ACOUSTIC ANALYSIS OF VOICE IN CHILDREN AND ADULTS

Tharmar (S)

Register No : M 8922

A Dissertation submitted as part fulfilment for

Final year M.Sc, [Speech and Hearing]

to the University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006
MAY - 1991

APPA & AMMA

for *what I am*

CERTIFICATE

This is to certify that the dissertation entitled **"ACOUSTIC ANALYSIS OF VOICE IN CHILDREN AND ADULTS"** *is the bonafide work in part fulfilment for the degree of Master of Science (Speech & Hearing), of the student with Register No. M 8922.*

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CERTIFICATE

This is to certify that the dissertation entitled

"ACOUSTIC ANALYSIS OF VOICE IN CHILDREN AND ADULTS"

has been prepared under my supervision and guidance.

May 1991

DR N.P.NATARAJA
Guide

DECLARATION

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

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ACKNOWLEDGEMENT

GURU VANDANA *to my guide* ***DR.*** **N.P. NATARAJA,** *Prof. & Head, Dept of Speech Science, for his patience and endurance during the entire course of the study.*

My sincere thanks to **DR. (Miss).S NIKAM,** *Director, AIISH, for permitting me to conduct the study.*

There are numerous times i seemed to he facing a dead end. I would have still been, if not for **Mr. C.S.VENKATESH, Mr. KRISHNAMOORTHY,** *and* **Mr.RAJASHEKAR,** *Asst, Prof, Manipal for their invaluable counsel / suggestions and help. Thank you very much*

My sincere thanks to the principal and staff of **DMS** *for permitting me to take their students as subjects for the study.* **BRAVO** *dear subjects for your cooperation during the course of data collection.*

To a parson who has been a part and parcel of the study and who has always been available to help me make order out of chaos....SURESHA.... Thank you is the least 1 can say.

To a person for her constructive criticism... **BHU** V **AN** A... *Thanks a million*

My thanks and appreciation is due **toBHUVANESHWARI.C.S., ARUN.K. GOKUL (GUNDU), ANITHA, "(S)IN(S)CR(S)ED(K)IB(V)LE (P)EI(R)GHT(R)˙ and NAMITHA.V.** *for their invaluable help and time during the crucial movements of data collection.*

I thank you my dear **SHANKAR, BHATTA, ANIMESH, KITTU, SOWMYAM, PEKKI, MYTHRA, SUCHA** *and all my class mates for their help and being a source of strength and encouragement.*

My thanks are also due to Mr. RAVI for the neat typing.

Last but not the least my sincere and heartfelt thanks to ail those, who directly or indirectly helped me in finishing the dissertation.

Once again **I THANK YOU ALL.**

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INTRODUCTION

Speech not only is one of the most complicated human behaviours but also represents one of the highest achievements of mans learning. It is physically a complex act which involves a high level functioning of the systems.

In terms of the structure and function involved speech is the result of 1) adjustment of the phonatory apparatus; 2) the shaping of the vocal tract; and 3) the timing and coordination of articultion. The conglomeration of these factors results in the acoustic output that is speech.

The constituents of speech or speech characteristics undergo a developmental change from childhood, adolescence to adulthood. The major change occurs at the time of puberty when vocal system evidences change in structural shape, size and consequently, a change in the physiological process of speech production. Predictably these changes leads to change in the acoustic characteristics of speech. Therefore the acoustic charecteristics of speech are studied to note the developmental changes. Some of them are,

- Maximum phonation duration
- S/z ratio
- Fundamental frequency in phonation
- Fundamental frequency in speech
- Speed of fluctuation in frequency in phonation
- Extent of fluctuation in frequency in phonation

- Speed of fluctuation in intensity in phonation.
- Extent of fluctuation in intensity in phonation
- Frequency range in speech and phonation.
- Intensity range in speech and phonation
- Rise and fall time in phonation

Since these acoustic characteristics reflect the changes in the vocal system and its function, they have been used to study the nature and function of the speech mechanism. Although, the physiologic and phonetic interpretation of acoustic data are sometimes uncertain, they are useful in testing certain hypothesis about the developmental changes in anatomy, motor control, and physiological functions. Thus in the event of abnormal structural and functional changes there will be a corresponding change in the acoustic characteristics of speech.

Therefore an insight into the varied characteristics of speech would in turn facilitate in differentiating normals from the abnormals. This would in turn add in delineating those parameters, Which are critical and vital in identifying the underlying disorders and diagnosing the condition precisely. This will in turn lead to effective management.

Further as the acoustic parameters of voice plays an important role in diagnosis and treatment of voice disorders. It is important to study the normal aspects of acoustic parameters of voice.

Some of the parameters which have been found sensitive to the developmental changes and also abnormal conditions have been studied by Kent (1976), Shigemore (1977), Mysak (1966), Snidecor (1943), Usha Abraham (1978), Kushal Raj (1983), Rashmi (1985), Gopal (1980) and Vanaja (1986).

There were very few studies on these parameters especially on Indian population. Therefore the present study aimed at studying the developmental changes of acoustic parameters of voice in children and adults. This study includes more age groups than that of similar study done by Rashmi (1985) and also includes more parameters than that of the above study. This study also aims at finding out the changes in acoustic parameters with reference to age and sex.

Statement of the problem.

The problem was to know how the aerodynamic and acoustic parameters with age and sex.

The present study therefore, aims at analysing some of aerodynamic and acoustic aspects of the speech of children and adults. Hirano(1980) has listed a number of parameters of voice. Some of these have been considered in this study, namely, maximum phonation time, mean fundamental frequency, frequency and intensity rage phonation and in speech, rise - fall time of phonation, speed and extent of fluctuation of frequency and intensity in phonation and speaking fundamental frequency. In addition the ratio of the maximum phonation time of /s/ to that of /z/ also have been studied.

Totally three hundred subjects, both males and females, age ranging from seven to twenty two years, were considered for the study. All the subjects were normal in terms of speech, language and hearing, and were attending normal schools.

Three trials of the maximum phonation duration of /a/, /i/, /u/, /s/ and /z/ were recorded for all the subjects. Using the data on vowel phonation, the following were determined.

(a) The maximum phonation duration
(b) The fundamental frequency
(c) Speed and extent of fluctuations in frequency and intensity.
(d) Frequency and intenstity range
(e) Rise and Fall time.

The phonation of fricative was used to measure :

(a) The s/z ratio, which was calsulated by dividing the maximum duration of /s/ by that of /z/.

Recordings of three repetitions of the sentences 'idu pa:pu', idu 'ko:ti' and 'idu kempu banna' were made for all the subjects. This was analyzed for

(a) The speaking fundamental frequency
(b) Frequency and intensity range in speech

The following hypothesis were made.

MAIN HYPOTHESIS

There is no significant difference in the aerodynamic and acoustic parameters with increase in age and between sex.

Auxiliary Hypothesis:

I (a) There is no significant change in the maximum phonation duration of the vowels with increase in age.

I (b) There is no significant difference between males and females of the same age group, when the maximum phonation duration of the vowels are compared.

II (a) There is no significant change in the S/Z ratio with increase in age.

II (b) There is no significant difference in the S/Z ratio between males and females of the same age group.

III (a) There is no significant difference in the fundamental frequency of phonation in males and females with increase in age.

III (b) There is no significant change in the mean fundamental frequency of phonation between males and females of the same age group.

IV (a) There is no significant difference in the speaking fundamental frequency in males and females with increase in age.

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XIV (b) There is no significant difference in the fall time of phonation with increase in age, between males and females of the same age group.

DEFINITIONS:

Maximum Phonation Duration (MPD):

Maximum duration of phonation has been defined as the maximum duration for which an individual can sustain phonation.

S/Z Ratio (S/Z):

The S/Z ratio is defined as the ratio of the maximum duration for which the fricative /s/ and /z/ were produced by the subject

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

Fundamental frequency in Speech (SFF):

The mean frequency of the speech stimulus displayed.

Fundamental frequency in phonation (PFF):

The mean frequency of the steady portion of phonation as displayed on the Pitch Analyzer.

Extent of Fluctuation in fundamental frequency in phonation (PFX):

The extent of fluctuation in frequency was defined as the means of fluctuations in fundamental frequency in a phonation of one second.

Fluctuation in frequency was defined as variations +/- and beyond in fundamental frequency.

Speed of fluctuation in fundamental frequency in phonation (PFS):

The speed of fluctuation in frequency is defined as the number of fluctuations in fundamental frequency in a phonation of one second.

Extent of fluctuation in Intensity in phonation (PIX):

The extent of fluctuation in intensity was defined as the means of fluctuations in intensity in a phonation of one second.

Fluctuation in intensity was defined as variations +/- 3 dp and beyond in intensity.

Speed of fluctuation in Intensity in phonation (PIS):

The speed of fluctuation in intensity was defined as the number of fluctuations in intensity in a phonation of one second.

Frequency Range in phonation (PFR) :

The frequency range in phonation was defined as the difference between the maximum and minimum fundamental frequency in phonation.

Intensity range in phonation (PIR):

The intensity range in phonation was defined as the difference between the maximum and minimum intensities in phonation.

Frequency range in speech (SFR):

The frequency range in speech was defined as the difference between the maximum and minimum fundamental frequency in speech.

Intensity range in speech (SIR):

The intensity range in speech was defined as the difference between the maximum and minimum intensities in speech.

Rising time in phonation (PRT):

The rising time in phonation was defined as the time required for an increase in intensity from 0dB to the beginning of the steady level of the intensity in the initial portion of the phonation.

Falling time in phonation (PFT):

the failing time in phonation was defined as the time required for the intensity to decrease from the steady level to OdB in the final portion of the phonation.

Implications of the study:

This study provides information regarding the changes in maximum phonation, s/z ratio, fundamental frequency in phonation, speaking fundamental frequency, Speed and extent of fluctuations in frequency and intensity, frequency range phonation and speech, intensity range in phonation and speech, rising and falling time of phonation as function of age, in the age range 7-22 yrars.

It also provides information regarding the differences in the above parameters between males and females.

This information will be helpful in,

1. In differential diagnosis of voice disorders and developmental disorders.
2. In understanding developmental changes in neuromuscular control of voice.
3. In speaker identification.

REVIEW OF LITERATURE

"Voice is the musical sound produced by the vibration of the vocal cords in larynx by air from the lunge. Normally voice plays the musical accompaniment to speech rendering it tuneful, pleasing, audible and coherent being essential to efficient communication by the spoken word" (Greene 1986).

The spoken utterance is an impact on the atmosphere, very short in duration and on a very small scale, in which the component sounds die away at different distances depending on their inherent energy... But these vibrations are of utmost complexity. Acoustic analysis resolves this tortous oscillation in a three-dimensional framework of frequency, intensity and time in which each sound is characterized by a typical display of energy in various frequency regions along the unlimited time axis (Cortz 1961).

The crucial event essential for voice production is vibration of the vocal folds. It changes DC air stream to AC air stream, converting aerodynamic energy to accoustical energy. From this point of view, the parameters involved in the process of phonation can be devided 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 specifies the nature of sound generated.

Hirano (1981) has further elabrated on this, by stating that, "the paremeters which regulate the vibratory pattern of the vocal folds can be divided into two groups: physiological and physical. The physiological factors are succinitly put, related to the activity of the respiratory. Phonatory and articulatory muscles. The physical factors include the expiratory force, the conditions of the vocal folds, and the state of the vocal tract. The expiratory force is the energy source of phonation and the state of the brancho pulmonary system and thoraeic cage. The condition of the vocal folds which are the vibrators is described with respect to the position shape, size, elasticity and viscosity of the vocal folds. It is influenced by the activity of the lxal muscles and pathological conditions of the vocal folds and the adjacent structures. The state of the vocal tract, the channel between the glottis and the lips, affects the vibratory pattern of the vocal folds to a certain extent and it is regulated chiefly by the articulatory muscles.

The vibratory pattern of the vocal folds can be described with respect to various parameters including the fundamental period or fundamental freqeuncy regularity or

periodicity in successive vibrations symmetry between two vocal folds, glottal area, waveform and so on.

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

Analysis of such acoustic parameters have been considered to be useful in knowing about the developmental disorders and thus in the treatment of developmental disorders of speech.

In many important respects, the development of motor control for speech is on instance of the more general problem of the developmental of skilled action. In defining this general problem of serially ordered acts, the performance of which is modified to achieve diminishing variability increased anticipationand improved economy. These attributes seen highly appropriate to describe the development of motor control for speech (Kent 1980).

Over the past two to three decades considerable research effort has been directed towards obtaining an understanding

of the organization and control of the process by which children learn to produce speech. Such research has involved observations of the aerodynamic and acoustic characteristic of speech (Mou, Zimmeran and Smith 1976).

Hirano (1981) has pointed out that the acoustic analysis of the voice signal may be one of the most attractive methods for assessing phonatory function or laryngeal pathology because it is non-invensive and provides objective and quantitative data. The technique of acoustic analysis has promising future as a diagnostic tool in the management of voice disorders. Many acoustic parameters, derived by various methods, have been reported to be useful in differentiating between the pathological voice and the normal voice. Hirano (1981) goes on to say that all the previous reports are preliminary reports and that further extensive basic and clinical research is required in order to obtain some algorithm for diagnostic purposes.

Further, a clinician will not really know what to except with a medical diagnostic having a complate physical description of the laryngeal together with some adjectives like "hoarse" for "rough", until he actually seens the case (Michal and Wendahl, 1971). On the other hand, if the clinician receives report which includes meares of frequency ranges, respiratory function, jitter volume-velocity of airflow during sustained phonation, etc., in the form of a

voice profile the clinician can then compare these values to the norms for each one of the parameters and thus have a relatively good idea as to how to proceed with therapy even before seening the patient. Moreover, periodic measurement of these parameters during the course of therapy may well provide a useful index as to the success of the treatment.

Therefore, the present study aims at investigating some aerodynamic (maximum duration of phonation and S/Z ratio) and acoustic (mean fundamental frequency in phonation and speech, mean intensiy, frequency and intensity range in phonation and speech, fluctuations in frequency and intensity, rise and fall time of phonation, vowel duration, speed and extent of fluctuation and ratio aspects of voice of the children and the adults.

Further, the review of literature shows the importance of these parameters is understadning the dynamics of normal speech and voice and thus helps in diagnosis and treatment of speech disorders.

MAXIMUM PHONATION DURATION

This measure has been suggested as a clinical tool for evaluation of vocal function for the past three decades. "A good criterion for the general quality of voice is immediately avilable by determining the phonation time" (Arnold 1955). Gould (1975) has stated that the maximum phonation duration measures give an indication of the overall

status of laryngeal functioning and tension in the larynx and any neuro muscular disability. A short phonation duration with a large air escape suggests a neuromuscular deficit such as laryngeal nerve paralysis. Boone (1977) and Yanagihara et al., (1966) reports similar view point on MPT.

Several authors have suggested "norms' for maximum phonation duration. These norms were found to vary from 10 seconds for consonents in children to 30 seconds for vowels (Arnold 1955), in normal-voiced individuals. According to Van Riper and Irwin (1958) normal individuals should sustain a vowel for atleast 15secs without difficulty. Fairbanks (1960) reported a duration of 20 to 35secs as normal. The normal values for MPD have been reported by several investigations. The average is greater for the males (25-35 secs) than for females (15-25secs).

Bless and Saxman (1970) studied MPD in boys and girls aged 8 and 9 years and found the MPD for girls was 19secs and boys it was 16secs. These results were contrary to most of the other studies in that the girls had longer MPD than the boys. Further, the results obtained by Coombs (1976) in her study of children with varying degrees of hoarseness indicated no significant relationship between sex and phonation duration. The difference may reflex the compounding aspects of hoarseness on the duration.

Launer (1971) measured MPD for /a/, /u/ and /i/ in children aged 9 through 17 years. There was no statistically significant difference between the three vowels. Phonatio duration increased with increasing age and boys and a longer sustained phonation time than girls.

Age	Time (secs)	
	F	M
9	8.8	11.4
10	9.4	10.4
11	11.5	12.8
12	12.2	12.2
13	11.0	12.3
14	13.3	17.6
15	12.4	18.9
16	12.9	17.8
17	13.5	16.9

Table 2.3: Averaged MPT in seconds for /a/, /i/ and /u/ (Launer, 1971)

Lewis casteel and Mc Mohan (1982) found no statitically significant relationship between phonation time and age using subjects of 8 and 10 years. However Ptacek, Sander, Naloney and Jackson (1966) found that MPD decreased a function of increasing age.

Harden and Looney (1984) have measured maximum substained phonation of /a/, /u/ and /i/ in 160 kindergarden children with mean age of 6.2 years. Subjects were grouped

based on sex and presence or absence of a voice disorders. Stop watch measurements of each subject's MPT were compared with graphic level recorder. The results indicated that:

1) The factor of sex had no significant effect on maximum phonation times.

2) The effect of normal voice group did result in a significant group with the voice disordered group achieving shorter phonation than the non-voice-disordered groups.

3) The phonation time obtained from two measurement procedures correlated significantly. Results also suggest that the vowel effect on maximum phonation time was significant for both the groups. The vowel /i/ was phonated significantly longer than either /a/ or /u/ for males to females in both groups.

Finegam (1985) studied 286 male and female children between the ages of 3.6 to 17.11 years and found that there was on influence of sex, age and repeated trials on MPT.

It has been concluded that males phonated significantly longer than females, both before (pre 10th trial) and after the practice effect (post 10th trial). Males sustained phonation on the avarage 2 seconds longer than the females.

MPT increases as a function of age. This has been supported by several authers (Lanner 1971; Haris 1971; Platt

et al 1975; Jait and Michel 1977). Launer noted a range of 5-6secs between phonation times for a and 17 years olds. Jait and Michal (1977) observed a difference of 9 and 6 seconds in the length of sustained phonation for 5 and 9 year old males and females.

This lack of agreement in the results of different studies made several investigators to study the variables which affect MPD variabiles investigated include vital pasity and air flow rate (Yomagihava et al 1966; Beke H 1971) vocal pitch and intensity (Ptacek and Sander 1963, Yangihra et al 1966, Yanagihara and Koike 1967) sex (Ptacek and Sander 1963; Yanagihara et al 1966; Yanagihara and Koika 1967; Yanagihara and Vonlender 1967; Coombs 1976) age (Launer 1971; Coombs 1976) and highest and weight (Lanner 1971).

Yanagihara and Koike (1967) indicated that the air volume available for maximally sustained phonation (ie., phonation volume) varied in proportion to vital capacity and this was specific to sex hight age and weight of individual. Additionally they suggested that the longer phonation duration was generally related to the larger phonation volume. They concluded tht the maximum sustained phonation was achieved by three physiological factors. They are;

1) Total air capacity available for voice production.
2) The expiratory power and
3) The adjustment of the larynx for eiffcient air usage.

The results of study by Isshiki et al (1967) indicated that none of the exprimental subjects utilized the total capacity for phonation. The amount of air volume expired during the longest phonation ranged from 68.7 to 94.5% the subjects vital capacity. Yanagihara and Koike (1967) obtained similar findings with the percentage ranging from 50 to 80% for males from 45 to 70% for males; Lusib et al (1982) found a significant and dominant relationship betwen vital capacity and the length of phonation of /a/. They also suggestes that with twenty trials, the maximum phonation obtained could reflexs utilization of a higher percentage of the vital capacity.

The amount and kind of training an individual had has been considered as yet another variable affecting the duration. Less and Michel (1969) indicated tha altheletes generally did better than non-altheletes and also trained singers than the non-singers. However, the results obtained by Sheela (1974) showed no significant relationship between phonation duration trained to unstrained singers. Sawashima (1966) has found no significant difference in the MPD in the sitting or standing position.

Sanders (1963) found MPD with twele trials and found no difference between first and 12th trails. Stone (1977) indicated that adults demonstrates greater maximum duration of /a/ when fifteen trials were used. However most of the

studies have been based on three trials (Yanagihara et al 1966; Yanagihara and Koike 1967; yanagihara and Von Lenden 1967; Lanner 1971; Coombs 1976).

Ptacek and Bandar (1963) appear to be the first to suggest that the maximum duration of phonation may be influenced by the frequency ad sound pressure level of voice, then the male subjects could sustain phonation longer than the females especially at low frequency and sound pressure levels. As both frequency and sound pressure level increased the phonation duration between males and females tend to become more similar. However, a considerable degree of variability among subjects was still evident in that significant difference existed for frequencies and sound pressure levels for male phonations, but not for female phonations. Conversely, the frequency sound pressure level interaction was significant for the females but not for the males.

Yamagihara et al (1966) and Yanagihara and Koike (1967) measured the maximum phonation duration at three different pitches, low, medium and high in normal adults. Phonation duration was reduced at high frequency for both males and females. The MPDs for males were 28.4sec for low pitch, 30.2sec for medium pitch and 23.7sec for high pitch while those for females were 21.7sec for low pitch 22.5sec for medium pitch and 16.7sec for high pitch.

Maximum duration of phonation has been used as a diagnostic tool. A significant reduction below normal levels can be related to inadequate voice production.

Arnold (1959) reports that in the case of paralytic dysphonia, the phonation duration was always 3-7sec.

According to Hirano (1981) clinically the maximum phonation time values were smaller than ten sec, should be considered abnormal.

Jayaram (1975) reported a significantly lower MPD in a dysphonic group than in a mached normal group. Further while a significant difference in MPD was found between males and females in the normal group, no such difference was seen in the dysphonic group. These results are similar to those reported by Coombs (1976) where no significant difference was observed with respect to the MPD, betwen males and females with hoarseness.

Ptacek and Sander (1963) appear to be the first to relate the MPD to he perception fo breathiness. Although none of the voices of their subjects were considered non-normal they were due to divide their subjects into two grous long-phonators and short-phonators. When these two groups were judged as to the degree of breathness from least to most on a seven point scale they found that long phonators tended to be judged as having less breathiness than the short

phonators. In addition perceived breathiness decreased as function of increase in intensity, and high frequency phonation tended to be rated as more breathy, than corresponding low frequency phonations.

That the short MPD are associated with laryngeal pathology and can be improved by treatment, was shown by Von Lenden, yanagihara and Werner (1967). They reported that increase in phonation duration from 1.33 to 14.79sec in one case and from 3.91 to 8.66sec in another case (both of whom had unilateral vocal fold paralysis) after injecting teflon into the affected folds. Michel, Kirchner, Shelton and Hollinger (1968) also demonstrated an increase in phonation duration from 4sec to more than 20sec as a results of teflon treatment of unilateral vocal folds paralysis.

Shigemori (1977) reports that MPD is valuable for monitoring the effects of surgical treatment in selected disorders of the laryngeal especially in recurrent laryngeal nerve paralysis, sulus vocalis, nodules and polyps.

Few studies in children in Indian population are available. Rashmi (1985) reports an increasing trend in MPT in children in the age range 4-15yrs, in both males and females. Vanaja (1986) studied MPT in adults (16-65yrs) and reported that the MPT decreased with increase in age and also significant differences between males and females were not found.

Jayaram (1975) reported a mean value of 22.23sec in males and 14.11sec in females subjects in age range 16-30yrs. He found a difference between males and females in MPT. Nataraja (1988) in a recent study in normal adults found 22sec in males and 15.13sec in females. He also reported a significant difference between males and females in terms of MPT measure.

The rationale for this measure has been given by Arnold (1959) who writes that this simple test gives information about the efficiency of pneuophonic sound generation in the laryngeal. He further states that "it also demonstrates the general state of the patients respiratory coordination". This statement can be modified to say that this measure can demonstrate the general status of the patient's respiratory coordination but more accurately indicates the relative effieiency of the penunolaryngeal interactions (Michel and Wendhal 1971). The measurement of MPD is also useful in derining the phonation quotient. Thus the measurement of MPD in very useful in diagnosis and treatment of voice disorders. The measurement of this parameter was included in the present study, since not much information is available regarding this with reference to the Indian population.

MAXIMUM DURATION OF SUSTAINED /S/ AND /Z/ OR S/Z RATIO:

Michel and Wendhal (1971) have suggested maximum phonation duration of sustained blowing as a possible

aerodynamic measures which provided an estimate of the amount of control of respiratory system and which can hence be used to evaluate the voice and its disorders. It is defined as the maximum length of time an individual can maintain an oral air flow". This measure may indicate the ability of an individual to maintain the subglottal air pressure required for voice production. According to Michel and Wendahl (1971) "this isolated measures may be of value only to show that the "power" or supportive functions necessary for speech are intact".

According to Boone (1971) the clinical evaluation of vocal fold function should consider not only the maximum phonation time but it should be comnrasted with a sustained expiration with out phonation. He suggests the ratio between /s/ and /z/, /s/ being a voiceless fricative and /z/ being a voiced fricative to assess the function of respiratory and phonatory systems.

This measures thus includes the maximum sustained phonation time as suggested by Ptacek and Sander (1963) and the maximum sustained blowing as recommended by Michel and Wendhal (1971) but with little modification in the articulatory posture of the vocal tract. Based on clinical observation, Boone (1971) states that "The typical prepubertal child can sustain the vocalless exhalation for about l0secs. The dysphonic patient without vocal fold

pathology will typically be able to extend the voiceless S...s.S....S. and the voiced z... z...z.. for about the same length of time". While a shorter than normal maximum phonation duration would indicate difficulty at the level of the laryngeal a shorter maximum phonation duration also be the result of reduced vital capacity. Thus this measure of S/Z ratio not only reflects the larynx function but also gives information regarding the respiratory system.

Tait et al (1980) gives normative data on five, seven and nine year old children for the maximum duration of /s/ and /z/ and their ratio for both males and females.

They report that there was a significant increase in MPD of both /s/ and /z/ for both the sexes as a function of age. While the five year old child should sustain /s/ for just five secs the seven year old child sustain it for l0secs. Whereas it was 16secs for nine year old children.

Robert et al (1985) studied 20 hearing impaired males and 20 hearing impaired females who range of tension or harshness from severe to normal/relaxed. The subjects were asked to read the rainbow passage. The first two sentences were used for analysis, S/Z ratio and Fo was calculated from these audio-recordings using computer program. The results indicated significant correlations between S/Z ratios and degree of perceived tension/harshness, as well as between the average Fo and perceived tension/harshness.

Rashmi (1985) studied the maximum duration of /s/ and /z/ in 110 males and 110 females age ranging from 4 years to 15 years. The results indicated that no significant difference in maximum duration between /s/ and /z/, both in males and females, throughout the age range studied. In male subjects, the maximum duration for /s/ at four years was 10.38secs and it did not show change upto 11 years. After 11 years of age a decrease was noticed upto 15 years. The maximum duration was seven seconds. A similar trend was been obtained in the case of females also.

According to Vanaja (1986) the maximum duration for /s/ and /z/ both in caseof males and females decreased with age ie., from a mean of ll.3secs at 16-25 years age group to a mean of 7.35secs for the age group 56-65 years for /s/ is found between males. No significant difference was also found between sexes at any age studied. It was also noticed that the S/Z ratio was approximately 1.00 for all the age groups, both in males and females.

Nataraja and Sargunamoorthy (1988) compared the relation between maximum sustain blowing, phonation duration and S/Z ratio. Their results show that the MPD value was not significantly difference from /s/ and /z/ in case of males, but the mean (S) value was significantly difference than MPD value in females. The mean MPD values were higher than both mean /s/ and /z/ both is males and females. After compared

they have concluded that measurement of any one of these parameters would be sufficient to know the condition of the respiratory and laryngeal system. However they gave more importance to measure MPD since MPD is useful i deriving phonation quotient and in earring out further voice analysis.

Wilson (1979) recommends the S/Z ratio as a part of routine clinicial examination for voice disorders.

Eckel and Boone (1981) also recommend that S/Z ratio can be used as one indicator of voice treatment effectiveness. They have demonstrated the ability of S/Z ratio with reference to one case of vocal nodules.

Thus "alone or in conjunction with other measures, the S/Z ratio appears an excellent indicator of poor laryngeal function as a result of glottal margin".

FUNDAMENTAL FREQUENCY IN PHONATION

Fo is the lowest frequency that occurs in the spectrum of a complex tone. In voice also, the fundamental frequency is the lowest frequency in the voice spectrum. This keeps varying depending upon several factors.

"The quality and loundess of voice are mainly dependent upon the frequency of vibration. Hence it seens apparent that frequency is an important parameters of voice" (Anderson 1961). There are various objective methods to measure the Fo of the vocal folds.

The changes in voice with age and within the speech of an individual have been the subject of interest to speech scientists. Various investigations dating back to 1939 have provided data on various vocal attributes at successive developmental stages from infancy to old age. Fairbanks (1940, 1949), Curry (1940), Snidecor (1943), Hanky (1949), Mysak (1950), Samuel (1973), Usha Abraham (1978), Gopal (1980) and Kushal Raj (1983), are some among those who have studied the changes in fundamental frequency of voice with age.

The aging trend for males with respect to the mean fundamental frequency is one of a progressive lowering of; pitch level from infancy through middle age followed by a progressive raise in the old age (Mysak, 1966).

However, among females, the mean fundamental frequency levels of the 7 and 8 year olds was the highest. A progressive lowering of fundamental frequency level is then seen till the age of a young adult female. No significant change in seen from young adulthood to the aged group which is in contrast to the male population (Mysak, 1966).

