. Baltimore, University Park Press.

Fritzell, B., Sundberg, J., Ebbesoen, A.S. (1982). Pitch change after stripping of oedematous vocal folds. Folia Phoniatrics, 34, 29-32.

Fu, F.B., Ping, H. (1986). Acoustical characteristics of voice in nodule carries investigated by LTAS. Folia Phoniatrics, 38, 292.

Fu, F.B., Ping, II. (1986). Clinical classification of occupational hoarseness. Folia Phoniatrics, 88, 295.

Fukazawa, T., Hongo, T. (1986). Quantitative evaluation of breathy voice. Folia Phoniatrics, 58, 299.

Geetha, P. (1974). Relation between fundamental frequency and resonant frequencies of vocal tract. Unpublished Master's Dissertation, University of Mysore.

George, S. (1973). A study of fundamental frequency of voice and natural frequency of vocal tract. as on a Indian population of different age ranges. Unpublished Master's Dissertation, University of Mysore.

Gopal, N.K. (1986). Acoustic analysis of the speech in normal adults. Unpublished Master's dissertation. University of Mysore.

Gordon, M.T., Morton, F.M., Simpson, I.C., (1978). Airflow measurements in diagnosis, assessment and treatment of mechanical dysphonics. Folia Phoniatrics, 30, 161-174.

Gray, G.W., and Wise, CM. (1959). The bases of speech. Harper and Row Publishers, N.Y.

Green, M.C.L. (1964). The voice and its disorders. Mitman Medical, London.

Hammarberg, B., Fritzell, B., Gauffin, J., Sundberg, J., Wedin, L. (1980). Perceptual and acoustical correlates of abnormal voice qualities. Acta Otolaryngologica, 90, 441-451.

Hanson, R.J. (1982). A two state model of Fo control. Journal of Acoustical Society of America, 64, 534-544.

Henry, H. , Karnell, M. (1993-94). Common voice disorders : A primary case approach. NCVS, 5-7, 187-196.

Higgins, M.B., Netsell, R., Schulte, L. (1994). Aerodynamic and Electroglottographics measure of normal voice production : Inter-subject variability with and across session. Journal of Speech and Hearing Research, 37, 38-45.

Hirano, M. (1981). Clinical examination of voice, disorders of human communication, 5, Springer Wien.

Hirano, M. (1989). Objective evaluation of human voice, voice, clinical aspects. Folia Phoniatrics, 41, 89-94.

Hirano, M., Ohala, J., Vennard, W. (1969). The function of laryngeal muscles in regulating fundamental frequency and frequency, intensity of phonation. Journal of Speech and Hearing Research, 12, 616-628.

Holmberg, E.B., Hillinan, R.E., Perkell, J.S., and Gess, L. (1994). Relationship between intra-subject speaker variation in aerodynamic measures of voice production and variation in SPL across repeated recordings. Journal of Speech and Hearing Research, 37, 484-495.

Horii, Y. (1979). Fo perturbations observed in sustained phonation. Journal of Speech and Hearing Research, 22, 5-19.

Horii, Y. (1979). Vocal shimmer in sustained phonation. Journal of Speech and Hearing Research, 23(1), 202-209.

Hou, C.Y., Yu, Z.M., Yiang, Z.R. (1986). Vocal nodules and some information on the mechanism of its formation. Folia Phoniatrics, 38, 287.

Imaizumi, S. (1986). Acoustic correlates of pathological voice. Folia Phoniatrics, 38, 309-315.

Jayarama, K. (1975). An attempt at differential diagnosis of dysphonia. Unpublished Master's Dissertation, University of Mysore.

Jodella, D., Deem, F., Walfor, M.H., Joseph, K.V., Joseph, M.S. (1991). Comparison of pitch, perturbation extraction procedures with adult male and female speakers. Folia Phoniatrica, 43, 234-245.

Josef, P. (1990). Complex mechanism of laryngeal phonation, (A) Description of activity, (B) Analogue pattern of the larynx. Folia Phoniatric, 42, 201-222.

Kanen, L., Maria, A. (1994). Artificial pitch changing in auditory feedback as a possible method in voice training and in therapy. Folia Phoniatric, 46, 86-96.

Kaseya, H., Kikuchi, Y., Vchidas, S., Ebihara, S, Utsunomiya, Y.A, (1986). Acoustic methods for evaluating pathological voice. Folia Phoniatrics, 38, 315-319.

Kitzing, P., Aberlund, L. (1978). Speaking Fo characteristics associated with voice pathologies. Journal of Speech and Hearing Disorders, 43(3), 374-379.

Kreiman, J., Geevatt, B.R., Kenpstar G.B., Erman, A., and Breke, G.S. (1993). Perceptual evaluation of voice quality : Review, tutorial and a framework for future research. Journal of Speech and Hearing Research, 36, 21-40.

Leena, H.M. (1990). Provoked laryngeal dysfunction. Folia Phoniatrics, 42, 157-169.

Liu, T. (1986). Voice disease and voice health projection. Folia Phoniatrics, 38,326.