The voice of a new born has been found to be around 400Hz (Grutzman and Plateau, 1905, Indira, 1982). Upto puberty there is little difference between the voice of boys and girls. The voice change in prominent at puberty. In majority of the cases this change takes place without

appreciable pitch breaks during speech. But in sone, a period of pitch breaks are observed, due to the inability of the individual to control the laryngeal muscles because of sudden changes in the larynx due to growth. Pitch breaks, however, have been observed in the children, long before the onset of puberty. In an examination of sixty children between the ages of seven and eight years, Fairbanks (1950), could find pitch breaks in both sexes. Therefore, the voice changes in puberty should be interpreted as the intensification of a process that begins already at a much earlier period (Broadnitz, 1959).

Unlike males, there is little change from the time of young adulthood to the time of advanced age, and little change between the two groups of differently, aged older females.

A longitudinal study of children's voice at puberty was earned out by Loebell and Karger (1976). The voice of twenty-five children were recorded during puberty for two years every month. The results showed a significant descent of fundamental frequency, for all subjects during the lapse studied.

Eguchi and Hirsh (1969) state that "It is well known that the fundamental frequencies of children and adult females are higher than those of the adult male". They further add that, "children have a fundamental frequency of

about 300Hz even upto the age of 8 and 10 years. There is no significant difference of fundamental frequency of speech between 7 and 8 years, or between boys and girls of those ages (Fairbanks, Herbert and Hammond, 1949; Fairbanks, Wiley and Larsman, 1949; Potter and Steinberg, 1950; Peterson and Barney 1952).

The fundamental frequency values are distinguished by sex only after the age of 11 years, although small sex difference might occur before that age (Kent, 1976).

The fundamental frequency drops slightly during the first three weeks or so, but then increases until about the fourth month of life, after which it stabilizes for a period of approximately five months. Beginning with the first year, fundamental frequency decreases shraply until about three years of age, when it makes a more gradual decline, reaching to the onset of puberty at 11 or 12 years of age. A sex difference is apparent by the age of thirteen years, which marks the beginning of a substantial drop for male voices, the well known adolescent voice change in the case of females. The decrement in fundamental frequency from infancy to adulthood among females is somewhat in excess of an octave, whereas males wxhibit an overall decrease approaching two octaves' (Kent, 1976).

Various studies have been conducted to investigate the changes in fundamental frequency with age. However, most of

these studies are cross-sectional. Therefore, Kent (1976) states that the above findings may be considered as the representative of the actual developmental course of voice fundamental frequency at various age levels.

Studies on the Indian population have shown that, in males, the lowering in the fundamental frequency is gradual till the age of 10 years, after which, there is a sudden marked lowering in the fundamental frequency, which is attributable to the changes in the vocal apparatus at puberty. In the case of females, a gradual lowering of fundamental frequency is seen (George, 1973; Usha, 1979; Gopal, 1980; Kushal Raj, 1983).

Among the several types of organic changes recognized leading to vocal involution, the vocal changes noticed during menopause in females and climactene in males are most obvious.

Paterson et al (1985) have investigated using multivariable statistical analysis of various parameters of voice as related to puberty in choir boys. They selected 48 boys age ranging from 8-19 years. The results of this statistical analysis depicted that sexual Hormon - Binding globulin (SHBG) is a predictive factor of the change in Fo from childhood to adulthood voice in boys.

Thus, the lowering of fundamental frequency is seen both in case of males and females with age, and these variations are attributed to the anatomical and physiological changes with age.

The study of FF obviously has clinical implications. Cooper (1974) used spectrographic analysis, as a clinical tool to determine and compare the FF in dysphonics before and after vocal rehabilitation.

Shantha (1973) and Jayaram (1975) found a significant difference in habitual frequency measures between normals and dysphonics.

Ashtema (1977) studied the cleft plate speakers to findout the effect of FF and intensity variations on the degree of nasality. The result of the study showed that cleft plate speakers had significantly less nasality at higher frequency levels than at the habitual frequency. But the degree of perceived nasality did not change significantly when the frequency was lowered.

Kene and Wellen (1985) studied the acoustical measurement of 10 children with vocal nodules, age ranging from 6.1 years to 11.6 years which included 6 males and 4 females. Results of this study showed a significant correlation between clinical judgemens of severity on the Wilson scale and pitch and amplitude pertubation measures from children pathological voices was demonstrated. Subjects .

rated as more severe on the wilson scale had greater pitch and amplitude pertubations than subjects with less severe ratings.

Thus it is apparent that measurement of the FF is important in the diagnosis and the treatment of voice disorders and also reflects the neuromuscular developmeant in children (Kent, 1976).

FUNDAMENTAL FREQUENCY IN SPEECH

An evaluation of the FF in phonation, may not represent the habitualy used FF of an individual many i-vestigators have studied FF as a function of age and in various pathological conditions. Difference types of speech samples, i.e., phonation reading, sponkeneous speech and singing have been used in different studies. In literature one oftan finds comparisons of results of difference studies. But it is not clear whether the same type of speech sample have been considered for such comparisons. And further it is not clear whether all the speech samples would yield the same results. However clinical experience has shown that the subjects use difference FFs under difference conditions. To varify this clinical impression an experiment was conducted by Nataraja and Jagadeesh (1984). They studied FF in phonation, reading, speaking and singing and also the optimum frequency in 30 normal males and females. They observed that the FF increased from phonation to singing with speaking and reading in between.

Michal, Hollien and Moore (1965) studied the speaking fundamental frequency characteristics of 15, 16- and 17-year old girls, in order to determine the age at which adult female speaking fundamental frequencies are established. Their results indicated that females attain adult speaking fundamental frequencies by fifteen years of age. It seems necessary, therefore, to study the girls, fourteen years of age and younger, in order to determine when adult frequencies are first evidenced (Michel, Hollien and Moore, 1965).

Kushal Raj (1983) studied the speaking fundamental frequency as a function of age, in children between four and twelve years. He reported that the fundamental frequency, both in the case of males and females, decreases with age, males showing a sudden decrease around eleven years of age. No significant difference in fundamental frequency was found until the age of eleven years, between males and females. The fundamental frequencies of the vowels /a/, /i/, /u/, /e/ and /o/, occuring in speech, indicated that the fundamental frequency of vowel /a/ was the lowest in both males and females, /u/ was the highest for males and /i/, the highest for females.

The age dependent variations of mean speaking fundamental frequency reported by Bohme and Hecker (1970) indicate that the mean speaking fundamental frequency decreases with age up to the end of adolescence. A marked

lowering takes place during adolescence in men. In advanced age, mean speaking fundamental frequency becomes higher in men but is slightly lowered in women.

Michael and Basmen (1985) studied the developmental trends in vocal fundamental frequency 14 young children between the age of 11 to 25 months, an age period characterized by changes in physiological and linguistic development. Subjects were grouped into 3 month age intervales reflecting a continum of physical development and were audiotape recorded during spontaneous speech productions. Acoustic analysis of average Fo and Fo variability was performed. Fo variability was found to decrease as subject age increased as did segment durations. They also concluded that when viwed with in the overall developmental period and in comparison with data from other studies of younger and older children, average Fo during this age is consistent with a decreasing trend throughout early childhood.

David Boorenson (1989) studied the fundamental frequency characteristics of 30 children between the ages of 6 and 10 years were investigated in a variety of speech tasks. The results indicated that average fundamental frequecy across tasks for the boys is approximately 262Hz and for girls approximately 281Hz. Statistical analysis indicated that there was no significant difference in the Fo of boys and

girls in this age range. High vowels were found to have higher Fo values than low vowles, sustained vowels had higher fundamental frequency values than either spontaneous speech or reading for both groups of speakers.

Hummerberg (1987) studied the pitch and quality characteristics of mutational voice disorders before and after therapy. This study included 13 young men with mutational voice disorders age ranging from 13 to 18 years. 10 subjects while 3 subjects were between 26 and 29 years. Results of this study showed that a difference of approximately 1 octave between the pitch levels of 13 and 18 years old group. The mean value speaking Fo pretherapy 221 lowered to a mean value of 119Hz after therapy.

Hudson and Holbrook (1981) investigated the mean modal frequency in reading, in two hundred young black adults whose age ranged from 18 to 29 years and found it to be 110.15Hz in males and 193.10 in females. Compared to similar white population studied by Fitch and Holbrook (1970) the black population had a lower mean modal frequency.

The mean SFF of males, in the age range of 20 to 89 years indicated a progressive lowering of the SFF from 20 years to 40 years, with a rise in level from age sixty through the eighties (Hollien and Shipp 1972).

Many hearing impaired speakers are unable to control their speaking fundamental frequency. Meckfessel (1964) and

Thornton (1964) reported speaking fundamental frequency data for 7- and 8- year old hearing-impaired speakers that were higher than values for normally hearing speakers. Enmovick (1965) and Gruenewald (1966) reported values that were equal to or lower than values for normally hearing speakers.

Meckfessel (1964) and Thornton (1964) reported speaking fundamental frequency values in post pubescent hearing impaired males that were higher than those obtained for normally hearing post pubescent males, while values obtained by Green (1956) were similar to those for normal hearing males. For hearing impaired females, Green (1956) reported higher values than those obtained for normal hearing females, while Ermovick (1965) and Gruenewald (1966) reported values that were similar.

Gilbert and Campbell studied the speaking fundamental frequency in three groups (4 to 6 years, 8 to 10 years and 16 to 25 years) of hearing impaired individuals, and reported that the values were higher in the hearing impaired groups when compared to values reported in the literature for normally hearing individuals of the same age and sex.

Duffy (1954) analyzed the speech of cerebral palsied individuals by means of an instantaneous fundamental frequency recorder. He detected pitch characteristics which were related to different types of cerebral palsy.

The speaking fundamental frequency characteristics of institutionalized mongoloid, girls, between 8- and 11 years were studied by Hollien and Copeland (1965). Their results showed that mongoloid girls do not exhibit abnormally low speaking fundamental frequency levels but rather possess vocal frequency characteristics generally similar to those of their age peers even though they are retarded with respect to physical size. These results agree with those of Michel and Carney (1964).

However, the above findings do not support the clinical observations of McIntire and Dutch (1964), Strazzula (1953) and Benda (1949) suggesting that the voices of children with mongolism are substantially lower in voice fundamental frequency than those of normal children.

Contrary to this, Weinberg and Zlatin (1970) reported that, the mean speaking fundamental frequency level for the sample of children with mongolism, studied by them, was significantly higher than the mean speaking fundamental frequency level for the control group. In 1974, Montague, Brown and Hollien supported the above findings. Their results indicated that while isolated Down's Syndrome children and relatively high fundamental frequencies, as a group no difference was found between Down's Syndrome and intellectually average children for that parameter. Further, no relationship was found within the Down's Syndrome group between speaking fundamental frequency and IQ.

Weinberg et al (1975) described selected speech characteristics of patients with acromegaly. Some of the patients with acromegaly were found to use a lower fundamental frequency than the normals. This lowering fundamental frequency was prominent in female acromegalies than in male acromegalies.

Studying the mean speaking fundamental frequency in stutterers and non stutterers, Healey (1982) reported no significant differences.

No significant difference and the mean and median of SFF between laryng-itic and nonlaryngitic voices has been reported by Shipp and Humtington (1965).

Sawashima (1968) reported a rise in mean SFF in cases of suclus vocalis and a fall in mean SFF in the case of polypoid vocal folds and virilism. Very high mean SFF values resulted from disturbances of mutation in males. According to Hirano (1981) at present MSF (the SFF) is measured as a clinical test value (paranthesis mine).

It is considered that the FF in voice disorders would act as a diagnostic and prognostic indicator.

Author(s)	N	Sex	Average		Range
Hayashi (1940)	20	M		22	
				25(/i/)	
Suzuki (1944)	21	M		24.8	15-37
	19	F		17.4	10-24
Nishikawa (1962)	10	Singer			19-38
	10	M			16-29
	10	F			12-21
Patacek and Sander	40	M	I	24.7	13.6-41.7
(1963)			II	25.7	14.3-48.0
			III	24.9	12.3-59.0
	40	F	I	16.8	9.3-34.0
			II	16.7	9.2-29.8
			III	17.9	8.4-39.7
Sawashima (1966)	70	M		29.7	
	78	F		20.3	
Yanagihara	11	M		30.2	20.4-50.7
et al (1966)	11	F		22.5	16.4-32.7
Isshiki et al	5	M		31	22-51
(1967)	5	F		17	9-36
Hirano et al	25	M		34.6	
(1968)	25	F		25.7	
Shigemori (1977)	25	M		30.1	15.8-66.6
	25	F		17.0	9.4-28.2

Table 2.1: Normal values of MPT (in seconds) in adults.

FLUCTUATIONS IN FREQUENCY AND INTENSITY

Presence of small pertubation or irregularity of glottal vibration in normal voice have long been known though oscillographic analysis of acoustic pressure waves and laryngoscopic high spead photographic investigations (Moore & Von lenden 1958, Von Lenden, Moore and Zimake 1960). Relatively few attempts have been made to note the perturbations in FF and intensity, although such a measure may have value in describing the stability of laryngeal control (Lieberman 1963).

Aperiodic largngeal vibratory patterns have been related to abnormal voice production by various investigators (Carhart 1938, Bowler 1964).

Lieberman (1963) found that pitch perturbations in normal voices nerver exceeded 0.5sec in magnitude in the steady state portion of long sustained vowels. Similar variations in fundamental periodicity of acoustic wave form have been measured by Fairbanks (1940), Rieberg (1961) and Baito et al (1958).

The cycle to cycle variation in period that occurs when an individual is attempting to sustain phonation at aconstant frequency has been termed as jitter.

There are number of methods for obtaining jitter measurements and when actual measurements are made, a number of alternative methods of data reduction are available to the investigators (Heiberger and Horii 1981).

While considering the neurophysiological significance of jitter, Heiberger and Horii (1981) state that "physiological interpritations of jitter is sustained phonation should probably include both physical and structural variations and myoneurological variations during phonation.

Baer (1980) explains vocal jitter as inherent to the method of muscle excitation based on the neuromuscular model of frequency FF and muscle physiology. He has tested his model usign EMG from cricothyriod muscle and voice signals, and claims neuromuscular activity as the major contributor for the occurence of perturbation.

Earning (1980) found a relationship between the physical condition of the speaker, resting heartrate, resting systolic blood pressure, resting diastolic blood pressure, percentage of fats presferred hand grip strength and forced vital capacity and the acoustic variables in speech. The sustained phonation was consistently greater in the group which was considered as "poor" in terms of physical condition when compared with the group which was considered as "excellent" in terms of physical condition. Based on these results Heiberger and Horii (1987) state that "these findings have substantial implications, for understanding the aging process in the larynx".

Research has shown that the intensity, the FF level and the type of phonatory initiation and termination are other

factors which affect the jitter magnitude in sustained phonation (Moore and Leden 1958; Jacob 1968; Koike 1973; Hollien et al 1973).

Frequency modulation characteristics of sustained vowel phonations in vibrato were investigated by Yoshiyuki and Harii (1989). Eight male singers produced sustained /a/ in vibrato at lowmiddle and high-pitch levels with comfortable loudness. The recorded voice samples were digitized and analysed by program yeilding a plot of Fo of individual fundamental cycles. Modulation of frequency extent, rates of Fo increase and decrease, and modulation, jitter and shimmer were measured for individual modulation cycles. Central tendency and variability of these measures, intercorrelations among there measures and temporal patterns of frequency modulations were investigated. Results indicated (1) significant effects of pitch levels on modulation of frequency (2) more regulatity in modulaion of frequency than in extent. (3) predominantly linear temporal patterns of frequency modulation and (4) faster Fo increase than decrease.

Susan et al (1990) have studied acoustic measures of laryngeal acitivity using adult speech to answer two questions i.e., by previous work (1) how each measures varies if at all with phoneic structure and (2) what aspect of laryngeal activity each measures specifies. Speech samples

of 15 syllables (three vowels in five prevocalic consonental contexts were collected from men and women at two tims of day (early morning and late afternoon). Eight measurements were made mainly on slices extracted from the middle of the vocalic portions and infrential and correlational statistics were applied to these measures. Results of the inferential tests indicated differences between men and women in how laryngeal adjustments are made, affecting related amounts of vocal jitter and spectral tilt of the voicing source. In addition the voicing and manner characteristics of the prevocalic consonant were found to affect Fo cycle-to-cycle perturbations and amount of aspiration noise. To a lesser extend vowel higher and front/back tongue placement also affected these acoustic source characteristics. Results of these correlational tests showed that different laryngeal mechanisms contributed differentially to signal-to-noise ratios for men and women, and these mechanisms were more affected by fundamental frequency for men's speech samples. Finally various acoustic measures of laryngeal noise were found to be related to the same underline mechanism.

Jitter and Shimmer have been applied to the early detection laryngeal pathology. Lieberman (1961, 1963) states that the pitch perturbation factor might be a useful index in detecting a number of laryngeal diseases.

Koike (1969) showed that a relatively slow period modulation of vowel amplitude was observed in patterns with

laryngeal neoplasms. He reasoned from this that the measurement and analysis of such modulation might be useful in assessing laryngeal pathology.

Crystal and Jacson (1970) measured both the FF 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.

Koike (1973) investigated the pitch periods of voice produced by pathologic speakers, and found that discrimination between laryngeal tranor and paralysis was possible. The perturbation factors during sustained vowels were significant in discriminating normal talkers from those with laryngeal cancer (Murry and Doherty 1980).

Kitajima and Gould (1976) studied the vocal shimmer during sustained phonation in normal subjects and patients with laryngeal polyps and found the value of vocal shimmer to range from 0.04dB to 0.21dB in normals and from 0.08dB to 3.23dB in the case of vocal polyps. Although some overlap between the two groups were observed they noted that the measured value may be a useful index in screening for laryngeal disorders or for diagnosis of such disorders and differentiation between the two groups.

The fluctuations in frequency and intensity in a given phonation sample may indicate the physiological

(neuromuscular) or pathological changes in the vocal machanism.

Kim et al (1982) have analysed the vowel /e/ (as this was earlier analysed by Imaizumi et al (1980) using the spectrograph, in two voices of patients with recurrent laryngeal nerve paralysis and normals to obtain the following acoustic parameters.

The acoustic parameters obtained from the spectrographs were:

1) Extent of fundamental frequency fluctuation: The extent of fluctuation was defined as the percent score of the ratio of the peak to peak value of fluctuation (Fo) to the mean FF (Fo).

2) Speed of FF fluctuation: This has been defined as the number of possitive peaks with in 1sec.

3) Extent of amplitude fluctuation: This has been defined as the peak to peak value in decibal measured on average amplitude display.

4) Speed of amplitude fluctuation: Which was defined as the number of possitive peaks on an amplitude display with in 1sec. Peaks of 3dB or greater from adjacent throughs have been counted.

The results of this study have indicated that among the acoustic parameters studied significant differences were

found between the control and the diseased groups in terms of fluctuation of Fo.

Yoon et al (1984) have studied the voice of patients with glottic carcinomas, using the range procedure and the parameters as described by Kim et al (1982). They have concluded that significant difference were found between the OQ and patients with advanced carcinoma in terms of extent of fluctuation, speed of Fo fluctuation, extent of amplitude fluctuation and speed of amplitude fluctuations. Rashmi (1985) based on the results of a study of normal subjects concluded that :

1) The flunctuations in frequency of the intitial and final segments of phonation of /a/, /i/ and /u/ showed a decreasing trend with age in males.

2) The 14 to 15 years old group showed an increase in range of fluctuation 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 nine years an increase in the range of fluctuations in the nine to-eleven years old females which again drops down till the age of 15 years.

4) The medial segment of phonation, both males and females was quite st-eady and the range of fluctuations as a function of age did not show much difference.

5) No difference in the ranges of fluctuations in frequency between males and females was observed in the younger age groups.

6) The males consistantly showed greater fluctuations in frequency in the phonation of /a/, /i/ and /u/ than the females of 14 to 15 years old group.

7) The fluctuations in the initial and final segments of phonation for all the three vowels was greater than the fluctuations in the medial segment, for both males and females.

8) 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 above 12 years groups in the case of males, for all three vowels.

Vanaja (1986) has reported that as the age increased there was increase in fluctuations in frequency and intensity of phonation and this difference was more marked in females.

The fluctuations in a given phonation sample may indicate the phisiological (Neuromascular) or pathological changes in the vocal mechanism. Not much information regarding these parameters with age is available. Hence it was considered that this information may be useful in understanding the physiological and pathological conditions

of the vocal system. It is therefore the aim of this study to measure these parameters as a function of age.

FREQUENCY RANGE IN PHONATION AND SPEECH

Humans are capable of producing a wide variety of acoustic signals. Success in decoding acoustic speech signals assumes that the speaker will produce: (1) acceptable phonemes, variously sequenced or combined, (2) changes in the use of time, (3) changes in fundamental frequency, and (4) changes in intensity or energy. These four comprise the basic elements of verbal communication (Brackett, 1971).

The patterned variations of pitch over linguistic units of differing length (syllables, words, phrases, clauses, paragraphs), yield the critical prosodic feature, namely intonation (Freeman, 1982). In other words, during speech, the fundamental frequency of phonation varies. This range is called the speech range or the speech frequency range (Hirano, 1981). Variations in fundamental frequency and the extent of range use also relate to the intent of the speaker as discussed by Fairbanks and Pronovast (1939). More specifically, the spread of frequency change use corresponds to the mood of the speaker, that is, as skinner (1935) reports, cheerful animated speech exhibits grater range use than serious, thoughtful speech. Changes in duration and fundamental frequency during syllable elements of words are basic to the melody and rhythm patterns unique to English.

Stressed syllables are perceived as being higher in pitch than unstressed syllables (Freeman, 1982).

Relatively little is known about developmental changes in the range or variability of fundamental frequency. Most of the literature on the new born infant's cry appears to have the capability of extending this range appreciably in either direction. Ringel and Kluppel (1964) reported a range of 290-508Hz for ten infants aged 4 to 10 years. Fairbanks (1942) observed a range of 153-888Hz for an infant in the first month of life and a range of 63-2631Hz for the first nine months of life. McGlone's (1966) investigation of children aged between one and two years revealed a total range of 16.2 tones, or about two octaves. Van Oordt and Drost (1963) concluded from a study of 126 children in two age groups (0 to 5 years and 6 to 16 years) that ".... even in very young children the physiological range of the voice has a broad, almost "adult' range...." and that, the change in the frequency of the speaking voice parallels that of the lowest reachable physiological tone...." Their data indicate that even young children have a fundamental frequency range of two-and-one-half to three octaves. If a conclusion is forced from these rather limited data, it would be that the range of vocal frequency, does not change appreciably during maturation (Kent, 1976).

As far as the variability of fundamental frequency is concerned, the most extensive study is that of Eguchi and

Hirsh (1969), who collected data for 84 subjects representing adulthood and the age levels of 3-13 years, at one year intervals, for the vowels /i/, /ae/, /u/, /s/, /a/ and /o/, as produced in the sentence contexts. The variability of fundamental frequency progressively decreased with age until a minimum was reached at about 10 to 12 years. If this is taken as an index of the accuracy of the laryngeal adjustments during vowel production, then the accuracy of control improves continuously over a period of atleast 7 to 9 years.

The discovery that fundamental frequency variability diminishes with age has important implications for the quantitative investigation of speech development. It is not known at what age, this apparent refinement of control begins to occur (Kent, 1976). Sheppard and Lane (1968) in a study of two infants during the first 141 days of life, reported a rather small and constant variability in fundamental frequency values. However, Prescott (1975) discovered small developmental increases in the fundamental frequency variability within the first nine moths of life. Possibly, at the same time that a child gains control over the accuracy of his laryngeal adjustments, he beings to vary fundamental frequency to achieve intonation-like effects. Of course to some degree, accuracy of adjustment is requisite to controlled variation. Concerning this subject, studies of infant intonation have revealed evidence that definite

patterns are established during the first year of life (Kent, 1976).

Alan et al (1989) studied the factors influencing Fo range estimates in children. Fourty normal children each responded to five audiotaped tone conditions (a) discrete steps (b) blow steps (c) blow glissando and (e) fast glissendo. The tonal stimuli were devised to elicit each child's maximal and minimal Fo. They concluded that the traditional discrete steps condition was associated with lower maximal Fo, higher minimal Fo and more restricted Fo range than all other conditions.

Hudson and Holbrook (1981) studied the fundamental vocal frequency range in reading, in a group of young black adults, age ranging from 18 to 29 years. Their results indicated a mean range from 81.95 to 158.50Hz in males and from 139.05 to 266.10Hz in females. Compared to a similar white population studied by Fitch and Holbrook (1970), the black population has greater mean frequency ranges. Fitch's white subjects showed a greater range below the mean mode than above. This behaviour was reversed for the black subjects. Hudson (1981) pointed out that such patterns of vocal behaviour may be important clues which alert the listener to the speaker's racial identity.

McGlone and Hollien (1963) studying the vocal pitch characteristics of aged women, 65 to 79 years, reported that

women's speaking pitch variability changes little with advancing age. However, Stoicheff (1981) reported an increase in variability of fundamental frequency in post menopausal adults, which was interpreted as indicating decreased laryngeal control over fundamental frequency adjustments.

Linville (1987) studied the maximum phonational frequency range capabilities of women's voices with advancing age of 67 women who were nonsmokers. They were devided into three groups 24 young (25-35 years) 20 middle aged (45-55 years) 23 elderly (70-80 years). Results of this investigation suggest that changes occur at both ends of the MPFR as women age and that change at the two ends of the range occur during difference stages of adult life. It appears difference stages of adult life. It appears that manopause brings about changes at the low end the range with middle-aged, postmanopuasal women demonstrating an ability to produce lower frequency than young adult women.

Elderly women did not maintain the expension at the low end of the MPER observed at the low frequency capabilities of young women. It was the loss of ability to produce high frequency seen in elderly women which caused a significant reduction in total pitch range. While middle aged women demonstrated an ability to produce lower frequency than young women, this increased capacity for the production of low

frequency was not great enough to significantly expend their total pitch range.

General conclusions about the diagnostic value of fundamental frequency variability are difficult to make because such measurements are helpful in certain pathological conditions but not in others (Kent, 1976).

Shipp and Huntington (1965) indicated that laryngitic voices had significantly smaller ranges than did post-laryngitic voices. The results of a study by Murry (1978) showed a reduced semitone range of speaking fundamental frequency in patients with vocal fold paralysis, as compared with normals. In a following study, Murry and Doherty (1980) reported that the variability in speaking fundamental frequency, along the directional and magnitudnal perturbation factors, enhanced the ability to discriminate between talkers with no laryngeal known vocal pathology and talkers with cancer of the larynx.

A number of studies have reported pitch variability in the speech of stutterers. Travis (1927) and Bryngelson (1932) found that stutterers exhibited less pitch variability than did nonstutterers, particularly during highly emotional conditions. Adams (1955) indicated that stutterers show a limited pitch range within an utterance when compared with "good" and "trained" speakers, but not when compared with "poor" speakers. With spectographic data Schilling and

Goeler (1961) and Luhsinger and Dubois (1963) showed that stutterers had less amount of pitch variation in their speech than did normal fluent speakers. Healey (1982) examined certain parameters of speaking fundamental frequency associated with stutterers and nonstutterers fluent production of a declarative and an interrogative utterance, and reported that the nonstutterers produced a significantly greater range of frequencies than did the stutterers across both the utterances. Lechner (19) found that the stutterers pitch variability increased more under delayed auditory feedback than in the normal auditory feedback mode. However, when stutterers spoke in the presence of masking noise, there were only a few changes in their speaking fundamental frequency patterns as compared with the normal auditory feedback mode. Ramig and Adams (1981) discovered that stutterers and non-stutterers used a range of fundamental frequencies while reading at a higher than normal pitch as when compared with reading in their habitual pitch. Moreover, reading in a lower-than-normal pitch produced less fundamental frequency variability than reading at habitual pitch levels.

The review indicates that it is important to have extensive data on the pitch variations, as a function of age, before it can be applied to the clinical population. Therefore it is intended to study the pitch variation or range in different age groups of Indian population.

INTENSITY RANGE IN PHONATION AND SPEECH

The study of phonology also includes intensity change or variations in energy. Increasing or decreasing total speech power, as discussed by Mol and Uhlenbach (1956), is one of the means of achieving dominance of syllables, words or phrases. Changes of energy signify degrees of emotional involvement, such as shouting when angry. Use of intensity changes also reveals speakers perception of physical and psychological distance.

Danste (1970), Komiyana (1972) and Coleman et al (1977) proposed a graphic representation of the fundamental frequency-intensity profile. The graph was named "phonotogram" by Damste and "Phonogram" by Komiyama. Rauhut, et al (1979) proposed the term "voice Area" for the representation of maximal or minimal intensity of voice as a function of pitch.

Coleman et al (1977) in a study of the fundamental frequency-sound pressure level profiles of adult males and females, noted an increase in SPL with an increase in frequency up till a certain limit, after which a decrease is seen with further increase in frequency. Generally, most subjects fundamental frequency - SPL profiles manifested a change in both minimum and maximum SPL curves at 60 to 80% fundamental frequency level.

According to Coleman et al (1977), the average intensity range of phonation (in SPL re: 0.0002 dynes/cm2) at a single fundamental frequency is 54.8dB for male and 51dB for female subjects.

Coleman and Mott (1978) found lower SPL ranges for female children (10 years to 13 years) than those for adult females. Further, they observed that the musical range, in terms of fundamental frequency and SPL, is more restricted, that is, it lies within the boundaries of the physiological range. The mean physiological SPL range was found to be 159dB, while the mean musical SPL range was 58dB.

Rashmi (1985) studied the intensity range in phonation and speech,in children (4-15yrs). she reported the following:

1. Intensity range in phonation decreased as a function of age only in males.

2. significant differences between males and females is seen only upto 10yrs.

3. In females, age group 9-llyrs had higher intensity range in speech. Intensity range in speech in males showed higher values below 6yrs and above 14yrs.

4. Significant differences between males and females did not show any consistent pattern with age.

Vanaja (1986) reported that intensity range in phonation in adults (16-65yrs) did not change in both males and females Nataraja (1988) also reported similar results in the age

range 16-45yrs. Similarly Gopal (1986) and Nataraja (1988) reported that intensity, range in speech did not change with age, in adults.

Ehime (1986) studied the effects of monitoring vocal intensity on oral air flow in children and adults.

This study aimed at the following:

a) To determine whether child and adult oral air flow data were parallel across two monitering methods.

(b) to determine whether an instruction to speak at a comfortable effort level" resulted in greater variability of peak oral air flow (vo) than visual monitering of vocal intensity level and (c) to explode possible sources of variation introduced by visual monitering. Peak Vo from children and adults was measured for stops and fricatives in connected speech during "comfortable effort level" task and during visually monitored vocal intensity task. The lack of an age by monitoring effect in the analysis of variance showed that child and adult data were parallel. The nonsignificance of F-max scores for testing across subject variability showed that the natural maintance of a comfortable intensity level did not produce greater Vo variance than visual monitering. Although the Vo of voiced consonants increased only slightly from comfor-level to visual monitoring, the Vo fo voiceless consonants increased more sharply. Thus visual monitering does not increased Vo

variability and does introduce spurious Vo values for some consonants.

Empirically, it is well known that disorders of vocal intensity constitute one of the important components of voice disorders. However, measurement of vocal intensity, as a clinical diagnostic tool has not proved as popular as that of fundamental frequency in voice clinics.

However, Watnebe et al (1977) reported of two patients with laryngeal polyps and laryngeal cancer, who showed nor abnormalities in the routine study, but showed an abnormality only in the study of vocal intensity. They, therefore, stressed the importance of vocal intensity as a parameter in showing phonetic dysfunction.

Darley et al (1969) in a report on the speech characteristics of dysarthric patients, reported equal and excess stress and monoloudness as one of the characteristics. In a spectrographic analysis of ataxic dysartria, Nataraja and Indira (1982), observed equal stress in the pathologic subject, while variations in terms of intensity on each syllable were seen in the speech of the normal subject.

Little information is available regarding the developmental changes in the range of intensity. However, on similar lines as fundamental frequency variability, it may be hypothesised that the variability in intensity decreases with

age. Thus it will be interesting and useful to investigate the intensity variation leading to determination of range in Speech of children of different age groups in a Indian population. It is intended to use this data to compare with the results of clinical population for the purpose of differential diagnosis of various developmental disorders in children. and adults.

RISE AND FALL TIME OF PHONATION

Rising and falling time have been considered with reference to intensity rising time has been defined as the time required for the increase in overall amplitude from a value of 10% of the steady level to 90% and similarly the "falling time" has been defined as the time required for the degrease from90% to 10% of the steady level (Imazumi et al 1980). Koike and Von Leden (1969) define rising or "rise time" as "the period extending from the onset of sound to the point at which the envelope amplitude reached the value of steady phonation". Similarly fall time has been defined as "the period extending from the end of the envelope amplitude with steady phonation (in terms of intensity) to the termination of phonation". This may be because the subglottal air pressure has to build upto reach a level of pressure to move the vocal cords away from the midline and vocal cords or the laryngeal muscles have to make the necessary adjustments to produce the required voice in terms of intensity and frequency.

Thus pathological cases, in whom laryngeal and/or respiratory systems are not functioning normally may show abnormality in terms of rising and falling time.

The rising time of voiceless affricates and fricatives, have been measured by Howell and Rosex (1983). These measurements have been made when the affricates and fricatives occured in sentences, in isolated words and in isolated nonsense syllables. They found that the rising time of affricates were significantly shorter than those of fricatives.

According to Hirano (1981) is many pathological conditions the abnormalities of voice will be more apparent during the transitional phases of phonation, including the onset and termination of phonation and hence of speech. And Hirano (1981) recommends further extensive clinical and research study in this aspect.

Recently studies have been carried out on Indian populations to note these parameters (Rashmi 1985 and Vanaja 1986, Gopal 1986; Rajanikanth 1986). Along with other parameters Rashmi (1985) studied the rising and falling time in phonation in 220 male and female normal children age ranging from 4-15 years. The/concluded that:

a) There was a gradual decrease in the rasing time of phonation of vowels with increasing age in both males and females.

b) A slight increase in the rise time was seen in the nine to ten years old group of males and the 10-11 years old group of females.

c) There was no significant difference in rising time of phonation of vowel between males and females.

Regarding fall time of phonation, she concluded that:

a) Both in males and females, the fall time of phonation for all the three vowels increased as a function of age and

b) There was no significant difference in the fall time of phonation between males and females.

These results can be considered as reflecting the changes in the neuromuscular control with age. Vanaja (1986) studied the rise and fall time in three vowels in /a/, /i/ and /u/ in 70 normal males 70 normal females in the age range 16 to 65 years the concluded that, no significant difference was found (a) between males and females and difference age groups and (b) between difference age groups both in males and females either in rising and falling time. These results indicate that adults the controls over respiratory as well as phonatory systems are stabilized.

Rajanikanth (1986) made an attempt to note the rising and falling time in three vowels by 31 males and 22 females hearing impaired individual in the age range 10-20 years. He found that there was a significant difference in rising time both in males and females between the two age groups ie., 10-15 and 15-20 years. He also reported a significant

difference between males and females in both the age groups. Both males and females showed a significant difference in falling time between the two groups.

Yoon et al (1984) report that there was significant difference between the normal males and females with carcinoma of larynx in terms of rising time. Regarding falling time Kim et al (1982) report that it "did not show any significant differences between males and females or between control and diseased groups". However, Yoon et al (1984) found falling time to be longer in cases of carcinoma of larynx than in normal males.

Therefore it was considered that the measured that the measurement of these two parameters would be useful in differentiating dysphonics from normals and between different types of dysphonics.

The primary value of this study stands in the presentation of normative data which reflects the physiological changes with age and against which the potentially pathological voice can be measured. Before a variable can be used to assess a pathologic condition, it is necessary to understand the valuable in relation to the normal voice and it is productive capabilities. Acoustic analysis may provide a significant non-invasive tool for the detection of laryngeal disease and developmental disorders. But before it can be used successfully larger normal populations and populations with variety of laryngeal disorders and developmental disorders must be studied.

METHODOLOGY

This study was designed to investigate the developmental change in the following parameters as these parameters have reported to be of significance in terms of diagnosis of voice disorders,

1. The maximum phonation duration of vowels.
2. The maximum duration of /s/ and /z/ and the S/Z ratio.
3. The fundamental frequency of phonation.
4. The speaking fundamental frequency.
5. Speed of fluctuation in frequency of phonation.
6. Extent of fluctuation in frequency of phonation.
7. Frequency range in phonation.
8. Frequency range in speech.
9. Speed of fluctuation in intensity of phonation.
10. Extent of fluctuation in intensity of phonation.
11. Intensity range in phonation.
12. Intensity range in speech.
13. Rise time in phonation.
14. Fall time in phonation.

Subject:

Subjects, both males and females age ranging from 7 years to 21 years were randomly selected for the study, from two Day-Schools and an Institute namely:

1. The Demonstration School, Mysore.
2. Government High Schools, Manasagangothri.
3. All India Institute of Speech and Hearing, Mysore.

The criteria for the selection of the subjects was the absence of any speech, hearing or respiratory problem, with no observable deformities of the nasal, oral or pharyngeal cavity.

Three hundred subjects were selected, such that 10 males and 10 females in each of 15 groups with one year intervals i.e. 7-8 to 21-22yrs.

Test Material:

Maximum duration of sustained phonation of three vowels /a/, /i/, /u/ and two fricative /s/ & /z/ were used in order to measure, meanFO, Frequency range, Intensity range, Speed & Extent of fluctuations, rise & fall time s/z ratio and MPT, in phonation.

Three kannada sentences were selected for the analysis of SFF, frequency range and intensity range in speech.

1. idu papu
2. idu koti
3. idu kempu banna

These three sentences were chosen, as they have been used by earlier investigator (Kushal Raj, 1983; Rashmi 1985). Hence it was considered that it would be possible to compare

the results of the present study and further provide more details about the acoustic parameters of speech in children and adults.

Instruments used for recording:

- Phillips Deck (F6121)
- Microphone (33-985C)
- Meltrack cassettes

Recording Room:

The subjects were taken into sound treated room at the speech sciences lab at AIISH to avoid the interference of external noise with the recording.

Data Collection:

The data was collected in two steps:

Step-1: In the first step the maximum phonation duration was recorded. The subjects were instructed as follows:

Take a deep breath and say /a/ as long as you can.

This was demonstrated before the subject phonated. The subjects were then asked to phonate /i/, /u/ and say /s/ and /z/ in a similar way. Three trials of each phonation and consonant production were recorded.

Step-2: In the second step, the speech samples were recorded. The subjects were instructed as follows.

"Now I will say three sentences repeat each sentence three times'. The sentences "Idu pa:pu", "Idu ko;ti" and "Idu kempu banna" were spoken by the investigator and the repetition of these sentence by the subject was recorded.

Analysis:

Measurement of the maximum phonation duration of vowels:

The recorded samples of the phonation of vowels were played back, and the duration of phonation were measured using a stop watch. The phonation duration of all the three trials of all three vowels /a/, /i/ and /u/ was measured. The longest phonation duration among the three trials was considered as the maximum phonation duration in seconds for each vowels for each of the subjects. Thus the phonation duration for each vowel for each subject was obtained.

2) Measurement of S/Z Ratio:

The recorded samples of the phonation of two fricatives /s/ and /z/ were played and the duration of their phonation was measured using stop watch for all the three trials as done in the previous analysis. The longer duration of each consonant was noted down as the maximum duration. The maximum duration of /s/ divided by the maximum duration of /z/, provided the S/Z ratio. Thus, S/Z ratio was obtained for each subject.

3. Measurement of the fundamental frequency of phonation:

The tape recorded speech samples were digitized at 8000Hz sampling frequency using 12 bit (ADC). Analog to digital converter and having antialaising filter at 3.5KHz "VSS-DATA ICN" program was used to digits. A PC-AT 386 computer having Intel 80386 as CPU and Intel 80387 as NDP with 16 MHz clock speed used in this digistization process.

The digitized speech samples are subjected to LPC-autocorrelation technique to extract fundamental frequency. The samples were analyzed having a window of 30 millisecond with a resolution of 10 milliseconds. "VSS-VAGHMI " program was used to extract to and obtained related measurements. The extracted Fo values were used to calculate the following parameters using PC-AT computer.

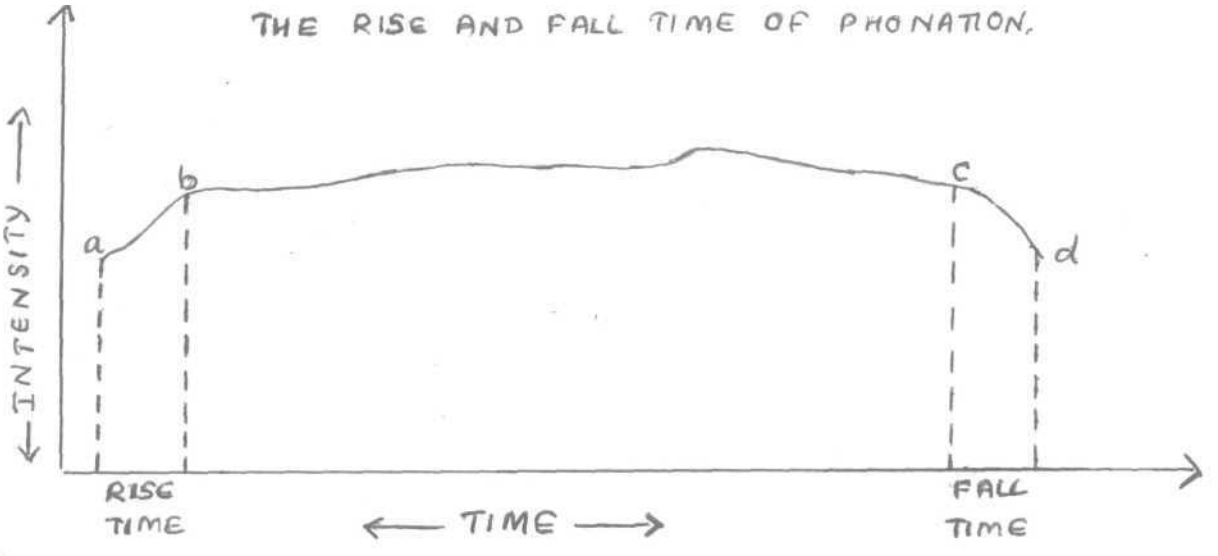
The same method of analysis was used for the following parameters.

- Measurement of frequency range in phonation.
- measurement of speed of fluctuation in frequency of phonation.
- measurement of extent of fluctuation in frequency of phonation.
- measurement of intensity in phonation
- measurement of range in intensity of phonation
- measurement of speed of fluctuation of phonation.
- measurement of extent of fluctuation of phonation.

SET UP FOR THE ANALYSIS OF Fo AND RELATED PARAMETERS

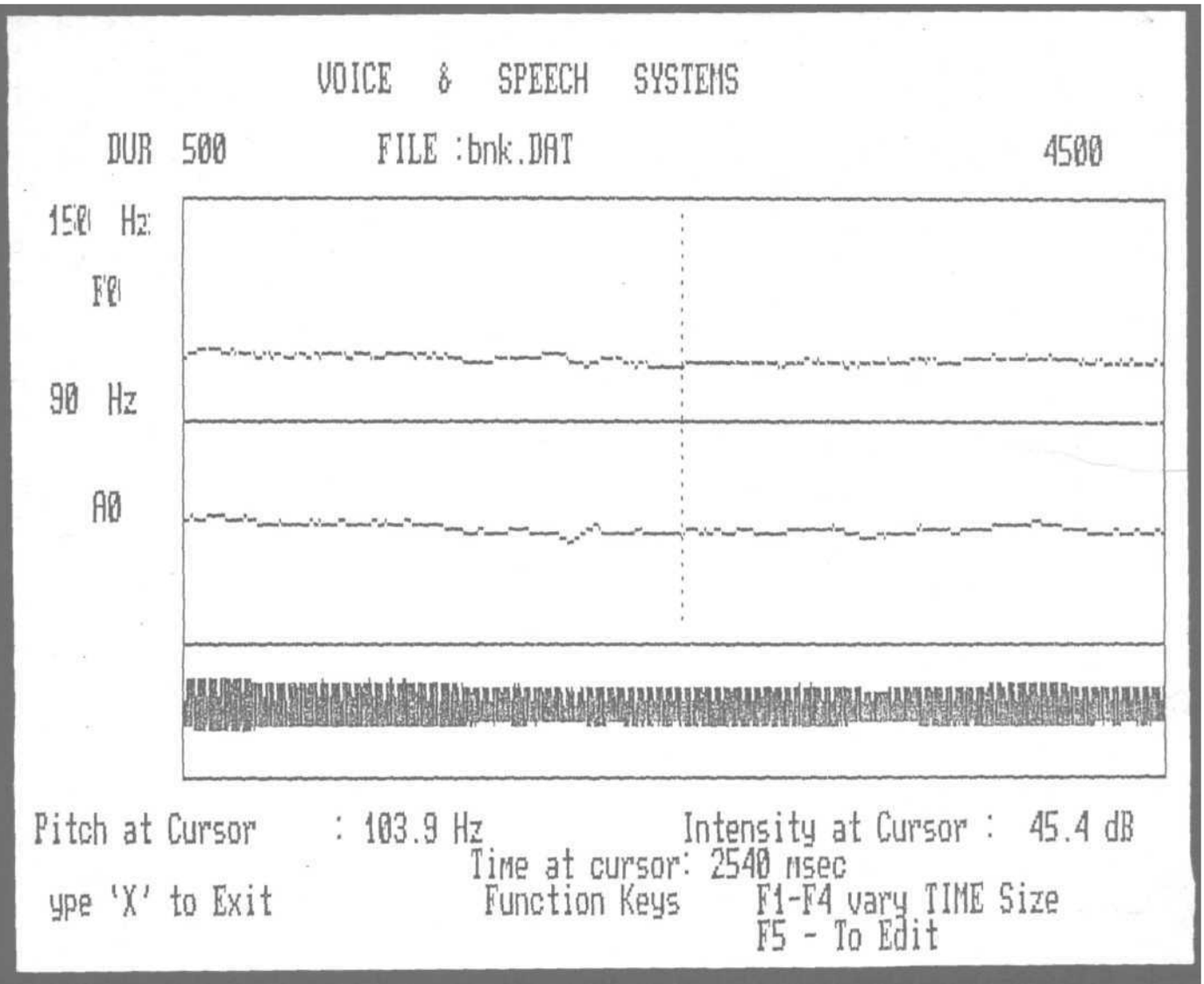
4. Measurement of the Rise time and Fall time of phonation:

With the experimental set up (photograph) the initial segment of the selected sample was fed to the pitch analyzer, The rise time in centiseconds was measured by moving the cursor from the point where the intensity curve begins to the point where the curve becomes steady (b) (above fig). The difference between these to points provided (a to b) provided the rise time in centiseconds.

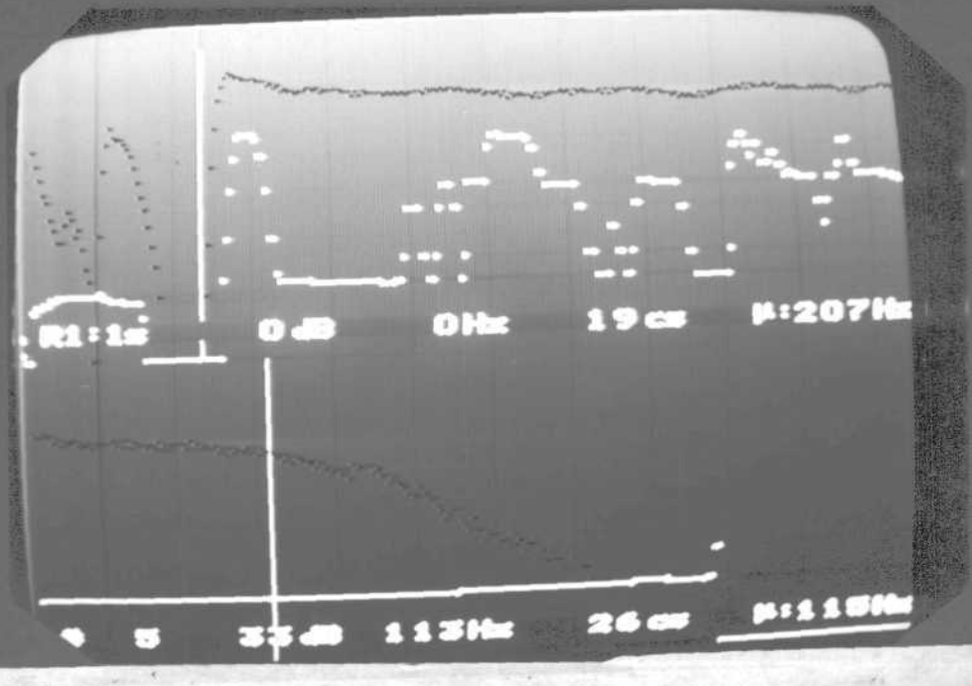


Similarly the final segment of the selected sample of phonation was fed to the pitch analyzer. The fall time was measured by moving the cursor from end of the steady portion of the intensity curve (c) to the last point where the curve (d) visible. The difference between these two (c and d) on, the time scale, was noted down as the fall time in centiseconds (Fig).

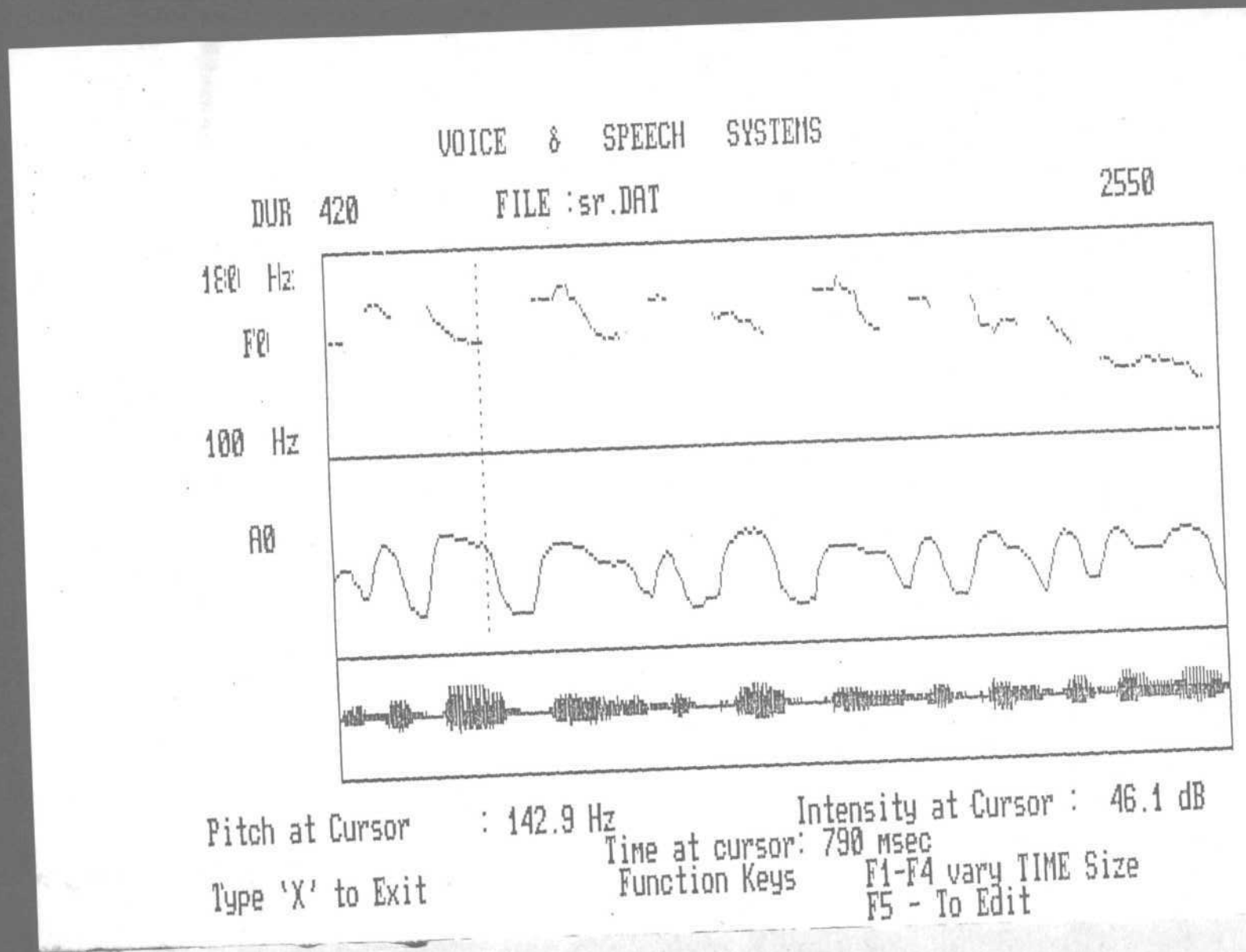
This was done for all the three vowels. The rise and fall time for each subject for each vowel was obtained. The



DISPLAY OF FREQUENCY AND INTENSITY CURVE IN PHONATION FOR THE SAMPLE DURATION OF 5 Sec.



DISPLAY OF RISE TIME AND FALL TIME IN PHONATION



GRAPH: SHOWING FRECUENCY vs TIME AND INTENSITY vs TIME FOR SPEECH OF 5 Sec.

average of the three readings provided the R.T & F.T in phonation for each vowel.

5. Measurement of the speaking Fo:

To determine the speaking Fo, the same experimental set up as above was used. The display duration was set to 9 seconds so, that all the three stimulus sentences (idu pa;pu; idu ko;ti, idu kempu banna) could be displayed together. After feeding the sentences to pitch analyzer, the mean Fo for all the three sentences were directly read on the digital display at the end of the screen. Thus the mean frequency used for speaking for each subject was obtained.

6. Measurement of frequency range in speech:

With the same experimental set up and stimulus sentences fed to the pitch analyzer as in analysis of the previous parameter. The frequency range used by each subject in speech was determined, by moving the cursor to the highest and lowest frequency occurring in the test sentence and the difference between the two provided the frequency range used by each subject, in speaking.

7. **Measurement of Intensity range in speech:**

This measurement was made similar to the measurement of frequency range in speech in analysis and with the test sentence moved to the highest and lowest intensity occuring in the sentence. The difference between these two, provides, the intensity range in dB, used by each subject.

Thus the results for all the parameters were obtained for all the 300 subjects. The obtained values were then tabulated and subjected to statistical analysis to determine the mean, S.D and significance of difference. Mann-Whitney 'U' test was applied to know the significance of difference.

RESULTS AND DISCUSSION

The study was aimed at examining the variations in the below listed parameters, as a function of age and sex in children and adult with age ranging from 7 to 22 years.

1. The maximum phonation duration of vowels.
2. The maximum duration of /s/ and /z/ and the S/Z ratio.
3. The fundamental frequency of phonation.
4. The speaking fundamental frequency.
5. Speed of fluctuation in frequency of phonation.
6. Extent of fluctuation in frequency of phonation.
7. Frequency range in phonation.
8. Frequency range in speech.
9. Speed of fluctuation in intensity of phonation.
10. Extent of fluctuation in intensity of phonation.
11. Intensity range in phonation.
12. Intensity range in speech.
13. Rise time in phonation.
14. Fall time in phonation.

The mean and standard deviation of all the parameters in each age groups have been calculated for both males and females. The significance of difference between the age groups and between males and females have been determined using the Mann-Whitney 'U' test.

Reliability check: Five males and five females belonging to different age groups were retested and using Mann-Whitney 'U' test the diference between the two sets of scores was determined and there was no significant difference. Therefore it was considered that the measurements and porcedures were reliable.

MAXIMUM PHONATION DURATION

Maximum phonation duration (MPD) was calculated for all the subjects using the recorded samples of phonation, as described in methodology. The mean and S.D. of MPD for /a/, /i/ and /u/ for both males and females are provided in table la, lb and 1c. The graph (Gl) shows age related changes in MPD for average values of three vowels /a/, /i/ and /u/.

The inspection of mean values (Table la, lb and 1c) shows that MPD increases with increase in age, gradually, for all the three vowels. The age group 21-22 years shows the highest value ie., for /a/ 25.8sec, /i/ 25sec and /u/ 24.4sec. The age group 7-8 shows the lowest values of MPT ie., for /a/ 8.3, /i/ 8.0 and /u/ 8.5. Interestingly there is a sudden decrease i MPD at the age of 12-13 years for all the three vowels. The successive group shows again an increase in MPD values. The mean MPT drops from 12.5secs at 11-12 years to ll.8secs at 12-13 years for /a/, from 13.9secs at 11-12 years, to 12.6secs for /i/ and from 13.1secs at 11-12 years to 12secs at 12-13 years for /u/.

Mann-Whitney 'U' test was applied to know the significance of difference across the age groups. It shows that the lower age groups show significant difference with both adolescent age groups and young adults. But adolescent age group ie., 13-14 and above do not show significant difference with higher age groups except with 21-22 years. The drop at the age group 12-13 years significantly different for only vowel /u/.

In females also, the MPT is found to increase as a function of age which is evident from the study of table 5, 6 and 7 and graph-1. They show a sudden drop only at 12-13 years for all the three vowels.

The results of Mann-Whitney 'U' test shown in tables 5, 6 and 7. Interestingly they show much gradual increase than in males. Among lower age groups 7-8 and 8-9 years show significant difference only with age groups 17-18 years and above. Where as age groups 9-10 and 10-11 years show significant differences with 11-12 and 13-14 years and above. Age groups 12-13 to 15-16 years show significant differences only with higher age groups.

However age group 14-15 years shows significant difference only with age group 21-22 years. Age groups 17-18 years and above also shows similar results.

It can also be seen that the age groups 10-11 years and 11-12 years in /a/, 11-12 years in /i/ and 10-11, 11-12 and

12-13 years in /u/ show significant difference with immediate higher age groups.

Thus the hypothesis stating that there is no significant difference in maximum duration of phonation as a function of age, is partly accepted and partly rejected with reference to both males and females studied.

The significant difference between males and females in seen only with reference to only a few age groups for all the three vowels for /a/ 8-9 years, 12-14 years, 15-16 years, 19-20 years and 21-22 years for /i/ 7-9 years, 15-16 years and 19-20 years and for the vowel /u/ the age groups 8-9 years, 12-13, 14-16 and 19-20 years.