Maria, Z.K. (1990). Acoustic evaluation of laryngeal pathology. Folia Phoniatrics, 42, 170-172.

Marshall, S., Steven, G. (1993-94). Voice. NCVS, 5-7, 155-170.

Marybett, A.S., John, Pettit, M. , Sharblom, J.C. (1991). Management of vocal nodules : A regional survey of otolaryngologists and speech-language pathologist. Journal of Speech and Hearing Research, 34, 229-235.

Menon, D., (1996). The analysis of voice before and after treatment. Unpublished Master's Dissertation, University of Mysore.

Michael, and Wendahl, R. (1971). Corrrelates of voice production in Travis, L.E., Handbook of Speech Pathology and Audiology. Prentice Hall Inc., Englewood Cliffs, N.J. 465-480.

Murphy, A.J. (1964). Functional voice disorders. Englewood Cliffs, Prentice Hall, In., N.Y.

Nataraja, N.P. (1972). Objective method of locating optimum pitch. Unpublished Master's dissertation. University of Mysore.

Nataraja, N.P., and Jayaram, M. (1902). A new approach to the classification of voice disorders. Journal AIISH, 8, 21-28.

Nataraja, N.P. (1904a). Phonation duration and optimum frequency. Journal of AIISH, 15, 117-122.

Nataraja, N.P. (1904b). MAFR and optimum frequency- Journal of AIISH, 15, 133-136.

Nataraja, N.P. (1986). Differential diagnosis of dysphonics. Doctoral Thesis, University of Mysore, Mysore.

Pedersen, M.F. (1991). Computed phonetograms in adult patients with benign voice disorders before and after treatment with a non-sedatingartihistamine (Lorafreline). Folia Phoniatrica, 43, 60-67.

Rashmi, M. (1985). Acoustic aspects of speech of children. Unpublished Master's dissertation, University of Mysore.

Robert, O.F., Babon, R.J. (1990). Considerations of the relationship between the fundamental frequency of phonation of vocal jitter. Folia Phoniatrica, 42, 31-40.

Ronald, S. (1993-94). Laryngeal function during phonation. NCVS, 5-7, 171-186.

Sasaki, Y., Yumoto, T., Okamura, H.(198). Sound spectrographic analyses of hoarseness. Folia Phoniatrics, 38, 399.

Senderholm, E., McMllister, A., Dalkrist, J., Senderberg, J. (1995). Aetiological factors associated with hoarseness of voice. Folia Phoniatrica, 47, 262-278.

Schindbr, O., Gonlla, M.L., Pisoni, R. (1990). Doppler ultra sound examination of the vibration speed of vocal folds. Folia Phoniatrica, 42, 265.

Schutte, H.K., Vander Beng, J., Hocksema, P.T. (1980). Effects of voice therapy measured by comparing vocal efficiency values. Folia Phoniatrics, 32, 234-251.

Shipp, T., Huntington, D.A. (1965). Some acoustic and perceptual factors in acute laryngitic hoarseness. Journal of Speech and Hearing Disorders, 30, 350-359.

Sram, F., Klabackora, H., Filieu, J., Samak, B. (1986). Voicemetry : Investigations of the basic parameters of voice. Folia Phoniatrics, 38, 355.

Sundberg, D. (1995). Vocal fold vibration patterns and modes of phonation. Folia Phoniatrics, 47, 218-228.

Susheela, M.V. (1989). The effectiveness of pre and post operative study of laryngeal lesions based on aerodynamic and acoustic measurements. Unpublished paper.

Titze, I.R. (1992). Acoustic interpretation of the voice range profile (phonetogram). Journal of Speech and Hearing Research, 35, 21-34.

Titze, I.R., Darrell, W., Milder, A.M., Henslay, S.R., Ramig, L.O., Pinto, B. (1993-94). Comparison between clinical assisted and fully automated procedures for obtaining a voice range profile. NCVS, 5-7, 53-54.

Usha, A.A. (1989). A study of fundamental frequency in Indian population. Unpublished Master's dissertation, University of Mysore, Mysore.

Yanagihara, N. (1967). Significance of harmonic changes and noise component in hoarse voice. Journal of Speech and Hearing Research, 10, 531-541.

Vanaja, C.S. (1986). Acoustic parameters of normal voice. Unpublished Master's Dissertation, University of Mysore, Mysore.

West, R., Ansberry, M., and Carr, A. (1957). The rehabilitation of speech (III Edn.), Harper and Row, N.Y.

Yanagihara, N. (1967). Significance of harmonic change and noise components in hoarseness. Journal of Speech and Hearing Research, 10, 531-541.

Zee, E. (1978). Duration of intensity as correlates of fundamental frequency. Journal of Phonetics, 6, 213-220.

Zemblin, W.R. (1968). Speech and hearing science. Englewood Cliffs, N.J., Prentice-Hall, Inc.

Zoran, M. (1994). Social environment and incidence of voice disturbances in children. Folia Phoniatrics, 46, 134-138.