Thus the hypothesis stating that there is no significant difference in MPD between males and females is partly accepted and partly rejected.

1) The mean MPT values increase gradually with increasing age. All three vowels is show a gradual increase in MPT upto 14-15 years and then stable upto 21-22 years.

2) In females there is gradual increases in MPT values of /a/ from 9-10 years to 16-17 years. There after it steadies upto 20-21 years and then shows very slight increase. The vowel /i/ shows a gradual increase upto 15-16 years there after it is stable upto 17-18 years and it

increase gradually from 18-19 years onwords. The vowel /u/ shows similar trend as in /a/.

3) The significant difference between males and females is seen with reference to only few age groups. Age groups 15-16 years, 19-20 years show significant difference is all the 3 vowels.

Developmental changes in MPT has been studied by Launer (1971), Cunning ham - Grant (1972) and Shigamori (1977). The findings in the present study are similar to the reports made by the above mentioned researchers ie., there is an increase in MPT with age in children. The results found in this study in case of adults are in agreement with the findings of Yanagihara et al (1966) and Yanagihara and Koike (1967) who reported that the MPD values of 28.4secs in case of adult males and 22.5secs in adult females. The increase trend in MPT values is late adolescence and adulthood. Rashmi (1985) reports that gradual increase in MPT values with age can be atributed to the increase in physical growth due to which more air is available for phonation. The present results can also be explained on this basis. Present study also shows that vowel /u/ has longer MPT values than other vowels which is in agreement with the earlier reports. The results of the present study can be used as norms for the purpose of evaluation of pathological cases.

Table la: Mean and Standard Deflation of phonation duration of /a/ (in seconds) in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
BALE:															
Mean	8,3	8.7	9.0	10.3	12.5	11.8	13..7	15.1	15.8	15.4	16.5	16.9	17.4	20.1	25.8
SD	1.49	1.55	2.0	1.77	3.03	3.01	3..16	4.51	3.61	2.5	3.21	3.87	2.27	4.33	6.53
FEMALES															
Mean	8.9	8.4	8.6	10.0	11.5	9.5	10..8	12.1	12.7	13.8	14.0	14.7	15.2	16.1	16.8
S.D.	2.88	2.01	1.78	1.33	2.46	1.65	2.1	2.23	3.34	4.02	3.2	3.53	2.7	3.57	3.46

Table-lb: Mean and S.D. of the phonation duration of /i/ (in seconds) in males and females

MALES:															
Mean	8.0	8.2	9.8	10.0	13.9	12.6	14..1	16.5	16.8	17.8	17.3	17.0	19.1	22.6	25.0
S.D.	1.36	1.32	2.52	2.79	3.75	2.8	2..65	3.72	3.52	3.01	3.02	6.72	2.51	5.41	6.57
FEMALES:															
Mean	8.0	8.3	8.5	10.9	12.1	10.0	11..8	13.2	14.1	15.9	15.2	16..4	17.2	18.3	19.7
S.D.	2.9	2..5	3.24	1.45	2.23	2.26	2..70	4.13	3.38	6.37	3.77	3..13	2.86	4.66	5.74

Table-lc: Mean and S.D. of the phonation duration of /u/ (in seconds) in males and females

MALES:															
Mean	8.5	8.6	9.4	10..1	13.1	12.0	13..7	15.2	15.2	16.5	16..8	16.3	18.9	19..3	24..4
S.DL	1.35	1.71	2.41	2..47	2.96	2.89	2..95	3.36	3.49	3.68	2..42	2.95	1.97	3..66	5..17
FEMALES:															
Mean	8..3	10..6	8.8	9.5	11.3	9..2	10..8	12..2	11.2	14.1	14.3	16..0	15.7	16.6	15.5
S.D.	2..31	2..07	1.4	1.68	2.31	1..32	1.69	4..42	2.97	3.84	3.2	3..4	2.79	4.66	4.9

Table-2 Significance of difference between difference age groups of males in N.P.T. of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15 16	16-17	17 18	18-19	19-20	20-21	21-22
7'- 8	A	A	P	P	P	P	P	P	P	P	P	P	P	P
8 - 9		A	P	P	P	P	P	P	P	P	P	P	P	P
9 - 10			A	P	P	P	P	P	P	P	P	P	P	P
10 - 11				A	A	P	A	P	P	P	P	P	P	P
11 - 12					A	A	A	A	P	P	P	P	P	P
12 - 13						A	A	A	P	P	P	P	P	P
13 - 14							A	A	A	A	A	P	A	P
14 - 15								A	A	A	A	P		P
15 - 16									A	A	A	A		A
16 - 17										A	A	A		P
17 - 18											A	A		P
18 - 19												A		P
19 - 20														P
20 - 21														P

Table-3 Significance of difference between difference age groups of males in M.P.T. of /i/

	8 9	9 10	10-11	11 12	12-13	13 14	14-15	15 16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	P	P	P	P	P	P	P	P	P	P
8 - 9		A	A	P	P	P	P	P	P	P	P	P	P	P
9-10			A	P	P	P	P	P	P	P	P	P	P	P
10-11				P	P	P	P	P	P	P	P	P		P
11-12					A	A	A	P	P	A	P	P	P	P
12-13						A	A	P	P	P	P	P	P	P
13-14							A	A	P	P	A	P	P	P
14-15								A	A	A	A	A	A	P
15-16									A	A	A	A	A	P
16-17										A	A	A	P	A
17-18											A	A	A	P
18-19												A	A	A
19-20													A	A
20-21														P

Table-4 Significance of difference between difference age groups of males in M.P.T. of /n/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	P	P	P	P	P	P	P	P	P	P
8 - 9		A	P	P	P	P	P	P	P	P	P	P	P	P
9 - 10			A	P	P	A	P	P	P	P	P	P	P	P
10 - 11				P	A	A	P	P	P	P	P	P	P	P
11 - 12					P	A	A	A	P	A	P	P	P	P
12 - 13						A	A	P	P	P	P	P	P	P
13-14							P	P	P	P	P	P	P	P
14 - 15								A	A	A	A	A	P	P
15 - 16									A	A	A	A	P	P
16 - 17										A	A	A	P	A
17 - 18											A	A	P	P
18 - 19												A	A	P
19 - 20													A	P
20 - 21														P

Table-5 Significance of difference between difference age groups of females in M.P.T. of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	A	A	P	A	P	P	P	P	P	P
8 - 9		P	A	A	A	A	A	A	A	P	P	P	P	P
9 - 10			A	P	A	P	P	P	P	P	P	P	P	P
10 - 11				P	A	P	P	P	P	P	P	P	P	P
11 - 12					P	A	A	A	A	A	P	A	A	P
12 - 13						A	A	A	P	P	P	P	P	P
13 - 14							A	A	A	A	P	A	P	P
14 - 15								A	A	A	A	A	A	P
15 - 16									A	A	A	A	A	P
16 - 17										A	A	A	A	A
17 - 18											A	A	A	A
18-19												A	A	A
19 - 20													A	P
20 - 21														A

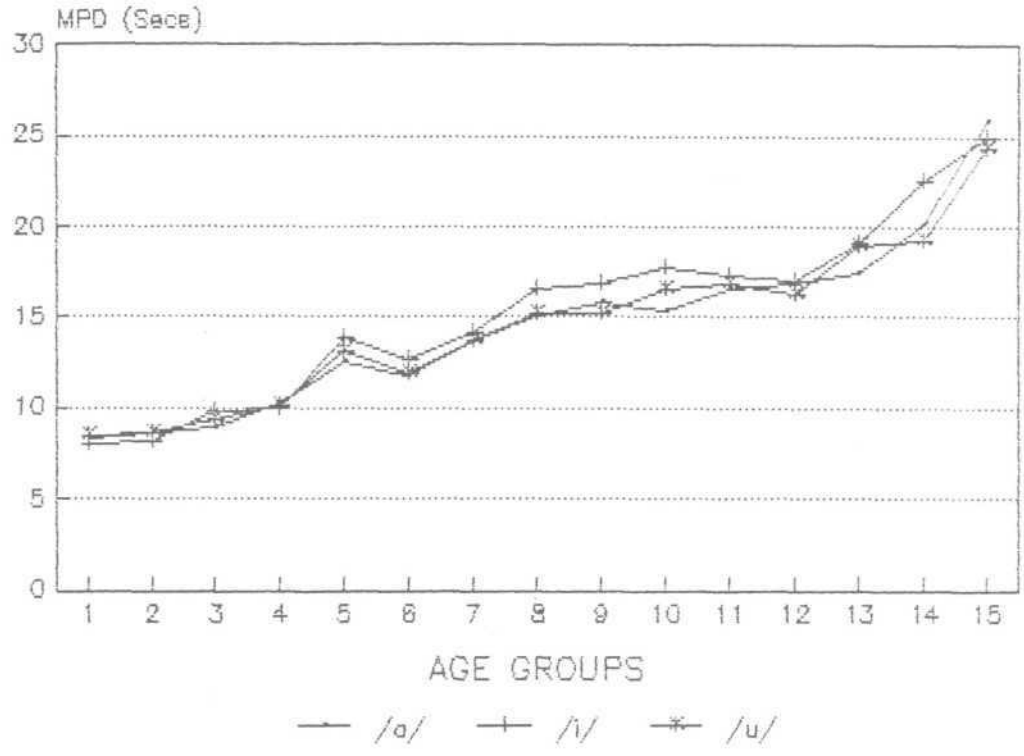
Table-S Significance of difference betieen difference age groups of females in M**.P.T. of** /i/

	89	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	**A**	A	A	A	A	A	A	A	P	P	P	P	P	P
8 - 9		P	A	A	A	A	A	A	P	P	P	P	P	P
9 - 10			**A**	P	A	P	P	P	P	P	P	P	P	P
10 - 11				A	A	A	A	A	P	P	P	P	P	P
11 - 12					P	A	A	A	A	P	P	P	P	P
12 - 13						A	P	A	P	P	P	P	P	P
13 - **14**							A	A	A	A	P	P	P	P
14 - 15								A	A	A	P	A	A	P
15 - 16									A	P	P	P	P	P
16 - 17										A	A	A	A	P
17 - 18											A	A	A	A
18 - 19												A	A	A
19 -20													A	P
20 - 21														A

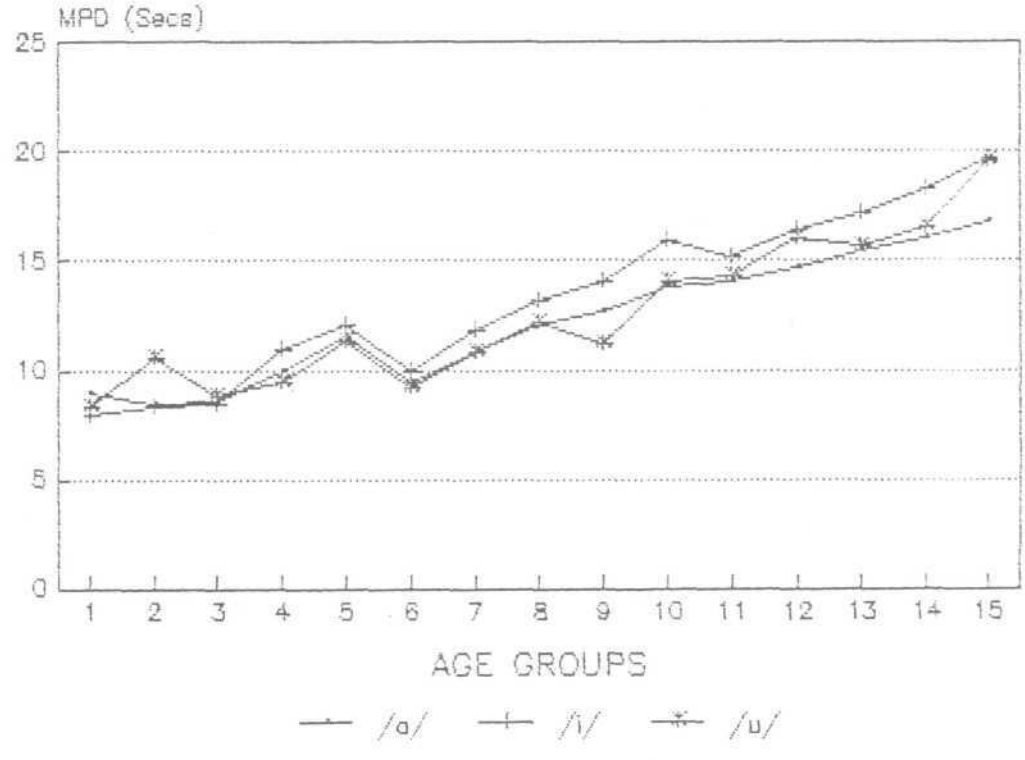
Table-7 Significance of difference between difference **age** groups **of females in M.P.T. of /u/**

	89	9-10	10:11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	A	A	P	A	P	P	P	P	P	P	P	P	P
8 - 9		P	A	A	A	A	A	A	P	P	P	P	P	P
9 - 10			A	P	A	P	P	P	P	P	P	P	P	P
10 - 11				P	A	A	A	A	P	P	P	P	P	P
11 - 12					P	A	A	A	A	P	P	A	P	P
12 - 13						P	P	A	P	P	P	P	P	P
13 - 14							A	A	P	P	P	P	P	P
14 - 15								A	A	A	A	A	A	P
15 - 16									A	P	P	P	P	P
16 - 17										A	A	A	A	P
17 - 18											A	A	A	A
18 - 19												A	A	A
19 -20													A	P
20 - 21														A

GRAPH-1: SHOWS PHONATION DURATION OF /a/, /i/ & /u/ IN MALES



GRAPH-1: SHOWS PHONATION DURATION OF /a/, /i/ & /u/ IN FEMALES



S/Z RATIO

The Table 8 presents the mean and standard deviation values for the ratio of S/Z in males and females.

The study of table reveals that the ratio of maximum duration of /s/ to that of /z/ more or less the same that is it varied from 0.93 to 1.12 in males and from 0.87 to 1.03 in females across the age groups studied. This is clearly shown in graph 2.

The inspection of S.D values shows that, for males the lowest value is .12 at 7-8yrs and the highest is .33 at 11-12yrs. on the whole the adolescent age groups show higher S.D values. In females the lowest is .1 at ll-12yrs and the highest is .26 at 15-16yrs. Unlike males the S.D values do not change much with age. Only age groups 15-16yrs 19-20yrs show higher values than the rest of the age groups.

The results of the statistical analysis is shown in tables 9 & 10 which reveal that there is no significant difference across age groups in both males and females.

Thus the null hypothesis stating that there is no significant difference in the ratio of duration of /s/ to /z/ as a function of age in both males and females is accepted.

Comparison between males and females as shown in the table 83 reveal that there is no significant difference between males and females in terms of s/z ratio in majority

of age groups. Hence the null hypothesis stating that there is no significant differnce between males and females in terms of s/z ratio is accepted.

Similar results has been reported by Rashmi (1985) and Vanaja (1986). These findings also agree with the results reported by Tait, Michal and Carpenter (1980). they reported no difference in maximum duration for either /s/ or /z/ at any one age level but indicated significant increase in maximum durattion of both /s/ and /z/ for both sexes as a function of age. They further observed that when the ratio of /s/ and /z/ is computed, there is no significant difference in these ratio between males and females nor there a significant difference as a function of age.

In summary, significant differnces are not found across age groups in both males and females. Greater variability in s/z values are seen only during adolescence which may be due to pubertle changes that are taking place in these age groups. Further the results of the present study can be used as norms for clinical evaluation of pathological cases.

FUNDAMENTAL FREQUENCY OF PHONATION

The mean and standard deviation fdr the fundamental frequency of phonation for the vowels /a/, /i/ & /u/ across different age groups are tabulated in Tables lla, l1b and l1c respectively, for both males and females.

Iable-8: Mean and S.D. of the ratio of the phonatioa time of /s/ to /s/ Ratio in males and females

	7-!	89	9-10	10-11	11-12	12-13	13-H	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	1.09	1.03	0.96	0.93	1.12	1.01	1.04	1.10	1.	0.99	0.96	0.93	1.04	0.91	1.05
SD	0.12	0.17	0.21	0.16	0.33	0.20	0.26	0.26	0.24	0.12	0.14	0.19	0.28	0.17	0.19
FEMALES:															
Mean	0.88	0.93	0.95	0.93	0.93	0.93	0.95	0.92	1.03	0.95	0.93	0.89	0.98	0.90	0.87
S.D	0.16	0.17	0.17	0.12	0.10	0.15	0.14	0.15	0.26	0.11	0.14	0.11	0.24	0.13	0.14

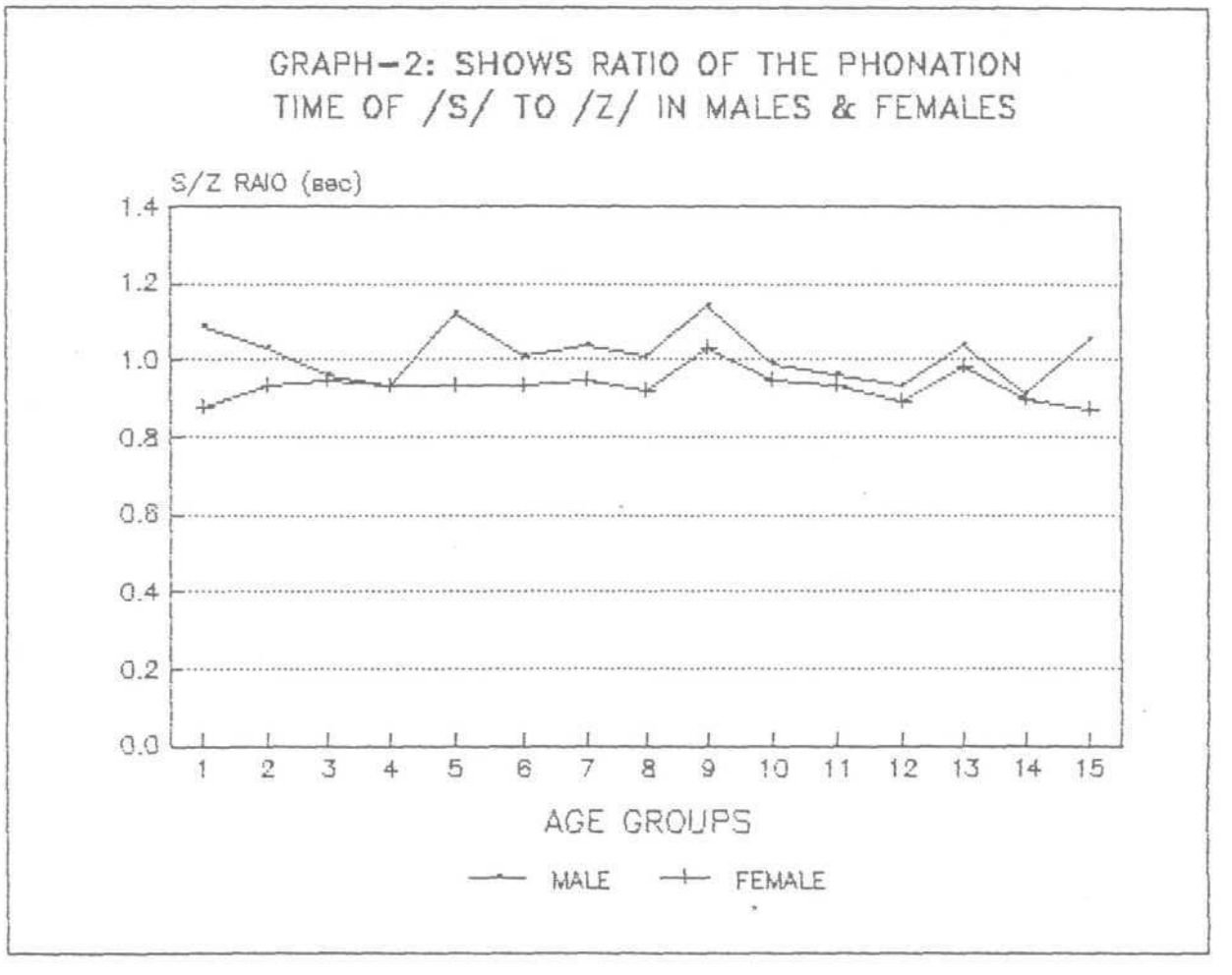


Table-9: The significance of difference between different age groups of males on the S/Z ratio

	89	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 9	A	P	P	A	A	A	A	A	A	A	P	A	A	A
8 - 9		A	A	P	A	A	A	A	A	A	A	A	A	A
9-tO			A	A	A	A	A	P	A	A	A	A	A	A
to tt				A	A	A	A	P	A	A	A	A	A	A
11-12					A	A	A	A	A	A	A	A	A	A
M-t3						A	A	A	A	A	A	A	A	A
H - H							A	A	A	A	A	A	A	A
H-15								A	A	A	A	A	A	A
15-16									A	A	P	A	P	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-10: The significance of difference between different age groups of females on the S/Z ratio

	89	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	A	A	A	A	A	A
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	A
9-10			A	A	A	A	A	A	A	A	A	A	A	A
10-11				A	A	A	A	A	A	A	A	A	A	A
tt-12					A	A	A	A	P	A	A	A	A	A
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
H-15								A	A	A		A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19 - 20													A	A
20 - 21														A

The study of tables indicate that there is a decrease in mean Fo as age progrssess in males, for all the three vowels. The highest for /a/ being 262.9Hz at ll-12yrs and the lowest is 119.23Hz at the age group 21-22yrs. The highest value for /i/ being 279.5Hz at the age group 9-10yrs and the lowest is 119.6Hz at the age group 18-19yrs. For the vowel /u/ the highest is 279.IHz at the age group ll-12yrs and the lowest is 122.93Hz at the age group 21-22yrs. It can also be seen that there is drop in Fo at the age groups 12- 13yrs and 15-16yrs. This is true with all the three vowels. This can be clearly seen in graph-2.

The S.D. values for the phonation of /a/ do not show any consistent change with age. The age groups 10-llyrs and 11-12yrs show the highest S.D. values. In the phonation of vowel /i/ S.D. values tended to decrease with the age. Younger children (7-12yrs) show higher variability except for the age groups 8-9yrs and 9-10yrs. The older children show lower values than the younger children. Among the adult age groups (18-22yrs), age group 18-19yrs and 19-20yrs show higher value. Similar trend is found in the phonation of /u/ also.

The Mann-Whitney 'U' test was applied to know the significance of difference. Tables 12, 13 and 14 shows that the changes in mean Fo from 7-8yrs upto 12-13yrs is not significant of both 0.01 and 0.05 levels. There is a significant decrease in mean Fo at 12-13yrs to 15-16yrs.

This drop for vowel /a/ is 250Hz at 7-8yrs to 235.25Hz at 12-13yrs and 135. 1Hz at 15-16yrs. The values for the vowel /i/ decreases from 278.33Hz at 7-8yrs to 248.3Hz at 12-13yrs and to 143.6Hz at 15-16yrs. For vowel /u/ the decrease is from 278.73Hz at 7-8yrs to 246.13Hz at 12-13yrs and to 141.17Hz that 15-16yrs.

Inspection of tables also reveals that younger children show significant differences with both older children and adults. Older children show significant differences with adult age groups. Older children also show significant differences when compared with their immediate higher age groups in all the three vowels.

The mean Fo values for the females shows slow decrease in Fo as a function of age for all three vowels. The highest mean value for /a/ is 276.27Hz at 7-8yrs and the lowest is 227.22Hz at 14-15yrs. The highest mean value for /i/ is 274.99Hz at 7-8yrs and lowest is 235.07Hz at 14-15yrs and for vowel /u/ the highest is 286.47Hz at ll-12yrs and lowest is 236.6Hz at 14-15yrs. As shown in the graph there is drop in mean value of Fo at the age group 14-15yrs, after which there is gradual increase in mean value. This can be observed in all the three vowels.

The S.D. values shows that there is slow increase in variability as a function of age in all the three vowels. The lowest S.D. values for /a/ is 10.32 at 7-8yrs and the

highest value is 25.67 at the age group 19-20yrs. The lowest S.D. value for /i/ is 10.93 at 9-10yrs, the highest value is 27.87 at 19-20yrs. The lowest value for /u/ is 9.05 at 9-lOyrs and the highest is 30.73 at 19-20yrs.

Mann-Whitney'U' test was applied to know the significance of difference across the age groups. Tables 15, 16 and 17 reveal the results of the test for the significance of difference. It can be seen that there is no significance difference in mean Fo values between the older children and adults. The young children show significant differences with older children and adults. Hence there is a gradual decrease upto the age group of 12yrs after which there is little change in Fo with age.

Hence the null hypothesis stating that there is no significant difference in Fo of phonation across age group in males and females is partly rejected and partly accepted.

Comparison between males and females in terms of MFo in phonation as indicated in the table 81 shows that significant differences are present from the age group 14-15 onwards.

Hence the null hypothesis stating that there is no significant difference in Fo of phonation between males and females in all age groups is partly rejected and partly accepted.

The results of earlier studies by Samuel (1973), Usha (1978) and Gopal (1980) on the Indian population have indicated that in males the lowering in Fo is gradual till

the age of 10 years (Gopal, 1980), 15 years Samuel (1973), 13 years Usha (1985) after which there is a sudden marked lowering in the Fo. In the present study the marked lowering of Fo was observed at the age of 15 years. However the present study also shows that the Fo stabilizes after 16 years upto the age group studied ie., 22 years.

The Graph-3 shows that Fo of /i/ is the highest followed by /u/ and /a/ which is in contrast with the results reported by Rashmi (1985) that is /a/ is lowest followed by /u/. Also the present study do not show any difference between /i/ and /u/ values in younger age groups. The highest Fo of /i/ found in this study is in good agreement with the study by Vanaja (1986).

The gradual decrease is Fo seen in females is agreement with the studies by Gopal (1980) Rashmi (1985). The Fo highest in /u/ followed by /i/ and /a/ is in agreement with earlier investigators. The S.D. values for both males and females is less than that is seen quoted by Rashmi (1985). Nataraja (1988), have reported the similar results as shown in the present study.

The results of present study is in close agreement with the observation made by Kent (1976), that is beginning with first year Fo decrases sharply untill about 3 years of age and when it make more gradual decline reaching to the onset of Puberty at 11 or 12 years age. A sex defference is apparent by the age of 13 years, which marks the beginning of substantial drop for male voices.

Table-11a: Mean and Standard Delation of the Fundamental freqaency of phonation of /a/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES															
Mean	250.27	219.33	259.60	256.10	262.90	235.23	239.60	222.90	135.1o	132.53	134.17	125.60	130.78	121.37	119.23
SD	12.97	12.58	14.46	28.28	32.48	10.79	14.19	11.15	16.18	13.29	14.47	10.94	19.22	10.86	13.70
FEMALES:															
Mean	276.27	261.70	262.63	259.99	258.13	239.23	232.67	227.22	229.87	238.37	242.73	230.05	231.49	236.90	229.63
S.D	10.32	12.35	14.78	13.11	18.05	14.22	24.83	12.12	17.11	16.25	12.46	21.11	25.67	21.33	21.71

Table-l1b: Mean and Standard Deviation of the Fundamental freqaency of phonation of /i/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	278.33	263.67	279.50	276.90	275.C7	248.30	252.10	226.10	143.60	141.30	143.13	119.60	135.57	129.27	124.13
SD	(0.76	17.21	12.65	30.95	40.21	10.83	14.35	10.66	19.02	15.02	3.34	37,97	20.80	11.62	13.51
FEMALES:															
Meams	274.99	274.00	267.33	269.43	269.43	259.57	243.40	235.07	243.37	248.23	249.53	244.73	246.77	244.70	245.03
S.D	12.36	16.33	10.93	11.08	15.52	19.30	27.43	16.01	19.85	16.71	13.39	24.71	27.87	25.04	25.11

Table-llc: Mean and Standard Deviation of the Fundamental freqaency of phonation of /n/ in tales and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	278.73	275.63	269.33	277.90	279.10	246.03	230.73	249.00	141.17	137.04	141.24	130.93	132.37	129.11	122.93
SD	43.19	26.82	13.18	30.85	43.55	13.10	11.83	16.16	16.47	13.65	10.85	12.10	20.64	10.28	13.75
FEMALES:															
Mean	268.47	271.67	280.70	271.89	286.47	247.27	242.6	238.60	239.40	244.63	254.43	245.62	249.47	243.50	244.89
SD	15.64	11.37	9.05	14.68	23.35	17.03	28.08	15.30	17.80	14.86	14.95	25.79	30.73	23.50	25.89

Table-12: Significant of difference between different age groups of tales on fundatental frequency of phonation of /a/

	8-?	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	P	P	P	P	p	P	P	P	P	P
8 - 9		P	A	A	P	P	P	P	P	P	P	P	P	P
9-10			A	A	P	P	P	P	p	P	P	P	P	P
10-11				A	p	P	P	p	P	P	P	P	P	P
11-12					P	P	P	P	P	P	P	P	P	P
12-13						A	P	P	P	p	P	P	P	P
13-14							P	P	P	p	P	P	p	P
14-15								P	p	P	p	P	P	P
15-16									A	A	A	A	P	P
16-17										A	A	A	A	A
17-18											A	A	A	p
18-19												A	A	A
19-20													A	A
20-21														A

Table-13: Significant of difference between different age groups of males on fundamental frequency of phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	P	p	P	P	P	p	p	P	P	P
8 - 9		A	A	A	P	P	A	p	P	p	p	P	P	P
9-10			A	A	P	p	P	p	P	p	p	P	P	P
10-11				A	A	p	P	P	P	P	p	P	P	P
11-12					A	p	A	P	P	p	p	p	P	P
12-13						p	a	P	F	p	p	P	P	P
13-14							p	P	P	P	p	P	P	P
14-15								P	p	A	p	P	P	P
15-16									A	A	p	A	A	P
16-17										A	p	A	A	P
17- 18											p	A	P	P
18-1?												A	A	A
l?-20													A	A
20-2!														A

Table-14: Significant of difference between different age groups of Males on fundamental frequency of phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	P	P	P	P	P	P	P	P	P	P
8 - 9		A	A	A	P	P	P	P	P	P	P	P	P	P
9 - 10			A	A	P	P	P	P	P	P	P	P	P	P
10-11				A	P	P	P	P	P	P	P	P	P	P
11-12					P	P	A	P	P	P	P	P	P	P
12-13						P	A	P	P	P	P	P	P	P
13-14							P	P	P	P	P	P	P	P
14-15								P	P	P	P	P	P	P
15-16									A	A	A	A	A	P
16-17										A	A	A	A	A
17-18											A	A	P	P
18-19												A	A	A
l9-20													A	A
20-21														A

Table-15: Significant of difference between different age groups of females on fundamental frequency of phonation of /a/

	8-9	9-10	10-11	11-12	12-1!	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	P	P	P	P	P	P	P	P	P	p
8 - 9		A	A	P	P	P	P	P	P	P	P	P	P	P
9 - 10			A	A	P	P	P	P	P	P	P	P	P	P
10-11				A	P	P	P	P	P	P	P	P	P	P
11-12					p	P	P	P	P	P	P	P	P	P
12-13						A	a	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

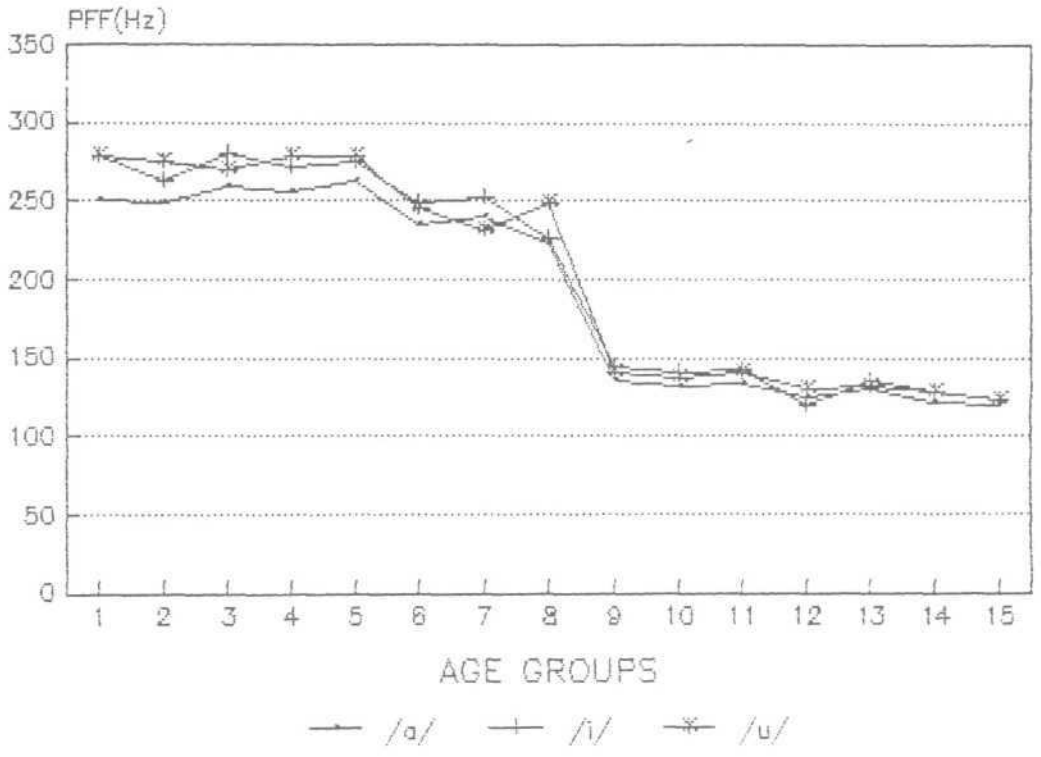
Table-14: Significant of difference between different age groups of females on fundamental frequency of phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	P	P	P	P	P	A	P	A	P	P
8- 9		A	A	A	P	P	P	P	P	P	P	P	P	P
9-10			A	A	P	P	P	P	P	P	P	P	P	P
10-11				A	P	P	P	P	P	A	P	A	P	P
11-12					P	P	p	p	P	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	P	A	A	A	A
15-16									A	P	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

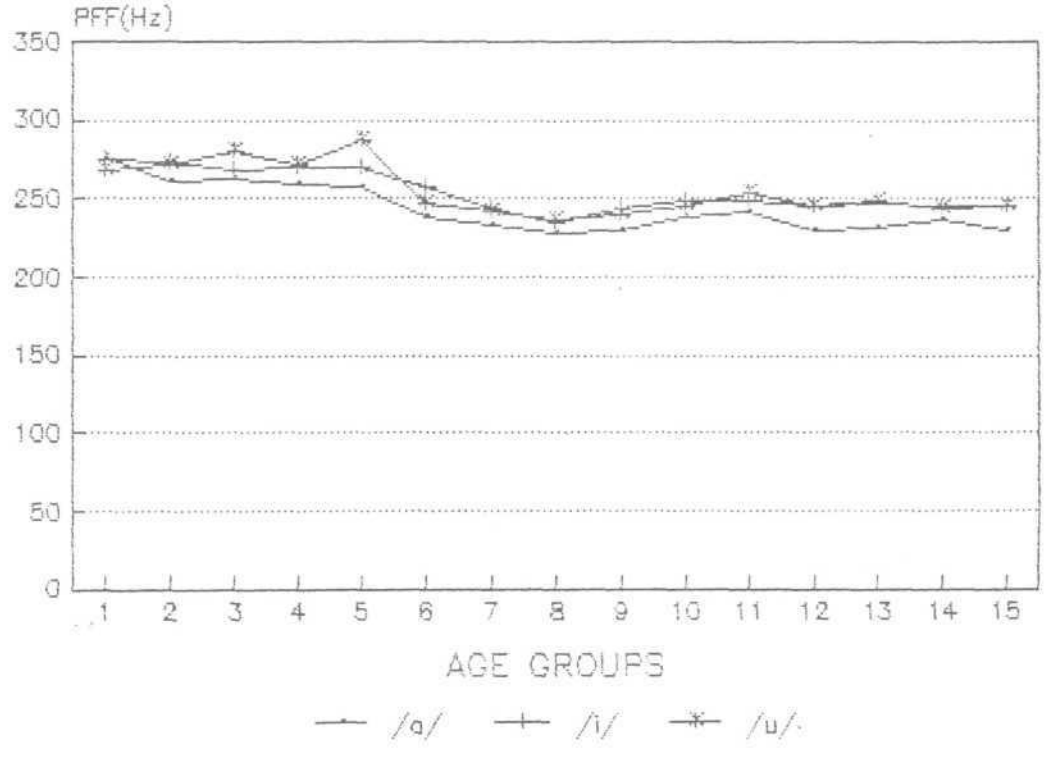
Table-17: Significant of difference between different age groups of females on fundamental frequency of phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-13	18-19	19-20	20-21	21-22
7 - 8	A	P	A	P	P	P	P	P	P	A	P	A	P	P
8 - 9		P	A	A	P	P	P	P	P	P	P	P	P	P
9-10			P	A	P	P	P	P	P	P	P	P	P	P
10-11				A	P	P	P	P	P	P	P	P	P	P
11-12					P	P	P	P	P	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	A	A	A	A	A
15-16									A	P	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

GRAPH-3: SHOWS FUNDAMENTAL FREQUENCY OF PHONATION IN MALES FOR /a/, /i/ & /u/.



GRAPH-3: SHOWS FUNDAMENTAL FREQUENCY OF PHONATION IN FEMALE FOR /a/, /i/ & /u/



SPEED OF FLUCTUATION IN FREQUENCY OF PHONATION

This parameter can be considered as a gross measure of jitter. The analysis of speed of fluctuation in frequency of phonation is found to be helpful in differential diagnosis of normal and dysphonics (Kim, 1982; Nataraja, 1988). Hence an attempt is made here to know the developmental changes of voice using this parameters.

The mean and S.D. values of the speed of fluctuation in frequency is shown in tables 18a, 18b & 18c for vowels /a/, /i/ and /u/ respectively for both males and females.

The mean and S.D. values of speed of fluctuation in frequency of phonation shows decreasing trend with age, in all the three vowels for males. The decrease is as follows; for /a/ it is from 8.73 at 7-8yrs to 0.76 at 21-22 years, for /i/ it is 7.6 at 7-8 years to 0.86 at 21-22 years and for /u/ its from 10.09 at 7-8 to 0.99 at 21-22 years.

It is evident from the graph (4) that for vowel /a/ there is a gradual decrease in mean values from 7-8yrs to 16-17yrs. There is a sudden drop from 5.89 at 16-17yrs to 1.96 at 17-18yrs. This decrease continues upto 19yrs. Then a stable value is seen vowel /i/ shows slight increase from 7.6 at 7-8yrs to 10.52 at 8-9yrs. Which remains same upto l0yrs of age. There is a gradual decrease from lOyrs to 16yrs as in /a/, after which it follows the same trend as in /a/. Vowel /u/ shows a similar trend as /a/ ie., a sudden decrease

at the age of 8-9yrs followed by a gradual decrease upto 16-17yrs and a sudden decrease at 17-18yrs. All the three vowels show sudden increase at the age group 16-17yrs.

S.D. values also show similar trend as mean values in all the three vowels.

The test of significance applied shows that the age group 17-18yrs and above are significantly different from the age groups below them (tables 19, 20 & 21). The age groups 7-8yrs to 16-17 years do not show significant differences with each other. Same results is observed with age groups 17-18 years and above. This is true with all the three vowels.

Thus the null hypothesis stating that there is no significant difference in speed of fluctuation in phonation in male is partly accepted and partly rejected.

The study of graph-4 for females reveals that in /a/ there is an increase in mean value between 7-8yrs and 8-9yrs. Later, the mean values decreases gradually upto 15-16yrs followed by a sudden decrease at 16-17yrs. The values decrease gradually from 17 to 21 years followed by a slight increase at 21-22 years. Age group 11-12 years shows highest mean value and variability. A similar trend is also seen in vowels /i/ and /u/. However mean values do not show any consistent pattern.

The test of significance of difference (Mann-Whitney 'U' test) was applied, the results which are shown in table 22, 23 and 24. This indicates that changes are gradual increasing age. No significant changes are seen between 8-9yrs and 13-14yrs. The lower age groups ie., 7-8yrs to 12-13yrs show significant differences with age groups 15-16yrs and above. Among the adolescent age groups 15-16yrs and 16-17yrs show significant differences with their immediate higher age groups. These adolescent age groups 13-14yrs to 17-18yrs show significant differences with both younger and adult age groups. No significant differences are found between adult groups 18-19yrs to 21-22 years. Vowel /i/ also shows significant differences between younger age groups 8-9yrs to ll-12yrs and adult age groups. Among adolescent age groups only 12-13yrs and 14-15yrs show significant difference with adult age groups. But they show significant differences with immediate higher age groups.

For vowel /u/, the significant differences are. found between 16-17yrs to 19-20yrs and 7-8yrs to 14-15yrs. Age groups 14-15yrs, 15-16yrs and 16-17yrs show signficant difference with their immediate age groups.

Thus the null hypothesis stating that there is no significant difference in speed of fluctuation in phonation is partly accepted and partly rejected.

The results can be summarized as follows:

1) In all the three vowels, in males, there is a gradual decrease in mean and S.D. value upto 17yrs, where there is a sudden decrease is noted. Further, no changes in mean and S.D. values are noted above the age 19yrs.

2) In /i/, however a slight increase in mean values upto l0yrs is seen.

3) In, females also similar trend as in males is seen. However S.D. measure do not show any consistent change with age.

4) There is significant differences between males and females in terms of speed of fluctuation in frequency in phonation in the adult age groups.

Nataraja (1986) studied normals and dysphonics on several parameters of which speed of fluctuation of Fo was one. He reported that this parameter was able to differentiate normals and disphonics in both males and females. He reported mean of 5-63year for normal males and 6.18 for normal females and a range 0-14 for males and 0-12 for females. The values for the younger age groups in the present study are higher than the values reported in the above study, but well with in range given by Nataraja (1988). This same indicate a progressive development of control over vocal cords vibration from childhood to adult.

Results of the present study are supported by Liberman (1963) Rieberg (1961).

Table-18a: Mean and Standard Deviation of the speed of fluctuation of frequency in phonation of /a/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	8.73	6.26	7.89	5.79	6.35	5.80	6.70	4.91	4.34	5.89	1.96	0.76	0.76	1.04	0.70
S.D	6.40	2.00	2.50	2.19	3.70	2.35	1.60	1.56	1.47	3.46	1.25	0.29	0.59	0.76	0.49
FEMALES:															
Mean	6.34	8.93	7.02	5.75	6.84	5.53	5.30	4.72	2.73	1.31	2.60	1.90	1.81	1.73	2.31
S.D	1.61	3.21	1.64	1.84	3.73	2.74	1.62	2.00	1.18	0.57	1.00	0.96	0.80	1.19	1.68

Table-18b: Mean and Standard Deviation of the speed of fluctuation of frequency in phonation of /i/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	7.60	10.52	10.13	7.74	7.09	7.31	8.61	10.20	5.04	6.79	2.07	0.97	0.94	0.75	0.86
S.D	2.70	6.79	5.79	2.35	3.35	4.00	2.22	2.20	1.75	4.87	1.46	0.71	0.88	0.65	0.37
FEMALES:															
Mean	6.65	10.148	8.29	6.37	7.99	6.18	5.48	7.76	3.79	1.95	3.61	2.90	2.75	3.35	3.30
S.D	1.70	2.52	2.43	1.68	5.02	3.73	2.32	2.78	2.28	1.36	1.11	1.86	2.10	2.03	2.36

Table-18c: Mean and Standard Deviation of the speed of fluctuation of frequency in phonation of /u/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	10.09	7.50	8.51	6.62	8.28	6.93	7.62	5.12	4.59	7.13	1.74	0.93	0.72	1.17	0.99
S.D	7.47	3.56	4.27	4.27	7.58	2.82	1.73	1.52	1.20	3.85	1.45	0.67	1.02	0.67	0.35
FEMALES:															
Mean	6.80	10.77	7.77	6.68	5.95	5.66	7.08	9.07	4.72	1.79	3.72	3.49	3.24	5.26	5.11
S.D	1.70	4.32	2.93	2.24	3.31	3.50	2.95	3.39	3.09	1.28	1.90	3.39	1.81	4.52	3.75

Table-19: The significance of difference between different age groups of males on the speed of fluctuation of frequency on phonation of /a/

	8-9	9-10	10-1l	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	P	A	P	P	P	P	P
8 - 9		A	A	A	A	A	A	P	A	P	P	P	P	P
9-10			A	A	A	A	p	P	A	P	P	P	P	P
10-11				A	A	A	A	A	A	P	P	P	P	P
11-12					A	A	A	A	A	P	P	P	P	P
12-13						A	A	P	A	P	p	P	p	P
13-14							P	A	A	P	P	P	P	P
14-15								A	A	P	p	P	P	P
15-16									A	P	P	P	P	p
16-17										P	P	P	P	P
17-18											A	A	p	P
18-19												A	a	A
19-20													A	A
20-21														A

Table-20: The significance of difference betxeen different aqe groups of males on the speed of fluctuation of frequency on phonation of /i/

	9-9	9-10	19-11	11-12	12-13	13-14	H-15	15-16	16-17	17-18	13-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	P	P	A	P	p	P	P	P
8 - 9		A	A	F	A	A	P	p	A	P	P	P	p	P
9-10			A	A	A	A	P	P	A	P	P	P	P	P
10-11				A	A	A	P	P	A	P	p	P	P	P
11-12					A	A	A	A	A	P	P	P	P	P
12-13						A	A	A	A	P	P	P	P	P
13-14							P	P	A	P	P	P	P	p
14-15								A	A	P	P	P	P	P
15-16									A	P	P	P	p	P
16-17										P	P	P	P	p
17-18											P	P	P	P
18-19												A	A	A
19-20													A	A
20-21														A

Table-21: The significance of difference between different age groups of males on the speed of fluctuation of frequency on phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	A	P	P	A	P	P	P	P	P
8 - 9		A	A	A	A	A	A	P	A	P	P	P	P	P
9 - 10			A	A	A	A	P	P	A	P	P	P	P	P
10 - 11				A	A	A	A	A	A	P	P	P	P	P
11 - 12					A	A	A	A	A	P	P	P	P	P
12 - 13						A	A	P	A	P	P	P	P	P
13 - 14							P	P	A	P	P	P	P	P
14-15								A	A	P	P	P	P	P
15 - 16									A	P	P	P	P	P
16 - 17										P	P	P	P	P
17 - 18											A	P	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 2!														A

Table-22: The significance of difference between different age groups of females on the speed of fluctuation of frequency on phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 3	A	A	A	A	A	A	P	P	P	P	P	P	P	P
8 - 9		A	P	A	P	P	P	P	P	P	P	P	P	P
9 - 10			A	A	A	P	P	P	P	P	P	P	p	P
10 - 11				A	A	A	A	P	P	P	P	P	P	P
11 - 12					A	A	A	P	P	P	P	P	P	P
12 - 13						A	A	A	P	P	P	P	P	P
13 - 14							A	P	P	P	P	P	P	P
14 - 15								A	P	P	P	P	P	P
15 - 16									P	P	P	P	P	P
16 - 17										P	A	A	A	A
17 - 18											A	A	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

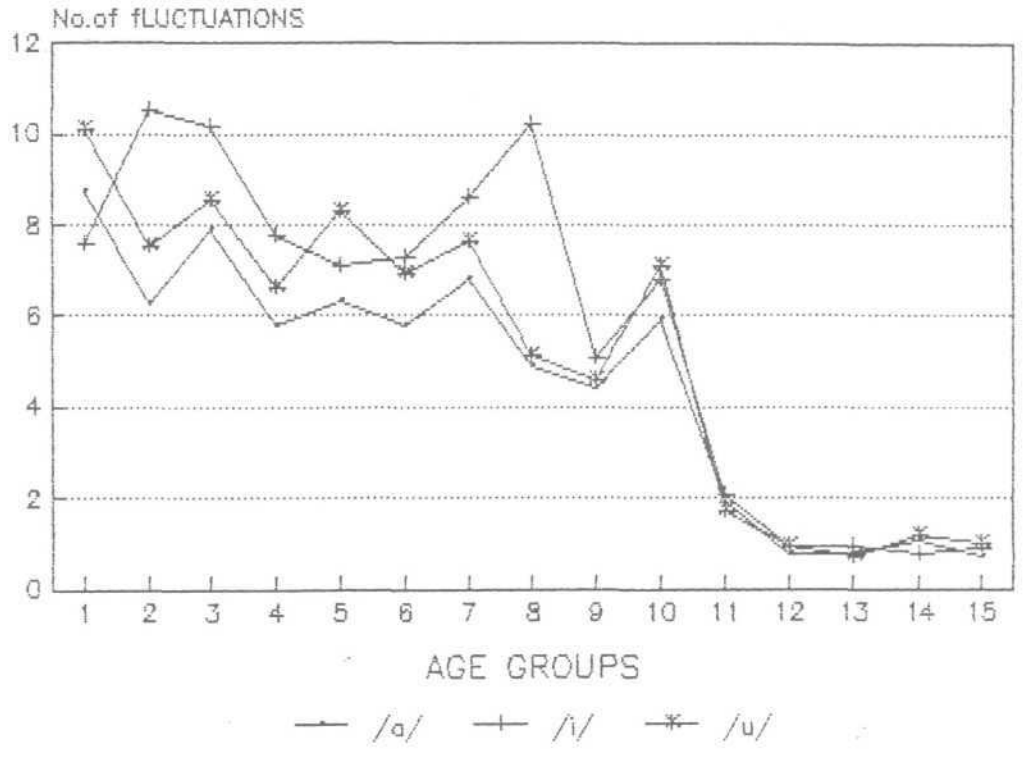
Table-23: The significance of difference between different age groups of females on the speed of fluctuation of frequency on phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	P	A	A	A	A	A	P	P	P	P	P	P	P
8 - 9		A	P	P	P	P	P	P	P	P	P	P	P	P
9-10			P	A	A	P	A	P	P	P	P	P	P	P
10-11				A	A	A	A	P	P	P	P	P	P	P
11-12					A	A	A	P	P	P	P	P	P	P
12-13						A	A	A	P	A	P	P	A	P
13-14							P	A	P	A	P	P	A	A
14-15								P	P	P	P	P	P	P
15-16									P	A	A	A	A	A
16-17										P	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

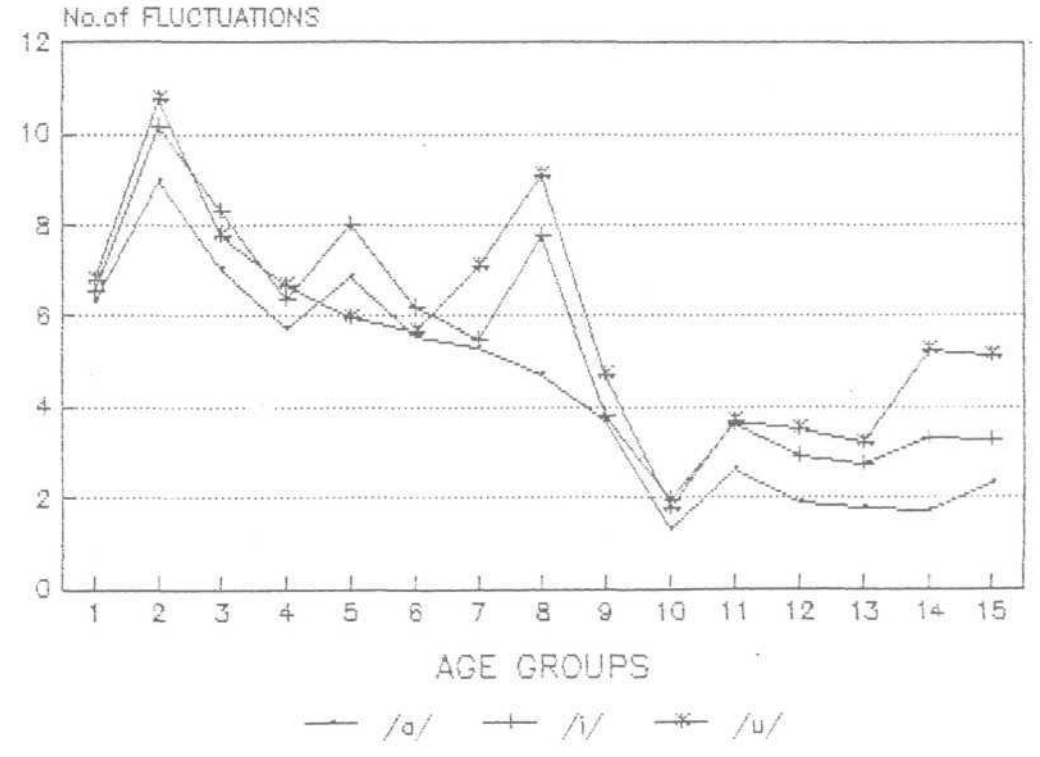
Table-24: The significance of difference between different age groups of females on the speed of fluctuation of frequency on phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	l9-20	20-21	21-22
7 - 8	P	A	A	A	A	A	A	A	P	P	P	P	A	A
8 - 9		A	P	P	P	A	A	P	P	P	P	P	P	P
9 - 10			A	A	A	A	A	P	P	P	P	P	A	A
10 - 11				A	A	A	A	A	P	P	P	F	A	A
11 - 12					A	A	P	A	P	P	P	P	A	A
12 - 13						A	A	A	P	A	A	A	A	A
13 - 14							A	A	P	P	p	P	A	A
14- 15								P	P	P	P	P	A	P
15 - 16									P	A	A	A	A	A
16 - 17										P	A	P	A	P
17 - 18											A	A	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

GRAPH-4: SHOWS SPEED OF FLUCTUATION IN FREQUENCY IN MALES FOR /a/, /i/ & /u/.



GRAPH-4: SHOWS SPEED OF FLUCTUATION IN FREQUENCY IN FEMALES FOR /a/, /i/ & /u/.



EXTENT OF FLUCTUATION IN FREQUENCY OF PHONATION

The analysis of extent of fluctuation in frequency of phonation is helpful in differentiating the normals and dysphonics (Nataraja, 1988, Kim 1982). Here an attempt is made to know the developmental changes in voice in children and adults using this parameter.

The mean and S.D. values for the extent fluctuation in frequency in phonation is shown in the tables 25a, 25b & 25c for /a/, /i/ and /u/ respectively for both males and females.

Investigation of tables 25a, 25b and 25c reveal that the values of mean and S.D., are highest at 7-8 years for all the three vowels and lowest at 20-21 years for /a/ and /i/ and at 19-20 years for /u/.

It is evident from the graph-5 that, for the vowel /a/, there is a sudden drop from 7-8 years (7.63) to 8-9 years (4.09). The mean values then decrease gradually upto the age of 21-22yrs. Vowel /i/ shows a slight increase from 7.69Hz at 7-8yrs to 10.52Hz at 8-9yrs, followed by a decrease to 5.81Hz and 9-10yrs. There is gradual decrease in mean values from 9-10yrs to 21-22yrs. But age groups ll-12yrs and 16-17yrs show a slight increase in mean values. Vowel /u/ shows a gradual decrease from 8Hz at 7-8yrs to 3.59Hz at 21-22yrs. Age group 16-17yrs shows a slight increase in mean values and age group 19-20yrs shows a decrease when compared to other age groups.

Mann-Whitney 'U' test was applied to know the statistical significance of difference (tables 26, 27 and 28), which shows that for /a/ groups 20-21 and 21-22 years show significant difference with the lower groups and their is a significant drop by 7-8 and 8-9 years. There is no significant difference when comapred with other groups. For vowel /i/ groups 14-15 years and above show a significant difference with the lower age groups. But age groups from 14-15yrs and above do not show any significant change. For vowel /u/ the pattern is different from that of /a/ and /i/. The groups 7-8 years to 13-14 years are significantly different from the group 17-18 and above. But age groups 7-8 and 9-10 years show a significant difference with all other age groups. Also like in /a/ and /i/ groups 14-15 and above do not show any significant change.

In females the values of mean and S.D. for the first group is 3.81 and 0.44; 4.67 and 1.18; 4.65 and 1.23 for /a/ and /i/ and /u/ respectively and that of last group is 3.87 and 0.92; 4.38 and 1.24; 4.25 and 0.88 for /a/, /i/ and /u/ respecitvely. Hence it can be seen that there is no consistent significant increase or decrease in the mean and S.D. values across age groups studied.

The tables 26, 27 and 28 presenting significance of difference shows that for vowel /i/ groups 8-9, 9-10 and 10-11 years show a significant difference with each other and

also with all other age groups. For vowel /u/ age groups 10-llyrs and 16-17yrs show a significant difference with most of the other age groups. With reference to vowel /a/ age groups 19-20yrs and 12-13yrs show significant difference with most of the other age groups.

Thus the null hypothesis stating that there no significant difference in extent of fluctuation in frequency in males across age group is partly accepted and partly rejected. In case of females it is accepted.

Comparison of mean values between males and females shows that

- for /a/ significant difference are present only at 7-yrs, 20-21yrs and 19-20yrs.
- for /i/ significant difference are present only at 7-8yrs and 21-22yrs.
- for /u/ significant difference are found only at 7-8yrs, 9-10yrs, 10-llyrs, 14-15yrs, 16-17yrs, 18-19yrs and 21-22yrs age groups.

Therefore there is no significant difference between males and females in terms of extent of fluctuation in frequency across all age groups, except at lower end and higher end of age groups studied.

Thus the null hypothesis stating that there no significant difference in extent of fluctuation in frequency between males and femaless is accepted.

The results can be summarized as follows:

1) The extent of fluctuation in frequency in phonation is low in higher age groups and high in younger age groups for all the three vowels. Vowel /i/ shows no significant difference upto 11-12 years and a significant drop at 12-13 years, after which there is very slow decrease upto age group 21-22 years. Vowels /a/ and /u/ show a sharp drop at the age group 8-9 years, after which there is slow decrease.

2) In females there is no consistent significant change with age.

There is no similar study to compare the data obtained here. However, Rashmi (1985) who studied fluctuations is frequency and intensity across age groups 4-15yrs reported that, (1) the fluctuation is frequency of the initial to final segments of phonation of /a/, /i/ and /u/ showed a decreasing trend with age in males. Similar finding is obtained in present study.

(2) 14-15 years old group showed an increase in the range of fluctuation for all the vowels. This was not found in present study.

(3) In females there was a decrease in the range of fluctuation in frequency of the initial and final segments upto 9 years and increase upto 11 years and drop till 15 years. However the present study does not show any systematic change in extent of fluctuation.

(4) No difference in the range of fluctuation in frequency between males and females was observed in younger age group.

In the present study only age group 7-8ys showed a significantly higher values for males for all the three vowels among the younger age groups.

(5) Males consistently showed greater fluctuations in frequency in the phonation of /a/, /i/ and /u/ than females of 14-15 years. In the present study males showed a lower value than females but it was not statistically significant. The differences between males and females is significant only at 19-20yrs and 20-21ys for /a/, for /i/ 21-22yrs and for /u/ 16-17yrs, 18-19yrs and 21-22 years age groups.

Nataraja (1988) has reported that mean of 2.74 and S.D. 2.5 in males and a mean 2.41 and S.D. of 0.72 in females in the age range 16-25yrs. The result of present study correlates with these values as shown by the adult age groups studied.

SPEED OF FLUCTUATION IN INTENSITY OF PHONATION

The tables 32a, 32b, & 32c shows the mean and S.D. values of the speed of fluctuation in intensity of phonation of /a/, /i/ and /u/ respecitvely in both males and females.

The inspection of tables shows that the mean value and S.D. values decrease slowly and steadily as a function of age for all three vowels. The decrease in mean value is from 2.14 at 7-8 years to 0.14 at 21-22 years for /a/, and 2.16 at 7-8 to 0.34 at 21-22 years for /i/ and 1.88 at 7-8 years to 0.35 at 21-22 years for /u/. However older children 12-13yrs to 17-18yrs show inconsistent changes in mean values with age. This is clearly shown in graph 6.

Tabie-25a: Mean and Standard Deviation of the extent of fluctuation in frequency in phonation of /a/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	29-21	21-22
MALES:															
Mean	7.63	4.09	7.89	4.27	4.86	4.37	4.25	3.83	4.08	3.88	3.77	3.64	3.48	2.01	2.77
S.D	4.72	1.28	2.50	2.19	2.50	1.24	1.01	0.82	1.59	0.82	0.63	0.63	1.29	9.94	1.55
FEMALES:															
Mean	3.81	3.90	3.95	4.01	4.82	4.68	3.78	4.43	4.01	3.74	3.63	3.56	3.34	3.57	3.87
S.D	0.44	0.58	0.44	0.64	1.81	1.06	0.47	1.68	0.58	0.42	0.53	0.24	0.54	9.20	0.92

TaMe-25b: Mean and Standard Deviation of the extent of fluctuation in frequency in phonation of /i/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	7.69	10.52	5.81	5.62	7.09	4.64	4.75	3.70	3.76	5.02	4.53	3.82	3.-88	3.25	3.40
S.D	4.38	6.79	1.29	2.25	3.55	0.87	1.17	0.44	0.78	1.57	1.59	0.51	0.65	1.37	0.47
FEMALES															
Mean	4.67	5.2!	5.76	6.6!	5.46	4.47	4.!0	4.49	4.14	3.77	3.84	4.13	3.87	1.96	4.28
	1.18	!.!6	0.64	!.12	2.53	1.06	0.76	!.07	0.74	0.63	0.64	0.87	1.10	9.73	!.24

Table-25c: Mean and Standard Deviation of the extent of fluctuation in frequency in phonation of /n/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	8.00	5.01	6.07	5.21	5.54	4.38	4.72	3.93	3.97	4.55	3.96	3.62	2.69	3.33	3.59
S.D	4.67	1.60	0.85	2.18	3.16	0.34	1.07	0.67	2.61	1.27	0.85	0.49	1.96	1.39	0.51
FEMALES															
Mean	4.65	4.53	4.52	5.36	4.76	4.17	4.08	4.65	4.11	3.49	4.47	4.21	3.8B	1.72	4.25
S.D	1.23	1.12	0.48	0.83	1.91	0.52	0.58	0.91	0.67	0.57	0.99	0.68	0.47	3.53	0.88

Table-24: The significance of difference between different groups of males on the extent of fluctuation of frequency on phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	P	P	P	P	P	P	p	P	P	P	P	P	P
8 - 9		P	A	A	A	A	A	A	A	A	A	A	P	P
9-10			A	A	A	A	A	A	A	A	P	A	P	P
10-l1				A	A	A	A	A	A	A	A	A	A	A
11-12					A	A	A	A	A	A	A	A	P	P
12-13						A	A	A	A	A	A	A	P	P
13-14							A	A	A	A	A	A	P	P
14-15								A	A	A	A	A	P	A
15-16									A	A	A	A	P	A
16-17										A	A	A	P	P
17-18											A	A	P	P
18-19												A	P	A
19-20													A	A
20-21														A

Table-27: The significance of difference between different groups of males on the extent of fluctuation of frequency on phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	P	P	P	P	P	P	P	P	P	P
8 - 7		A	A	A	A	A	P	P	A	P	P	P	P	P
9-10			A	A	P	A	P	P	A	P	P	P	P	P
10-11				A	A	A	P	P	A	A	P	P	P	P
11-12					A	A	P	A	A	A	A	A	P	P
12-13						A	P	P	A	A	P	P	P	P
13-14							P	P	A	A	A	P	P	P
14-15								A	P	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	P	p
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-28: The significance of difference between different groups of males on the extent of fluctuation of frequency on phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	A	P	P	P	P	P	P	P	P	P	P	P	P
8- 9		P	A	A	A	A	A	A	A	P	P	P	P	P
9 - 10			P	P	P	P	P	P	P	P	P	P	P	P
10-11				A	A	A	A	A		P	P	P	P	P
11-12					A	A	A	A	A		P	P	A	P
12- 13						A	A	A	A	A	P	A	P	P
13-14							A	A	A	A	P	P	P	P
14- 15								A	A	A	A			A
15 -16									A	A	A	A		A
16 -17										A	P	A	A	
17 - 18											A	A	A	
18 - 19												A	A	
19-20													A	
20-21														

Table-29: The significance of difference between different groups of females on the extent of fluctuation of frequency on phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	P	A	A	A	A	A	A	P	A	A
8- 9		A	A	A	A	A	A	A	A	A	A	P	A	A
9-10			A	A	A	A	A	A	A	A	P	P	P	A
10-11				A	A	A	A	A	A	A	A	P	P	A
11-12					A	A	A	A	A	A	A	P	A	A
12-13						P	A	A		P	P	P	P	P
13-H							A	A	A	A	A	P		A
It-15									A	A	A	P	A	A
15-16									A	A	P	P		A
16-17										A	A	A	P	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	
20-21														A

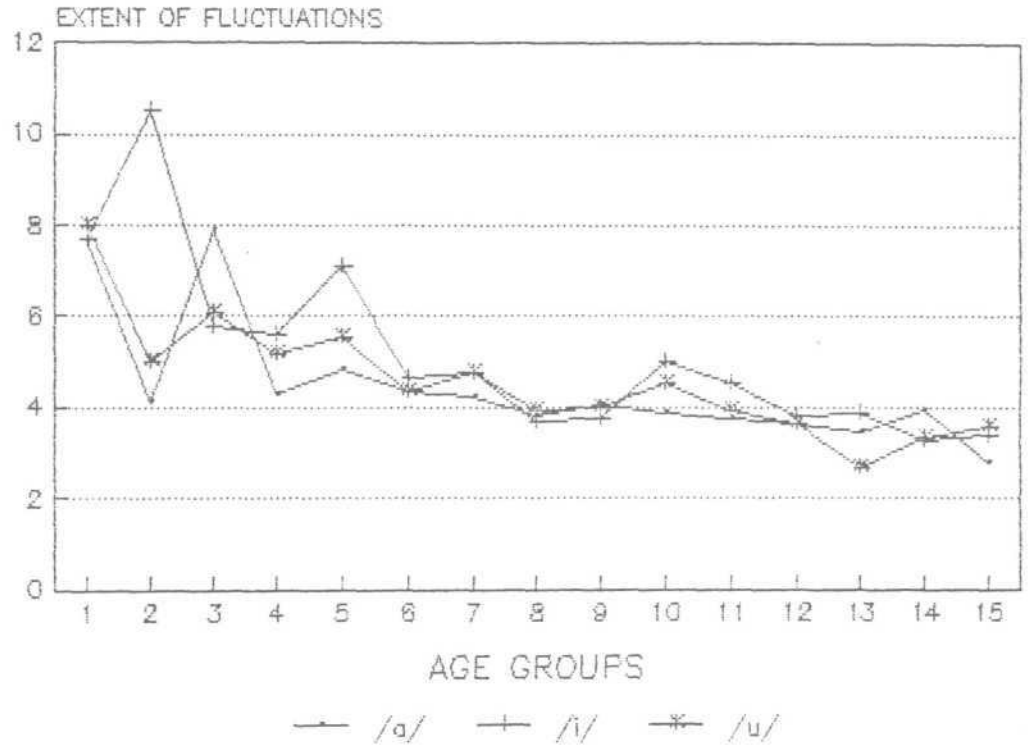
Table-30: The significance of difference between different groups of females on the extent of fluctuation of frequency on phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 9	A	P	P	A	A	A	A	A	A	A	A	A	A	A
8 - 9		A	P	A	A	P	A	P	P	P	P	P	P	A
7 -10			P	P	P	P	P	P	P	P	P	P	P	P
10-11				P	P	P	P	P	P	P	P	P	P	P
1l-12					A	A	A	P	P	P	A	P	A	A
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	P	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
l9-20													A	A
20-21														A

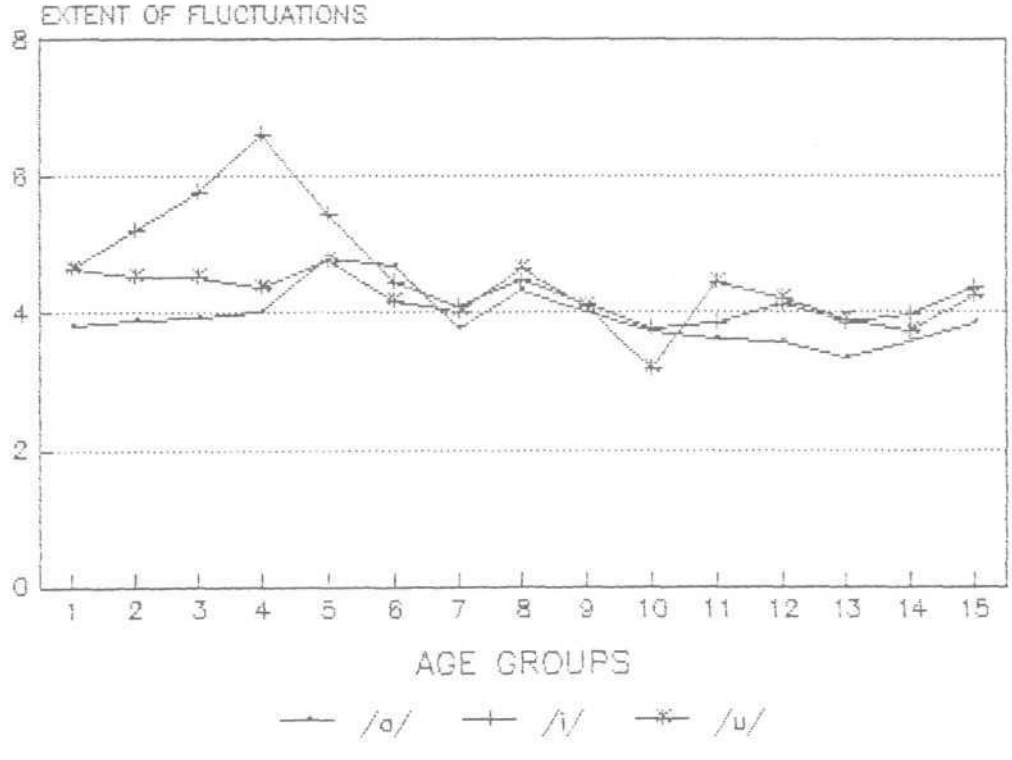
Table-31: The significance of difference between difference groups of females on the extent of fluctuation of frequency on phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-13	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	P	A	A	A	P	A
8 - 9		A	A	P	A	A	A	A	P	A	A	A	A	A
9-10			P	A	A	P	A	A	P	A	A	P	P	A
10-11				A	P	P	A	P	P	P	P	P	P	P
11-12					A	A	A	A	P	A	A	A	A	A
12-13						A	A	A	P	A	A	A	A	A
13-14							A	A	P	A	A	A	A	A
14-15								A	P	A	A	A	P	A
15-16									P	A	A	A	A	A
16-17										A	A	A	P	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

GRAPH-5: SHOWS EXTENT OF FLUCTUATION IN FREQUENCY IN MALES FOR /a/, /i/ & /u/.



GRAPH-5: SHOWS EXTENT OF FLUCTUATION IN FREQUENCY IN FEMALES FOR /a/, /i/ & /u/.



The result of test for significance of difference is shown in table 33, 34 & 35. The inspection of these tables reveal that for vowel /a/ the significant changes are seen across the age groups 14-15yrs, 15-16yrs & 16-17yrs, which may be related to the pubertle changes. On the whole the younger children do not show significant difference with each other. Adult age groups also do not show significant difference with each other. In older children 17-18yrs and 15-16yrs show significant differences with the lower age groups. The younger children and older children also show significant differences with the adult age groups, except for age groups 10-llyrs, 12-13yrs and 15-16yrs. Significant difference between younger and older children are random.

For the vowels /i/ and /u/ also the younger children and adults do not show significant differences with each other. Both older age groups and younger children show significant differences with adult age groups. Again no consistent significant differences are found between younger and older children.

Thus the hypothesis stating that there is no significant difference in speed of fluctuation in intensity of phonation as a function of age, is partly accepted and partly rejected with reference to males.

Females also show a decreasing trend in mean and S.D. values as in males. However, the decrease is lesser compare

to males. The decrease is from 0.77 at 7-8 years to 0.39 at 21-22 years for /a/, 0.61 at 7-8 years and 0.21 at 21-22 years for /i/ and 0.75 at 7-8 years to 0.22 at 21-22 years for /u/. The values are low for the phonation of vowel /i/. However age groups 8-9yrs, 13-14yrs and 15-16yrs show higher value than the rest.

The results of test for significance of difference are shown in tables 36, 37 & 38. The results reveal that the young children show significant difference with adults. But older age groups do not show., significant difference with either adults or younger age groups. The same trend is seen in all the three vowels.

Thus the hypothesis stating that there is no significant difference in speed of fluctuation as a function of age, is accepted with reference to females.

Comparison between males and females in terms of speed of fluctuation in intensity as shown in table-81 reveal,, that there is significant difference between males and females in the age group 14-15 years only.

Thus the hypothesis stating that there is no significant difference in speed of fluctuation in intensity of phonation as a function of age, between males and females is accepted.

The results can be summarised as:

1) The males show significant decrease in mean and S.D. values with age for all the three vowels.

2) There is increase in mean and S.D. values at the age group 14-15yrs.

3) Females also show a decrease in mean and S.D. values with age but more gradual than that of males.

4) The mean values of males are significantly higher than that of females in the lower age groups only.

No study with a similar definition has been carried out to study the developmental changes. Nataraja (1988) had carried out a study, with similar definition of the parameter in normals and dysphonics. Similar study also have been carried out on normal adults by Kim et al (1982) and Yoon et al (1984)]. This parameter shows change with age, probably indicating the neuromuscular maturity of the laryngeal system.

EXTENT OF FLUCTUATION IN INTENSITY OF PHONATION

The mean and S.D. of extent of fluctuation in phonation of /a/, /i/ and /u/ are shown in tables 39a, 39b & 39c respectively, for both males and females in the range studied.

Table-32a: Mean and Standard Deviation of speed of fluctuation in intensity phonation of/a/ in tales and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALE:															
Mean	2.14	2.50	1.16	0.76	1.66	1.30	1.38	2.27	0.36	1.27	0.40	0.42	0.42	0.23	0.14
S.D	2.42	3.00	1.15	0.54	0.89	1.46	1.02	1.13	0.38	0.97	0.28	0.3?	0.38	0.38	0.19
FEMALES;															
Mean	0.77	0.85	1.12	0.54	0.81	0.99	0.86	0.55	0.73	0.86	0.30	0.47	0.34	0.67	0.3?
S.D	0.56	0.45	0.58	0.36	0.59	0.97	0.86	0.50	0.90	1.18	0.22	0.39	0.43	1.13	0.37

Table-32b: Mean and Standard Deviation of speed of fluctuation in intensity phonation of/i/ in males and females

	7-8	8-9	9-10	10-11	H-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	2.16	0.98	1.07	0.63	1.39	1.06	0.96	2.17	0.37	1.66	0.4?	0.86	0.19	0.32	0.34
S.D	2.13	1.07	0.96	0.38	0.76	1.43	0.90	1.25	0.32	1.50	0.45	O.?7	0.34	0.37	0.25
FEMALES;															
Mean	0.61	0.81	0.71	0.66	0.71	0.60	0.83	0.51	0.73	1.09	0.42	0.31	0.1?	0.67	0.21
	0.42	0.50	0.44	0.44	0.58	0.84	0.93	0.43	0.62	1.27	0.42	0.44	0.24	1.06	0.1?

Table-32b: Mean and Standard Deviation of speed of fluctuation in intensity phonation of/u/ in tales and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	l9-20	20-21	21-22
MALES:															
Mean	1.88	1.01	1.10	0.39	2.38	0.69	1.53	2.53	0.43	1.42	0.50	0.56	0.39	0.13	0.35
SD	2.25	0.97	0.98	0.43	2.73	1.06	1.73	t.3t	0.44	1.74	0.67	0.67	0.31	0.15	0.28
FEMALES:															
Mean	0.75	1.23	0.85	0.60	0.88	0.63	1.15	0.54	1.04	0.61	0.30	0.37	1.09	0.34	0.22
S.D	0.57	1.44	0.82	0.50	0.83	0.68	1.10	0.49	1.35	0.89	0.27	0.37	1.13	0.27	0.30

Table-33: the significance of difference between different age groups of tales on speed of fluctuation in intensity of phonation of/a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-14	14-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	P	A	P	P	P	P	P
8 - 9		A	A	A	A	A	A	P	A	P	P	P	P	P
9-10			A	A	A	A	P	A	A	A	P	A	P	P
10-11				P	A	A	P	A	A	A	A	A	P	P
11-12					A	A	A	P	A	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	P
13-14							A	P	A	P	P	p	P	P
14-15								P	A	P	P	P	P	P
15-14									P	A	A	A	A	A
16-17										P	P	P	P	P
17-18											A	A	A	P
18-1?												A	A	A
19-20													A	A
20-21														A

Table-34: The significance of difference between different age groups of tales on speed of fluctuation in intensity of phonation of/i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-14	14-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	A	A	P	A	P	A	P	P	P
8 - 9		A	A	A	A	A	P	A	A	A	A	P	P	P
9-10			A	A	A	A	P	P	A	A	A	P	P	P
10-11				A	A	A	P	A	A	A	A	P	P	P
11-12					A	A	A	P	A	P	A	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							P	A	A	A	A	P	P	P
14-15								P	A	P	P	P	P	P
15-14									a	A	A	A	A	A
14-17										A	A	P	P	P
17-13											A	A	A	A
18-19												P	A	A
19-20													A	A
20-21														A

Table-34: The significance of difference between different age groups of males on speed of fluctuation in intensity of phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	P	A	A	P	A	P	P	P	P	P
8 - 9		A	A	A	A	A	P	A	A	A	A	P	P	A
9 - 10			P	A	A	A	P	A	A	A	A	P	P	P
10 - 11				P	A	P	P	A	P	A	A	A	P	A
11 - 12					A	A	A	P	A	P	A	P	P	P
12 - 13						P	P	A	A	A	A	A	A	A
13 - 14							A	A	A	P	A	P	P	P
14 - 15								P	A	P	P	P	P	P
15 - 16									A	A	A	A	A	A
16 - 17										A	A	P	P	P
17 - 18											A	A	A	A
18 - 19												A	P	A
19 - 20													A	A
20 -21														A

Table-35: The significance of difference between different age groups of females on speed of fluctuation in intensity of phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-25	20-21	21-22
7 - 8	A	P	A	A	A	A	A	A	A	P	A	P	P	A
8 - 9		A	A	A	A	A	A	A	A	P	A	P	P	P
9 - 10			P	A	A	A	P	P	A	P	P	P	P	P
10 - 11				A	A	A	A	A	A	A	A	A	A	A
11 - 12					A	A	A	A	A	P	A	P	A	P
12 - 13						A	A	A	A	P	A	P	A	P
13 - 14							A	A	A	A	A	A	A	A
14 - 15								A	A	A	A	A	A	A
15 - 16									A	A	A	A	A	A
16 - 17										A	A	A	A	A
17 - 18											A	A	A	A
18 - 19												A	A	A
1? - 20													A	A
20 - 21														

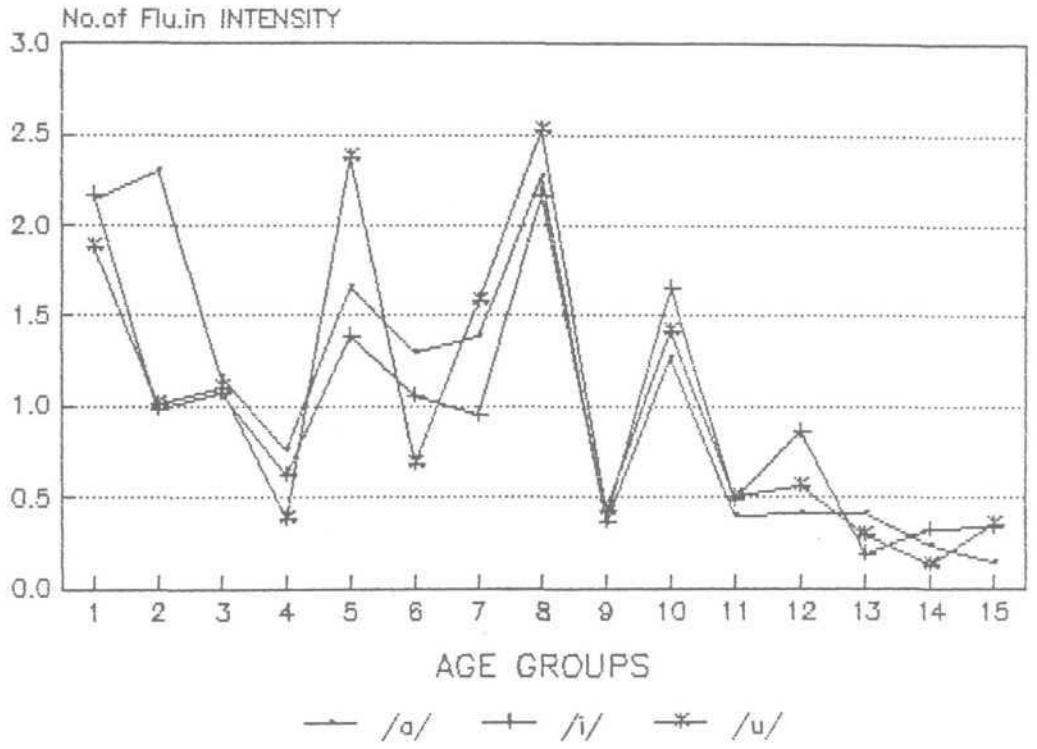
Table-36: The significance of difference between different age groups of females on speed of fluctuation in intensity of phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	P	A	P	P	P	A	P
8 - 9	A		A	A	A	A	A	A	A	P	P	P	P	P
9-10			A	A	A	A	A	A	A	P	P	P	A	P
10-11				A	A	A	A	A	A	A	P	P	A	P
11-t2					A	A	A	A	A	A	P	P	A	P
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	P	P	A	P
14-15								A	A	A	A	A	A	A
15-16									a	A	P	P	A	P
14-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
l9-20													A	A
20-21														A

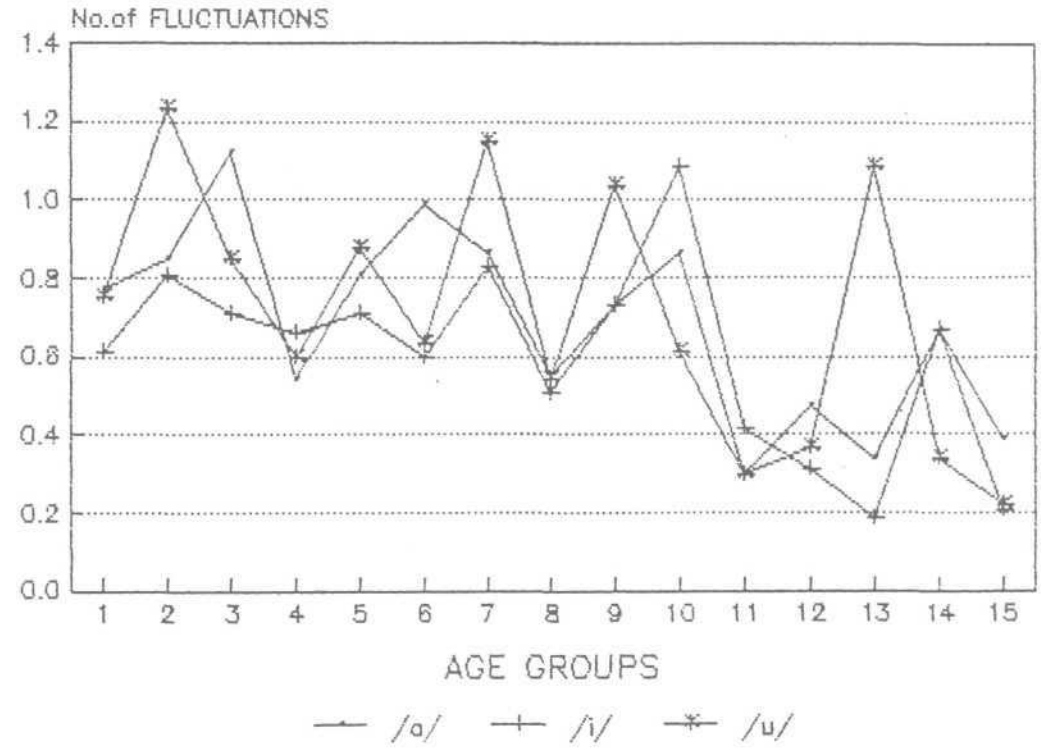
Table-37: The significance of difference between different age groups of females on speed of fluctuation in intensity of phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	A	P	P	A	A	P
8- 9		A	A	A	A	A	A	A	P	P	P	P	P	P
9-10			A	A	A	A	A	A	P	p	P	P	P	P
10-11				A	A	A	A	A	A	A	A	A	A	A
11-12					A	A	A	A	A	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	P
13-14							P	A	A	P	P	P	P	P
14-15								A	A	A	A	A	A	A
15-16									A	P	P	P	P	P
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

GRAPH-6: SHOWS SPEED OF FLUCTUATION IN INTENSITY IN MALES FOR /a/, /i/ & /u/



GRAPH-6: SHOWS SPEED OF FLUCTUATION IN INTENSITY IN FEMALES FOR /a/, /i/ & /u/



The investigation of these tables 40, 41 and 42 reveals that the mean values for /a/ shows a slow decreasing trend as a function of age. The highest mean value for /a/ is 3.32dB at 7-8 years age group and the lowest value is 1.16dB at 21-22 years. There is gradual decrease in mean values from 7-8 years to 16-17 years. But age groups 12-13 years and 15-16 years show a sudden drop in mean value (ie., 2.55dB and 2.07dB resceptively)., There is a significant difference at 17-18 years (2.54dB) and then remains stable upto 19-20 years. The age ranges 20-21 years to 21-22 years again show lower values than the rest of the age groups. This stepwise decrease is evident in the graph-7.

The S.D. values increase with age from 0.64 at 8-9 years to 1.53 at 21-22 years, but age group 10-11 years shows higher variability wit the S.D. values being 2.54.

The mean values for /i/ shows a sudden drop at 8-9 years and after that consistent trend in seen. The highest mean value for /i/ is 3,82dB at 16-17 years and lowest is 1.24dB at 18-19 years. The mean values of /i/ do not show any consistent pattern like that of /a/.

The S.D. values in the lowest, at the age group 7-8 years (0.49) and the highest at 15-16 years (1.55). But age groups 16-17 years and 18-19 years show a lower value than others as shown in table 39b.

The mean values for /u/ are lower towards the higher end. The mean values for /u/ decrease from 3.53dB at 7-8 years to 2.94dB at 21-22 years. The inspection of table 39c shows that age groups 17-18 years and above show lower values than the lower age groups. Among these lower age groups, however age groups 10-11, 12-13 years and 15--16 years show low values.

The S.D. values show a increasing trend with age from 0.41 at 7-8 years to 1.37 at 21-22 years. However age group 14-15 years lowest value is 0.23.

The significance of difference were found between the age groups 20-21yrs, 21-22yrs and 14-15yrs and below for vowel /a/. Age groups 9-10yrs, ll-12yrs and 14-15yrs show significant difference with age groups 17-18yrs to 19-20yrs. The age group 19-20 show significant difference with age groups 18-19, 16-17, 14-15 and 11-12 years and below when vowel /i/ is considered. Age groups 16-17yrs also show significant difference with the age groups 9-10yrs, 10-llyrs, 12-13yrs, 13-14yrs and 15-16yrs and also with age groups 17-18yrs and above. No other age group shows consistent, signficant difference with other age groups.

When vowel /u/ is considered the age groups 19-20yrs to 21-22yrs show significant difference with 7-8yrs and 8-9yrs age groups. Age group ll-12yrs show significant difference with most of other age groups except 13-14yrs and 16-17yrs.

Thus the null hypothesis stating that there no significant difference in extensive of fluctuation in males across age group partly accepted and partly rejected.

In case of females no consistent pattern is observed for mean values in all the three vowels. The lowest values are, for /a/ 2.26dB at 16-17 years and the highest value is 3.45dB at 13-14yrs age group. The lowest value for /i/, is 1.7dB at 18-19 years and the highest values is 3.52dB at 11-12 years. And the lowest mean value for /u/ is 1.47dB at 21-22 years, and highest value is 3.73dB at 8-9 years.

The S.D. values increases as age increases, the values are 0.48 at 7-8 years and 1.5 at 21-22 for /a/; 0.56 at 7-8 and 1.44 at 21-22 years for /i/; and 0.87 at 7-8 years and 1.58 at 21-22 years for /u/.

The test for significance of difference (tables 43, 44 & 45) do not reveal any consistent pattern except for that in /a/ and /u/ the age groups 13-14 is significantly different, from all other higher age groups, and for /i/ age group 21-22 years is significantly different from most of the lower age groups.

Thus the null hypothesis stating that there no significant difference in extensive of fluctuation in intensity across age group in females is accepted.

The comparison of males and females shows that there is no significant difference between sexes in the vowel /a/ and /u/. However for the vowel /i/ significant difference found at the age groups 7-8yrs and 14-14yrs, were the male shows higher mean values than females.

Thus the null hypothesis stating that there no significant difference in extensive of fluctuation in tensity between males and females is accepted.

The results can be summarized as follows:

1) In males the mean values of age groups 17-18 and above show a significanlty lower value than the other age groups for all the three vowels.

2) Females do not show any consistent pattern.

3) Male and female do not show significant difference at any of the age groups.

This parameter with a similar definition has not been studied in children and adult. Nataraja (1988) has carriedout a study on normal and dysphonics. The values reported in the present study are with in the range quoted by Nataraja (1988) (0-4dB). He also reported that there is no difference between males and females with respect to this parameter. The present study also showed no significant difference between males and females in majority of the age groups.

Table-39a: Mean and Standard Deviation of the extent of fluctuation in intensity in the phonation of/a/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Hean	3.32	3.32	3.28	3.16	3.54	2.55	3.01	3.47	2.07	3.07	2.54	2.5?	2.25	1.41	1.16
S.D	0.79	0.64	0.75	2.00	0.56	1.79	0.94	0.35	1.78	1.23	1.35	1.37	1.53	1.55	1.53
FEMLES:															
Mean	2.99	3.16	3.30	2.34	3.34	2.90	3.45	2.83	2.61	2.26	2.56	2.57	2.39	2.51	2.44
S.B	0.48	0.12	0.31	0.88	0.79	1.11	0.34	1.44	1.13	1.57	1.36	1.36	1.29	1.20	1.50

Tab!e-3?b: Mean and !Standard Beviation of the extent of fluctuation in intensity in the phonation of/i/ in males and fetales

	7-8	8-9	9-1o	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-198	19-20	20-21	21-22
MALES:															
Mean	3.53	2.99	2.87	2.78	3.53	2.37	2.71	3.31	2.23	3.82	2.33	2.92	1.24	2.03	2.?4
S.D	0.49	l.06	1.92	1.02	1.04	1.66	1.01	0.31	1.55	0.70	1.41	0.83	1.60	1.56	1.06
FEMALES;															
Mean	2.?5	3.31	3.21	3.2?	3.52	2.30	3.28	2.69	3.07	2.69	2.92	2.30	1.70	3.06	2.04
	0.56	0.64	0.58	1.26	0.30	2.46	0.65	1.22	1.24	1.41	1.06	1.59	1.60	2.36	1.44

Table-39c: Mean and Standard Deviation of the extent of fluctuation in intensity in the phonation nf/u/ in males and feMles

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	l9-20	20-21	21-22
MALES:															
Mean	3.48	3.06	3.00	2.61	3.67	1.94	3.39	3.24	2.27	3.17	1.68	2.74	2.51	1.47	2.47
S.D	0.41	1.019	1.07	1.40	0.64	2.09	1.24	0.23	1.57	1.31	1.58	1.23	1.32	1.51	1.37
FEMALES:															
Mean	2.99	3.73	3.40	2.43	3.11	3.08	3.37	2.64	2.75	2.73	2.22	2.55	2.50	2.26	1.47
S.D	0.87	1.06	0.65	1.54	0.71	1.19	0.60	1.27	1.44	1.51	1.54	1.36	1.21	1.39	1.58

Table-40: The significance of difference between different age groups of tales on extent of fluctuation of intensity in phonation of /a/

	8-9	9-10	10-H	M-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	A	A	A	A	P	P
8 - 9		A	A	A	A	A	A	A	A	A	A	A	P	P
9-iO			P	A	A	A	A	A	A	P	P	P	P	P
10-11				P	A	A	P	A	A	A	A	A	P	P
11-12						A	A	A	A	p	P	P	P	P
12-13						A	A	A	A	A	A	A	A	P
13-14							A	A	A	A	A	A	P	P
14-15								A	A	P	P	P	P	P.
15-16									A	A	A	A	A	A
16-17										A	A	A	P	P
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-41: The significance of difference between different age groups of <ales on extent of fluctuationof of intensity in phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	P	A	P	A	P	A	p	P	A
8 - 9		A	A	A	A	P	A	A	A	A	A	P	A	A
9-10			A	A	A	A	A	A	p	A	A	P	A	A
10-11				A	A	A	A	A	P	A	A	P	A	A
11-12					A	P	A	A	a	P	A	P	P	A
12-13						A	A	A	p	A	A	A	A	A
13-14							P	A	p	A	A	A	A	A
14-15								A	A	P	A	P	A	A
15-16									p	A	A	A	A	A
16-17										P	P	P	P	P
17-18											A	A	A	A
18-19												P	A	A
19-20													A	P
20-21														A

Table-42: The significance of difference between different age groups of tales on extent of fluctuationof of intensity in phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	A	A	P	A	P	A	P	P	P
8 - 9		A	F	A	A	A	A	P	A	P	A	P	P	P
9-10			A	A	A	A	A	A	A	P	A	A	P	A
10-l1				P	A	A	A	A	A	A	A	A	A	A
11-12					P	A	P	P	A	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	P	A	A	P	A
14-15								A	A	P	A	A	P	A
15-16									A	A	A	A	A	A
16-17										P	A	P	P	P
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-45: The significance of difference between different age groups of males on extent of fluctuationof of intensity,in phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	P	A	A	A	A	A	A	P	P
8 - 9		A	A	A	A	P	A	A	A	A	A	A	P	P
9-10			A	A	A	A	A	A	A	P	P	P	P	P
10-11				P	A	A	P	A	A	A	A	A	P	P
11-12					A	A	A	A	A	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	P
13-14							A	A	A	A	A	A	P	P
14-15								A	A	P	P	P	P	P
15-16									A	A	A	A	A	A
16-17										A	A	A	P	P
17-18											A	A	A	A
18-19												A	A	P
19-20													A	A
20-21														A

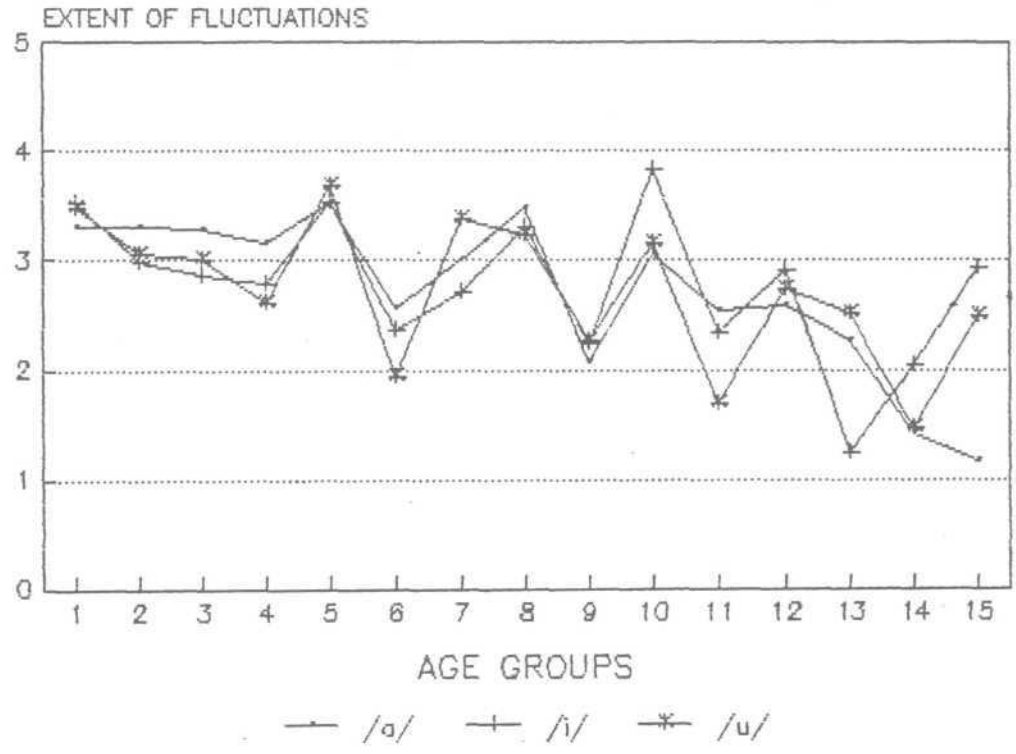
Table-44: The significance of difference between different age groups of females on extent of fluctuationof of intensity in phonation of / i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-14	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	P	A	P	A	P	A	P	P	A
8 - 9		A	A	A	A	P	A	A	A	A	A	P	A	A
9-10			A	A	A	A	A	A	P	A	A	P	A	P
10-11				A	A	A	A	A	A	A	A	P	A	A
11-12					A	A	A	A	A	A	A	P	A	P
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	P
14-15								A	A	A	A	A	A	P
15-16									A	A	A	A	A	P
16-17										A	A	A	A	P
17-18											A	A	A	P
18-19												A	A	A
19-20													A	A
20-21														A

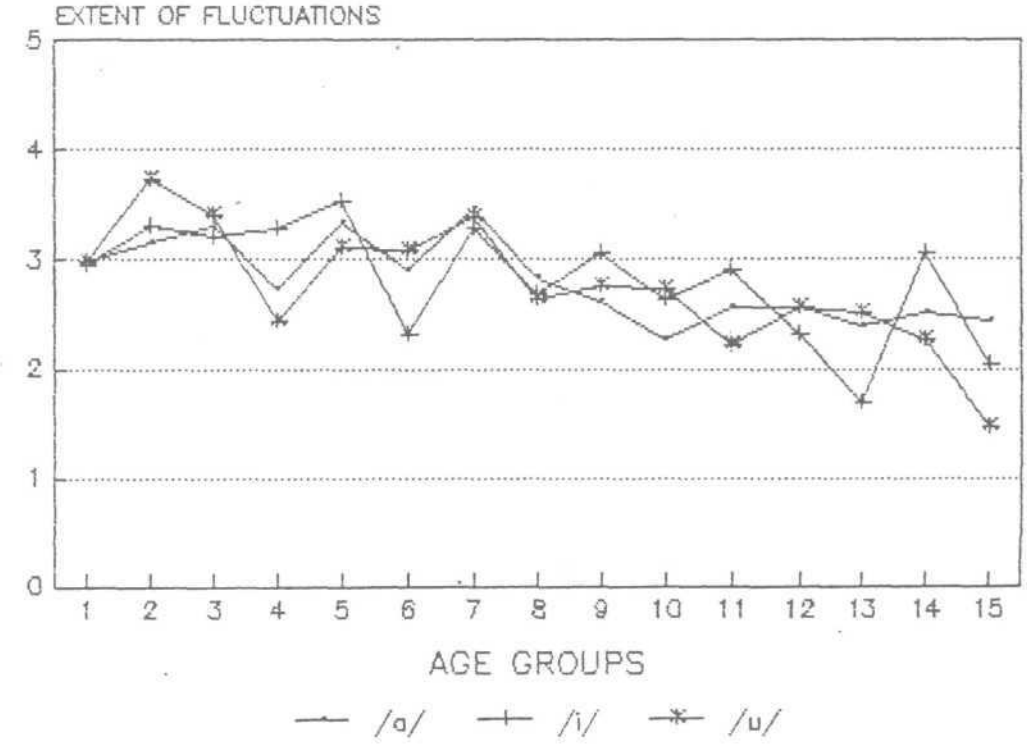
Table-45: The significance of difference between different age groups of feMles on extent of fluctuationof of intensity in phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	14- 17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	A	A	A	A	A	P
8 - 9		A	A	A	A	A	P	A	A	P	P	P	P	P
9-10			A	A	A	A	P	A	A	A	A	P	A	P
10-11				A	A	A	A	A	A	A	A	A	A	A
11-12					A	A	A	A	A	P	A	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							P	A	A	P	P	P	P	P
14-15								A	A	A	A	A	A	A
15-14									A	A	A	A	A	P
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

GRAPH-7: SHOWS EXTENT OF FLUCTUATION IN INTENSITY IN MALES FOR /a/, /i/ & /u/



GRAPH-7: SHOWS EXTENT OF FLUCTUATION IN INTENSITY IN FEMALES FOR /a/, /i/ & /u/



FREQUENCY RANGE IN PHONATION

The mean and Standard Deviation for the frequency range of phonation /a/, /i/ and /u/ are given in the Tables 46a, 46b & 46c respectively for both males and females.

The frequency range of the phonation decreases across the age groups studied. For vowel /a/ it;, decreases from 21.53Hz at 7-8 years to 6.67Hz at 21-22 years for vowel /i/ it is from 21.07Hz at 7-8 years to 6.87Hz at 21-22 years and for /u/ it decreases from 21.57Hz at 7-8 groups to 6.77Hz at 21-22 years. Also for the vowel /a/ and /i/ age group 20-21yrs shows lowest values and for /u/ age group 19-20yrs shows the lowest value as depicted in tables 46a, 46b and 46,c. This is clearly evident from graph-8. It is also found that among older children age groups 13-14yrs and 16-17yrs show higher values in phonation for all the three vowels.

The Mann-Whitney 'U' test was applied to know the significance of difference for all the age groups. When a group is compared with its immediate higher group significant difference was not found. This indicates a gradual decrease in frequency range phonation. Younger children as a group show significant difference with adult age groups and older age groups except for 13-14yrs and 16-17yrs. This could be due to slightly higher values found in those age groups. Older children show significant difference with the adult group except for age group 17-18yrs. Further it also indicates that there is a sudden decrease at 8-9yrs, 12-13yrs

and 14-15yrs for /a/, at 14-15yrs for /i/ and at 15-16yrs and 17-18yrs for the vowel /u/.

Thus the null hypothesis stating that there is no significant difference in Frequency range in phonation in males across age group is partly accepted and partly rejected.

In case females also mean values decrease as a function of age. The highest mean value for /a/ is 20.03Hz at 8-9yrs and lowest value is 7.8Hz at 19-20 years; for /i/ the highest values is 19.43Hz at 8-9yrs and lowest value 8.03Hz at 21-22yrs and for /u/ the highest mean values is 18.37Hz at 8-9yrs and lowest is 7.97Hz at 21-22yrs.

The S.D. values also show the same trend as mean values for all the three vowels. Further age group 10-11 years shows high vairability in all the three vowels.

The Mann-Whitney 'U' test was applied to know the statistical significance of difference for all the age groups. For the phonation of /a/ younger children age group show significant differences with older children and adult age groups. Older children show sigificant difference with the adult age group except for age groups 16-17yrs and 17-18yrs. This shows that adult values are reached by the age of 16-17yrs.

For the phonation of /i/, younger age groups show significant difference with the adult age groups. Among the older children age groups 12-13yrs, 14-15yrs and 15-16yrs

show significant difference with adult age groups. There also adult values are reached by 16-17yrs.

For the phonation of /u/ younger age groups show significant difference with old children and adults except for the age group 15-16 years. Among the older age groups only age group 12-13yrs, 13-14yrs and 15-16yrs show significant differences with adult age groups.

Thus the null hypothesis stating that there's no significant difference in Frequency range in phonation in females across age group is partly accepted and partly rejected.

The comparison of frequency range in phonation between males and females show that significant difference are present in the age group 7-8yrs in both the vowels /a/ and /i/. Again in /a/ significant difference are present at age groups 16-17yrs, 20-21yrs and 21-22yrs. For /i/ at the age groups 20-21yrs, 15-16yrs and 16-17yrs and for /u/ 15-16yrs, 16-17yrs, 19-20yrs and 20-21yrs.

Thus the null hypothesis stating that there's no significant difference in Frequency range in phonation between males and females is accepted.

The results can be summarized as following:

1) In males the frequency range in phonation decreases gradually with age reaching the adult value by the age 20-21.

2) Females the decrease in frequency range in phonation is more gradual than in more gradual than in males, reaching the adult value by 16-17yrs of age.

3) Significant difference in frequency range in phonation between males and females are present at adult age groups and also in 15-16yrs, 16-17yrs and 17-18yrs. At 7-8yrs males show higher value than female. Females show higher value in adult age ranges.

The decrease in the frequency range in phonation as a function of age in males and females is possibly an index of accuracy of the laryngeal adjustment during phonation. Therefore this reflects that the neuromuscular control improves with increasing age. The higher frequency ranges found in the group 13-14yrs of males and in females age group 8-9 may reflect disturbances in the neuromuscular control of the laryngeal system due to pubertal changes. These results are in agreement with the study by Rashmi (1985), Nataraja (1988) reported mean value of 3Hz for males and 7.6Hz for females in the age range 16-25yrs. The present study shows a higher value in both males and females in the adult age groups. Nataraja (1988) also reported significantly higher values for females which agrees with present study.

Very limited research data is avialable regarding the frequency range in the phonation (Rashmi 1985). Most of the studies have aimed at finding out the range of frequency that an individual is capable of producing. However Equchi and Hirsh (1969) studied the variability of Fo in vowels in sentence context and found that the variability progressively decreased with age.

Table-46a: Mean and Standard Deviation of the frequency range in the phonation of /a/ in tales and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	21.53	16.57	17.57	17.99	14.47	10.87	15.90	10.66	9.17	12.8	8.37	7.17	6.83	6.30	6.67
S.D	5.73	4.53	5.21	4.77	5.48	3.83	5.97	3.09	3.33	5.15	3.21	2.97	1.81	3.34	2.25
FEMALES;															
Mean	16.20	20.03	18.07	15.60	16.68	14.97	11.33	13.89	13.47	8.13	7.97	8.57	7.80	8.00	9.97
S.D	3.67	6.98	3.82	3.95	5.40	5.96	2.96	12.87	6.52	2.40	1.74	2.65	2.75	1.71	4.26

Table-46b! Mean and Standard Deviation of the frequency range in the phonation of /i/in tales and fetales

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	21.07	20.73	17.20	18.13	16.36	11.20	15.50	10.21	8.80	13.23	8.34	9.37	8.23	6.10	6.87
S.D	4.97	9.07	8.13	9.96	6.03	3.49	5.52	2.20	3.21	6.68	3.34	2.96	3.14	1.47	1.32
FEMALES;															
Mean	16.1	19.43	18.30	19.57	16.27	13.34	11.73	12.03	13.42	8.97	9.03	9.43	7.97	8.50	8.03
S.D	3.50	4.93	2.49	9.00	5.93	6.95	6.15	3.65	5.35	3.06	2.15	3.11	2.18	2.98	1.96

Table-46c: Mean and Standard Deviation of the frequency range in the phonation of /u/in tales and fetales

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Hean	21.57	16.83	15.33	14.27	18.23	10.83	13.30	13.23	8.66	12.50	7.88	8.47	5.10	6.17	6.27
S.D	5.73	7.72	4.60	2.99	10.02	2.97	5.70	6.65	2.79	5.00	2.90	2.47	1.45	1.84	1.41
FEMALES;															
Mean	15.51	18.37	16.63	16.96	14.80	12.47	11.43	10.40	15.56	8.87	8.53	9.37	8.50	8.80	7.97
S.D	4.85	4.98	3.50	6.71	7.08	4.68	4.31	3.58	7.21	1.44	2.24	2.58	2.27	3.59	1.43

Table-47: The significance of difference between different age groups of tales on the range of fo of phonation

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	A	A	A	P	P	P	P	P	P	P	P	P	P
8 - 9		A	A	A	P	A	P	P	A	P	P	P	P	P
9-10			A	A	P	A	P	P	A	P	P	P	P	P
10-11				A	P	A	P	P	A	P	P	P	P	P
l1-12					P	A	P	P	P	P	P	P	P	P
12-13						A	A	A	A	A	P	P	P	P
13-14							P	A	A	P	P	P	P	P
!4-!5								A	A	A	P	P	P	P
15-16				-					A	A	A	A	A	A
14-17										A	P	P	P	P
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-48: The significance of difference between different age groups of tales on the range of Fo of phonation /l/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	P	A	A	P	A	P	P	P	P	P	P	P	P
8 - 9		A	A	A	P	A	P	P	P	P	P	P	P	P
9-10			A	A	P	A	P	P	A	P	P	p	P	P
10-11				A	P	A	P	P	A	P	P	P	P	P
11-12					A	A	P	P	A	P	P	P	P	P
12-11						A	A	A	A	A	A	P	P	P
13-14							P	P	A	P	P	P	P	P
14-15								A	A	A	A	P	P	P
15-16									A	A	A	A	A	A
16-17										P	A	P	P	P
17-18											A	A	A	A
18-19												A	P	P
19-20													A	A
20-21														A

Table-49: The significance of difference between different age groups of tales on the range of Fo of phonation /u/

	8-9	9-10	10-H	11-12	12-13	13-14	14-15	15-16	14-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	P	P	A	P	P	P	P	P	P	P	P	P	P
8 - 9		A	A	A	A	A	P	A	P	P	P	P	P	P
9-10			A	A	P	A	A	P	A	P	P	P	P	P
10-11				A	P	A	A	P	A	P	P	P	P	P
11-12					A	A	A	P	A	P -	P	P	P	P
12-13						A	A	A	A	A	A	P	P	P
13-14							A	P	A	P	P	P	P	P
14-15								P	A	P	A	P	P	P
15-16									A	A	A	P	P	A
14-17										P	A	P	P	P
17-18											a	P	A	A
18-19												P	P	A
19-20													A	A
20-21														

Table-50: Ihe significance of difference between different age groups of females on the range of Fo of phonation /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	14-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	P	P	P	P	P	P	P	P	P
8 - 9		A	A	A	A	P	P	P	P	P	P	P	P	P
9-10			A	A	A	P	P	P	P	P	P	P	P	P
10-11				A	A	P	P	A	P	P	P	P	P	P
11-12					A	P	P	A	P	P	P	P	P	P
12-H						A	A	A	P	P	P	P	p	P
13-14							A	A	P	P	P	P	P	A
14-15								A	P	P	A	P	P	A
15-16									P	P	P	P	P	P
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

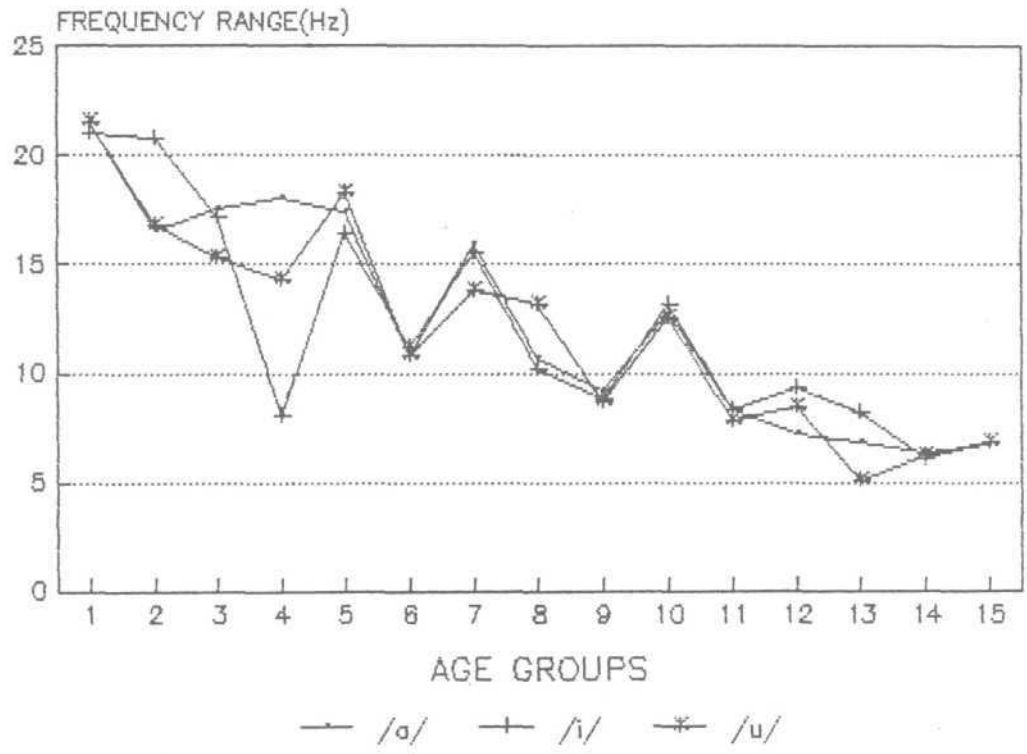
Table-51: The significance of difference between different age groups of females on the range of Fo of phonation /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	P	P	P	P	P	P	P	P	P
8 - 9		A	A	A	P	P	P	P	P	P	P	P	P	P
9-10			A	A	P	P	P	P	P	P	P	P	P	P
10-11				A	A	P	P	P	P	P	P	P	P	P
11-12					A	P	A	A	P	P	P	P	P	P
12-13						A	A	A	A	A	A	P	A	A
13-14							A	A	A	A	A	A	A	P
14-15								A	P	P	A	P	P	P
15-16									P	P	P	P	A	P
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	
20-21														A

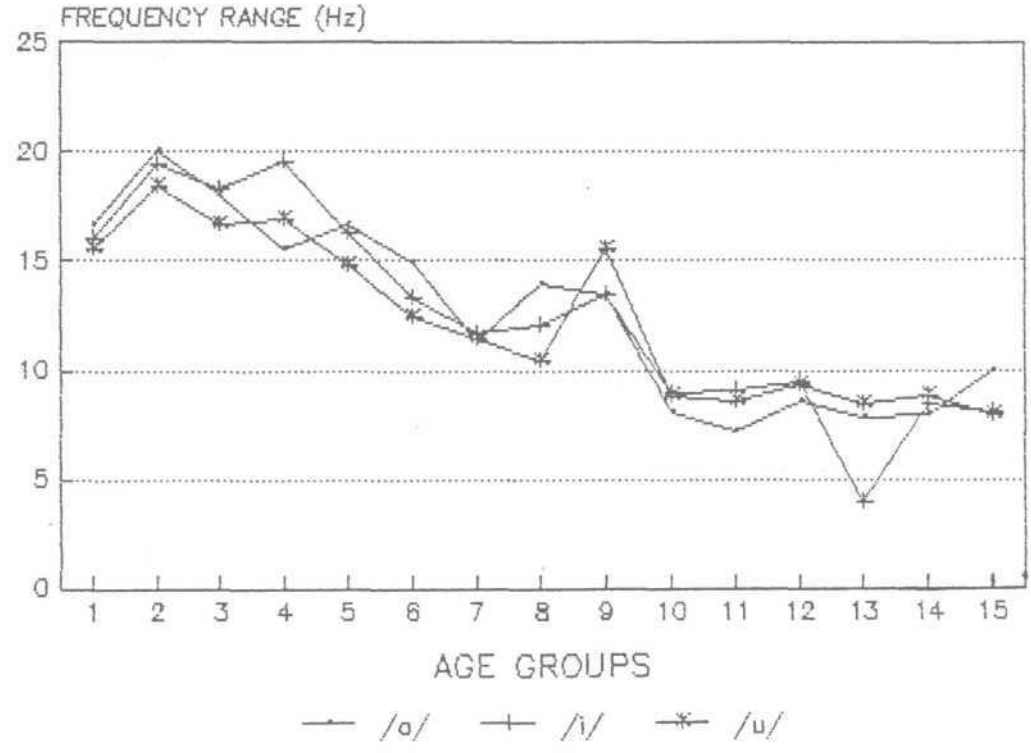
Table-52: The significance of difference between different age groups of females on the range of Fo of phonation /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	P	P	A	P	P	P	P	P	P
8 - 9		A	A	A	P	P	P	A	p	P	P	P	P	P
9-10			A	A	P	P	P	A	F	P	P	P	P	P
10-1l				A	A	P	P	A	P	p	P	P	P	P
11-12					A	A	A	A	P	P	P	P	P	P
12-13						A	A	A	A	P	A	P	A	P
13-14							A	A	P	A	A	A	P	P
14-15								P	A	A	A	A	A	A
15-16									P	P	P	P	P	P
14-17										A	A	A	P	A
17-18											A	A	A	A
18-t9												A	A	A
19-20													A	A
20-21														A

GRAPH-8: SHOWS FREQUENCY RANGE IN PHONATION IN MALES FOR /a/, /i/ & /u/



GRAPH-8: SHOWS FREQUENCY RANGE IN PHONATION IN FEMALES FOR /a/, /i/ & /u/



INTENSITY RANGE IN PHONATION

The tables 53a, 53b & 53c show the mean and S.D. values of intensity range in phonation of vowels /a/, /i/ and /u/ respectively for both males and females.

The investigation of tables 53a, 53b and 53c show that the mean values of 20-21yrs is lower than the mean values of 7-8yrs age groups for all the three vowels. The highest mean value for /a/ is 8.93dB at 7-8yrs and lowest is 3.93dB at 21-22yrs. There is a sudden drop in mean value from 8.93dB at 7-8yrs to 6.0dB at 8-9yrs. The highest mean value for /i/ is 8.6dB at 7-8yrs and lowest 4.9dB at 20-21yrs. The highest value for /u/ is 8.23dB at 7-8yrs and lowest is 4.7dB at 20-21yrs.

Both the vowels /i/ and /u/ shows significant decrease in mean value of intensity range in phonation from 7-8yrs to 8-9yrs age groups.

The S.D. values show a decreasing trend, in males with the lower values at 21-22yrs age groups. The S.D. values for /a/ 2.77 at 7-8yrs and the lowest S.D. value is 0.93 at 21-22yrs. The highest value for /i/ 2.73 at 7-8yrs, the lowest is 1.06 at 21-22yrs and the highest value for /u/ is 3 at 11-12yrs and lowest is 1 at 21-22yrs.

The test for significance of difference reveals (table 54, 55 and 56) that for vowel /a/ the mean values of 21-22 years age group is significantly different from age group 14-

15 and above. The age group 7-8 years is significantly different from 8-9 and above. The values of significant difference of /i/ and /u/ do not show any such a consistent trend.

Thus the null hypothesis stating that there's no significant difference in intensity range in phonation in males across age group is partly accepted and partly rejected.

In case of females the mean values are lowest towards the higher end as in males. The highest mean values for /a/ is 9.11dB at 8-9yrs and lowest is 4.63dB at 21-22yrs. There is a significant difference from 7-8yrs. The mean values drop again at 10-llyrs with changes little upto 16-17yrs. Again the mean values show that decrease with age upto 21-22yrs age groups. This changes are graphically presented in graph-9. The same trend is seen in both the vowels /i/ and /u/. But the S.D. values in female do not show any consistent pattern for the three vowels.

The test for significance of difference (tables 57, 58 & 59) reveals that the age group 17-18 and above are consistently significantly difference from lower age groups for all the three vowels with exception of 10-11 years, 12-13 years & 14-15 years in /u/ and 12-13yrs and 14-15yrs in case of /i/ which do not show any significant difference when compared with other groups.

Thus the null hypothesis stating that there is no significant difference in intensity range in phonation in females across age group is partly accepted and partly rejected.

Comparison between males and females shown that for /a/ significant difference were found only age groups 9-10yrs and 15-16yrs. In case of /i/ significant difference were found only age groups 7-8yrs, 8-9yrs and 14-15yrs and /u/ significant difference were found only for age groups 8-9yrs and 14-15yrs. Where ever significant difference were found female show higher values at lower age groups, but lower values at higher age groups.

Thus the null hypothesis stating that there no significant difference in intensity range in phonation between males and females is accepted.

The results regarding intensity range in phonation can be summarized as:

1) Both males and females show a gradual decrease in intensity range with the age.

2) Male show higher intensity range at 13-14 and females show in the age group 8-9 and 9-10yrs with corresponds to the onset of adolescent.

Rashmi (1985) reported similar results in case of male but in case of females reported no significant changes with age. This could be due to the difference in age range studied.

Nataraja (1988) reported mean values 3.8dB for adult males and 4.19dB for adult females in the phonation of /a/. The mean values range from 1 to 8dB in males and 1 to lldB in females. The mean values found in present study is slightly higher in males and females, in the ranges 18-19 years when compare to others that are reported.

So, it could be concluded that changes intensity range in phonation decreases with age and reaches adult values by 21-22 years in both males and females. And also it can be concluded that changes in intensity range with age will reflect neuromuscular changes.

FUNDAMENTAL FREQUENCY IN SPEECH

The mean S.F.F was determined for the three utterences i.e "idu papu", "idu koti" & "idu kempu banna" using the. method described in chapter III. The mean and S.D. values of speaking Fo for both males and females at each age group is presented in the Tables 60a. The mean values are also graphically presented in graph 4.

Table-53a: Mean and Standard Deviation of the range in intensity in the phonation of /a/ in tales and fetales

	7-8	8-?	9-10	10-11	H-12	12-13	13-14	14-15	15-16	16-17	17-18	18-1?	i9-20	20-21	21-22
MALES:															
Mean	8.?3	A.00	5.33	A.94	7.90	6.13	8.13	6.57	4.93	6.87	5.43	6.00	5.17	4.60	3.93
S.D	2.77	2.19	1.22	1.91	l.98	2.78	2.44	1.65	1.59	2.37	2.06	2.25	2.12	2.15	0.93
FEMALES:															
Mean	6.93	9.17	9.37	7.40	7.67	6.30	6.83	5.26	8.16	5.87	4.40	5.13	4.66	4.70	4.83
S.D	2.04	2.53	2.53	2.04	2.17	t.85	3.03	2.01	2.69	3.08	1.50	1.71	0.93	1.72	1.17

Table-53b: Mean and Standard Deviation of the range in intensity. in the phonation of /i/ in tales and females

	7-8	8-7	9-10	10-11	H-12	12-13	13-14	14-15	15-16	16-17	17-18	1B-19	19-20	20-21	21-22
MALES:															
Mean	8.60	5.60	5.40	5.57	7.26	4.97	7.44	6.83	5.10	7.56	4.97	5.33	4.93	4.90	5.23
S.D	2.73	2.12	1.64	1.89	2.05	2.28	2.77	0.59	1.96	2.05	1.71	1.40	1.46	2.09	1.06
FEMALES:															
Hean	6.35	8.10	A.73	7.23	6.90	5.40	7.00	5.10	7.75	5.60	4.33	4.73	4.13	4.54	4.40
	1.52	2.64	2.04	2.94	1.59	2.73	1.54	1.68	3.67	2.52	1.30	1.73	0.98	2.?t	1.31

Table-53c: Mean and Standard Deviation of the range in intensity in the phonation of /u/in tales and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	8.23	5.3616	8.56	5.49	8.87	5.03	6.97	6.87	5.00	6.64	4.80	5.27	5.53	4.77	4.80
S.D	2.35	1.65	1.73	2.00	3.00	2.84	3.23	1.33	1.71	2.42	1.92	1.62	1.93	1.46	1.00
FEMALES:															
Mean	6.72	8.80	7.30	5.41	7.47	5.53	6.60	4.60	7.65	6.03	4.57	4.53	4.80	4.50	4.20
S.D	1.83	2.49	1.79	1.90	1.42	2.33	2.10	2.51	2.72	2.70	1.91	2.53	1.28	1.73	1.34

Table-54: The significance of difference between different age groups of tales on intensity in phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	P	A	A	P	A	P	P	A	P	P	P	P	p
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	P
9-10			P	P	A	P	A	A	A	A	A	A	A	P
10-11				A	A	A	A	P	A	A	A	A	P	P
11-12					A	A	P	P	A	P	A	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							A	P	A	P	A	P	P	P
14-15								A	A	A	A	A	P	P
15-16									A	A	A	A	A	A
16-17										A	A	A	P	P
17-16											A	A	A	A
18-19												A	A	A
17-20													A	A
20-21														A

Table-55: The significance of difference between different age groups of males on intensity in phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	P	P	A	P	A	A	P	A	P	P	P	P	P
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	A
9-10			A	P	A	A	P	A	P	A	A	A	A	A
10-11				A	A	A	A	A	P	A	A	A	A	A
11-12					P	A	A	P	A	P	P	P	P	P
12-13						P	P	A	P	A	A	A	A	A
13-14							A	A	A	P	A	P	P	P
14-15								P	A	P	p	P	P	P
15-16									A	A	A	A	A	A
16-17										P	P	P	P	P
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-5&: The significance of difference between different age groups of males on intensity in phonation of/u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-14	14-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	A	P	A	P	A	A	P	A	P	P	P	P	P
8 - 9		A A		P	A	A	P	A	A	A	A	A	A	A
9-10			A	A	A	A	A	A	A	A	A	A	P	P
10-11				P	A	A	A	A	A	A	A	A	A	A
11-12					A	A	A	P	A	P	P	P	P	P
12-13						A	P	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								P	A	P	P	A	P	P
15-14									A	A	A	A	A	A
14-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-57: The significance of difference between different age groups of fetales on intensity in phonation of /a/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	P	A	A	A	A	P	A	A	P	P	P	P	P
8 - 9		A	A	A	P	A	P	A	P	P	P	P	P	P
9-10			A	A	P	P	P	A	P	P	P	P	P	P
10-11				A	A	A	P	A	A	P	P	P	P	P
11-12					A	A	P	A	A	P	p	P	P	P
12-15						A	A	A	A	P	A	P	P	P
13-14								A	A	P	A	A	A	A
14-15								P	A	A	A	A	A	A
15-14									A	P	P	P	P	P
14-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

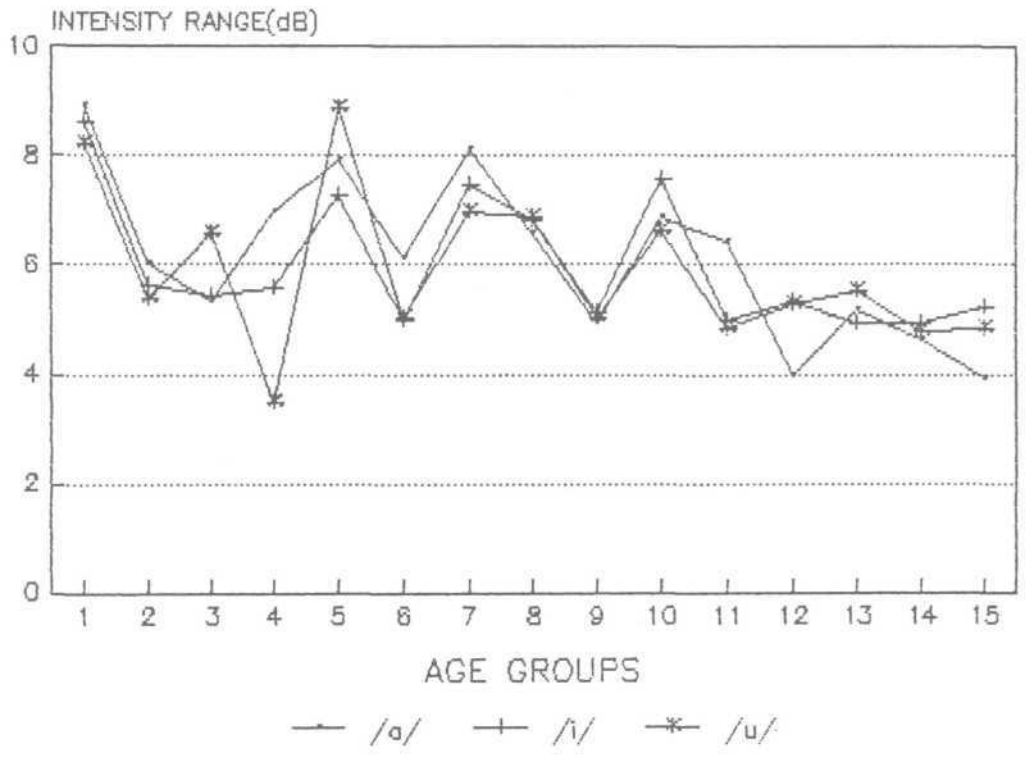
Table-58: The significance of difference between different age groups of females on intensity in phonation of /i/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	A	P	A	P	A	P
8 - 9		A	A	A	P	A	P	A	A	P	P	P	P	P
9 - 10			A	A	A	A	A	A	A	P	A	P	A	P
10-11				A	A	A	A	A	A	P	P	P	A	A
1l - 12					A	A	P	A	A	P	P	P	P	P
12 - 13						P	A	A	A	A	A	A	A	A
13 - 14							P	A	A	P	P	P	P	P
14 - 15								A	A	A	A	A	A	A
15 - 16									A	P	P	P	A	P
16 - 17										A	A	A	A	A
17 - 18											A	A	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

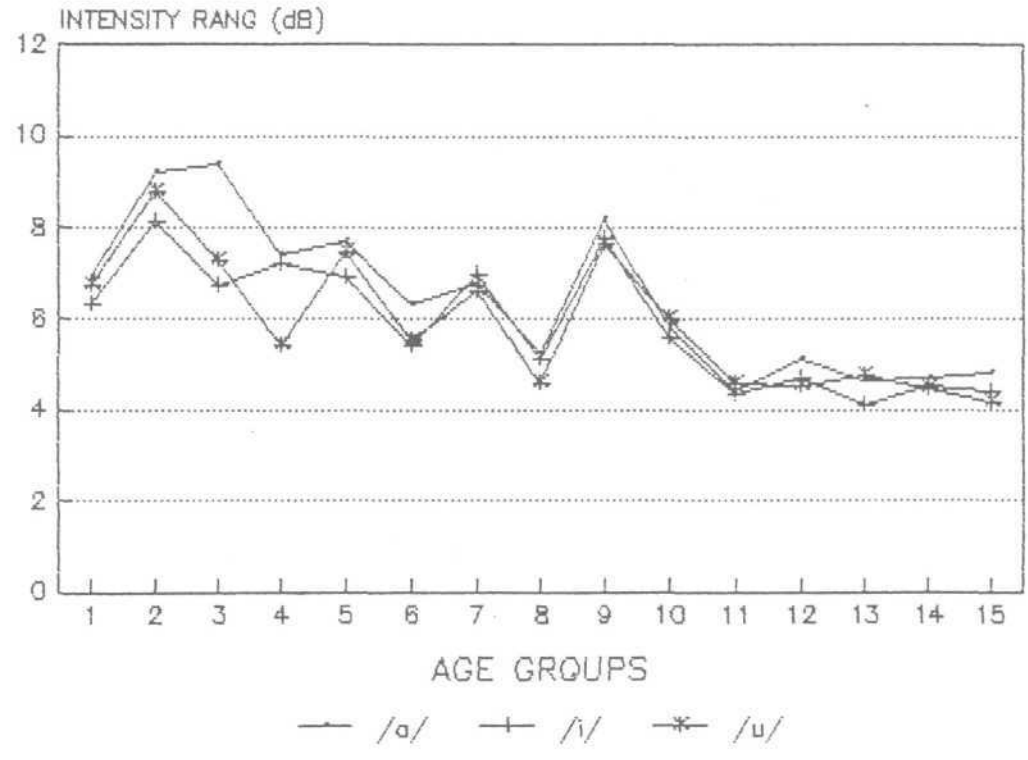
Table-59: The significance of difference between different age groups of females on intensity in phonation of /u/

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	P	A	A	P	P	P	P	P
8 - 9		A	P	A	P	P	P	A	P	P	P	P	P	P
9 - 10			P	A	A	A	P	A	A	P	P	P	P	P
10 - 11				P	A	A	A	A	A	A	A	A	A	A
11 - 12					P	A	P	A	A	P	P	P	P	P
12 - 13						A	A	P	A	A	A	A	A	A
13 - 14							P	A	A	P	P	P	P	P
14 - 15								P	A	A	A	A	A	A
15 - 16									A	P	P	P	P	P
14 - 17										A	A	A	A	A
17 - 18											A	A	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

GRAPH-9: SHOWS INTENSITY RANGE IN PHONATION IN MALES FOR /a/, /i/ & /u/



GRAPH-9: SHOWS INTENSITY RANGE IN PHONATION IN FEMALES FOR /a/, /i/ & /u/



The inspection of mean values for males shows that the mean S.F.F decreases with age gradually. The highiest value being 263.5Hz at 7-8yrs, the lowest is 130.7Hz at 21- 22yrs. The mean S.F.F decreases gradually from 7-8yrs to 14- 15yrs with an average decrease of only 28Hz. Then there is a sudden drop at the age group 15-16yrs i.e from 238Hz at 14- 15yrs to 150.3Hz at 15-16yrs. Again there is a small decrease at the age group 19-20yrs (from 152Hz at 18-19yrs to 135.3Hz at 19-20yrs) then reaching a plateau.

The S.D value also show a decrease with age. The highest value is 32.48 at ll-12yrs and the lowest is 6.76 at 16-17yrs.

The data on females also shows a decrease in SFF with age. However the change ig less as compared to that of males. The highiest is 273.9Hz at 7-8yrs and the lowest 235.6Hz at 18-19yrs. There is sudden drop at the age group 8-9yrs, after which the value do not change much upto 17-18yrs age group. Again there is small decrease at 18-19yrs of age. The S.D value do not show consistent change with age. The lowest is 14.06 at 21-2yrs and the highest is 22.42 at 18-19yrs.

The results of Mann-whitney 'U' test of significance of difference is reported in the tables 61 and 62. The inspection of these shows that the younger age group 7-8yrs to 13-14yrs shows significant difference when compared with

higher age groups 14-15yrs to 21-22yrs. The suddern drop in S.F.F. at 15-16yrs is significant at 0.0001 level. The drop at age group 19-20yrs is also significant at 0.0001 level when compared with the lower age groups. In females the S.F.F.value remains stable for most of the age groups. There is a drop in S.F.F. at 8-9yrs after which there is a gradual decrease. Significant differences are also found between 18-19yrs, 19-20yrs and 7-8yrs to 9-10yrs and 15-16yrs to 17-18yrs.

Hence the null hypothesis stating that there is no significant difference in S.F.F. across age group with refference to both males and females partly accepted and partly rejected.

Comparison between males and females, in terms of SFF as shown in table 81 reveals that significant differences are found after the age group 14-15yrs, i.e after the onset of puberty in boys. Hence the null hypothesis stating that there is no significant differences between males and females in all age groups is partly accepted and partly rejected.

The results can be summarized as follows:

1. Both males and females decreasing trend with age but the decrease in SFF is marked in males.

2. In males the significant drop in SFF is found at the age group 15-16yrs.

3. Age group 14-15yrs and above shows significant difference between males and females.

4. The changes are parellel to the changes in Fo of phonation.

The values of SFF found in the present in slightly higher than the values quoted by Rashmi (1985). The present study shows a drop in SFF for males at 15 to 16 years where as Kushal Raj (1983) reports drop at 11 years and Rashmi at 14 years. These variations may be due to the variations in the population studied. The results also shows no significant changes in lower age groups which is in close agreement with other investigators. (Kushal Raj,1983; Rashmi, 1985)

Hudson and Halbrook (1981) reported mean Fo in reading in black adults with age range of 18-29yrs. They reported Fo of 110.15Hz in males and 193.1Hz in femals. Compare to this the present study shows higher Fo in adults. This may be again due to difference in population studied.

A comparision with Fo- of the phonation also shows a similar trend for males and females.

Table-60a: Mean and S.D. of Fundamental frequency in speech (Hz) in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	263.50	248.20	249.10	250.90	261.30	237.00	257.30	238.00	150.30	144.10	157.60	152.00	135.30	143.06	130.70
S.D	27.83	14.65	12.30	28.43	32.48	13.96	22.16	13.03	15.00	6.76	16.27	16.00	10.15	13.66	14.84
FEMALES:															
Mean	273.90	254.30	255.70	241.50	264.60	245.30	253.00	251.00	260.00	252.20	253.20	235.60	237.10	241.50	241.00
	16.37	18.70	16.28	11.35	18.42	17.76	20.74	15.56	15.00	12.98	12.43	22.42	12.19	16.72	14.06

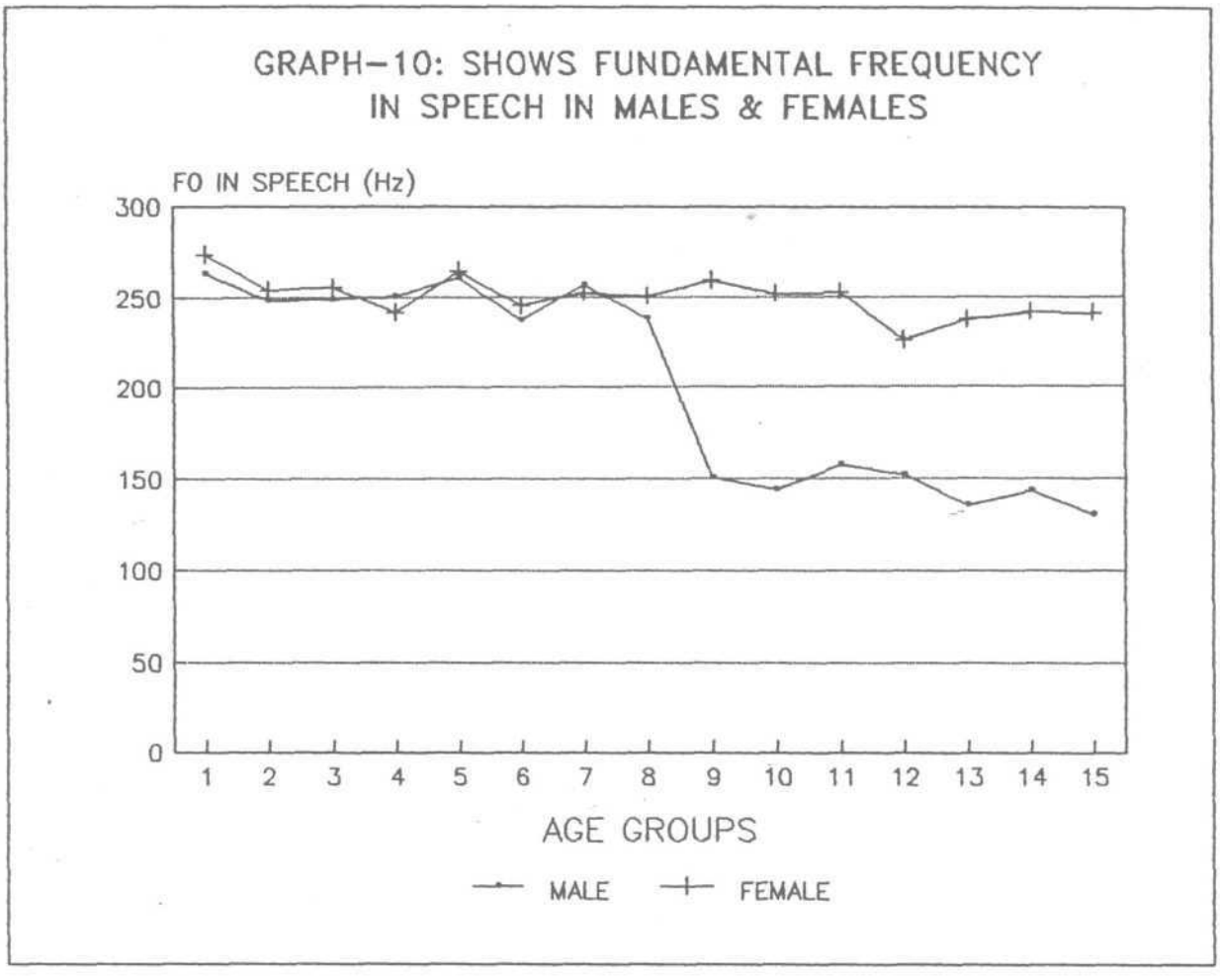


Table-61: Significance of difference between different age groups of males in Fundamental frequency of speech

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-i7	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	P	A	P	P	P	P	P	P	P	P
8 - 9		A	A	A	A	A	P	P	P	P	P	P	P	P
? - 10			A	A	A	A	P	P	P	P	P	P	P	P
10 - 11				A	A	A	P	P	P	P	P	P	p	P
11 - 12					A	A	P	P	P	P	P	P	P	P
12 - 13						A	P	P	P	P	P	P	P	P
13 - 14							P	P	p	P	P	P	P	P
14 - 15								P	P	P	P	P	P	P
15 - 16									A	A	A	P	A	P
16 - 17										P	A	P	P	A
17 -18											A	P	P	P
18 - 19												P	A	P
19 - 20													A	A
20 - 21														A

Table-62: Significance of difference between different age groups of females in Fundamental frequency of speech

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	P	P	A	P	P	P	A	P	P	P	P	p	P
8 - 9		A	A	A	A	A	A	A	A	A	P	P	A	A
9 - 10			P	A	A	A	A	A	A	A	P	P	P	P
10 - H				p	A	A	A	P	P	A	A	A	A	A
11 - 12					P	A	A	A	A	P	P	P	p	P
12 - 13						P	A	A	A	A	A	A	A	A
13 - 14							A	A	A	A	A	A	A	A
14 - 15								A	A	A	A	A	A	A
15 -16									A	A	P	P	p	P
16 - 17										A	P	P	A	A
17 - 18											P	P	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

FREQUENCY RANGE IN SPEECH

The frequency range in speech was analysed using the same three utterances "idu papu", "idu koti" and "idu kempu banna". The mean frequency range in speech and S.D. of frequency range in speech obtained for each age group in both males and females are provided in the table 60b. This is also graphically represented in graph 11.

The mean value of range for males show a decreasing trend with increasing age, whereas S.D. value do not show any consistent trend. The highest mean value is 100.6Hz at 8-9yrs and the lowest is 63.7Hz at 14-15yrs.

The test for significance of difference was aplied results of which are shown in table 63. Examination of this table shows that lower group(7-8yrs to ll-12yr) shows significant differences with the age groups 14-15 and above. Again age group 13-14yrs shows significant differncess with age groups 14-15yrs to 18-19yrs. Thus there is a decreases in mean frequency range of speech upto 14-15yrs after which it reaches a plateau.

Thus the null hypothesis statins that there is no significant difference in terms of frequency range in speech across age groups is partly accepted and partly rejected with reference to males.

Females do not exihibit any consistent trend in mean values with age, but S.D. values of the lower groups are

higher than the rest. The test of significance (table 64) do not show any significance changes with the age.

Comparisons between males and females show that, significant differences between males and females, in SFR is present in the adolescent age groups 14 to 17 years and in age groups 10-11 and 11-12 years. This again indicates inability to control laryngeal phonatory mechanism due to perbertal changes. Females show higher mean values than males, in these age groups.

Thus null hypothesis stating that there is no significant difference in terms of frequency range in speech between males and females is partly accepted and partly rejected.

The results can be summarized as follows:

1) Males show significant decrease with increase in age. Where as in females only age groups 7-8 and 9-10 years show a lower values than other age groups.

2) Significant difference between males and females are present in the age range 14 to 17 years.

The result in the present study is in agreement with the earlier studies Rashmi (1985), Kushal Raj (1983). In present study age group 7-8 and 8-9 shows significantly higher values than other groups. Whereas Rashmi (1985) reported higher values in age groups 4-5 and 7-8 years. In females the age range 8-9, 11-12 shows a significantly higher values in the

present study. Rashmi (1985) also has reported higher values in 8-9 and 5-6 years.

Eguchi and Hirsh (1969) in a study of fundamental frequency variability, for the vowels /i/, /ae/, /u/, /e/, /a/ and /o/ in the sentence context for the age range 8 to 13 years, found that the variability of fundamental frequency progressively decreased with age, until a minimum was reached at about 10-12 years. This is taken as an index of accuracy of laryngeal adjustments during vowel production, then the control improves continuously over a period of atleast 7 to 9 years.

Hudson and Holbrook (1981) studied the fundamental vocal frequency range is reading for subjects ranging in age from 18-29 years, and found a range from 81-95Hz to 158.50Hz in males and from 139.05Hz to 266.10Hz in females. The frequency range used by the subjects of this study are very similar, although it involved a younger age group.

INTENSITY RANGE IN SPEECH

The mean and S.D. for the intensity range in speech for all the age groups as measured using the atterances "Idu Papu", "Idu Koti" and Idu Kempu banna" is presented in table 60c.

The mean values for range of intensities used by the males shows the increasing trend in mean values of intensity range in speech and decreasing trend in S.D. values. The lowest mean value of 17.8dB at 7-8 years and highest of 29.1dB at 21-22 years are seen.

Table-60b: Mean and S.D. of Frequency Range in Speech (Hz) in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	94.30	100.60	87.30	74.30	85.00	71.50	84.80	63.70	73.10	64.20	64.10	67.50	79.70	82.70	73.00
S.D	13.98	24.50	18.92	16.79	16.69	13.35	16.74	6.58	13.00	8.07	9.87	11.54	2.27	17.02	14.19
FEMALES:															
Mean	83.40	104.10	89.90	100.30	105.60	95.60	93.50	95.60	100.80	97.40	102.00	92.40	92.70	92.70	97.60
S.D	23.13	23.54	15.10	22.04	11.08	14.24	13.25	12.11	11.37	11.17	12.62	14.65	8.00	15.14	15.28

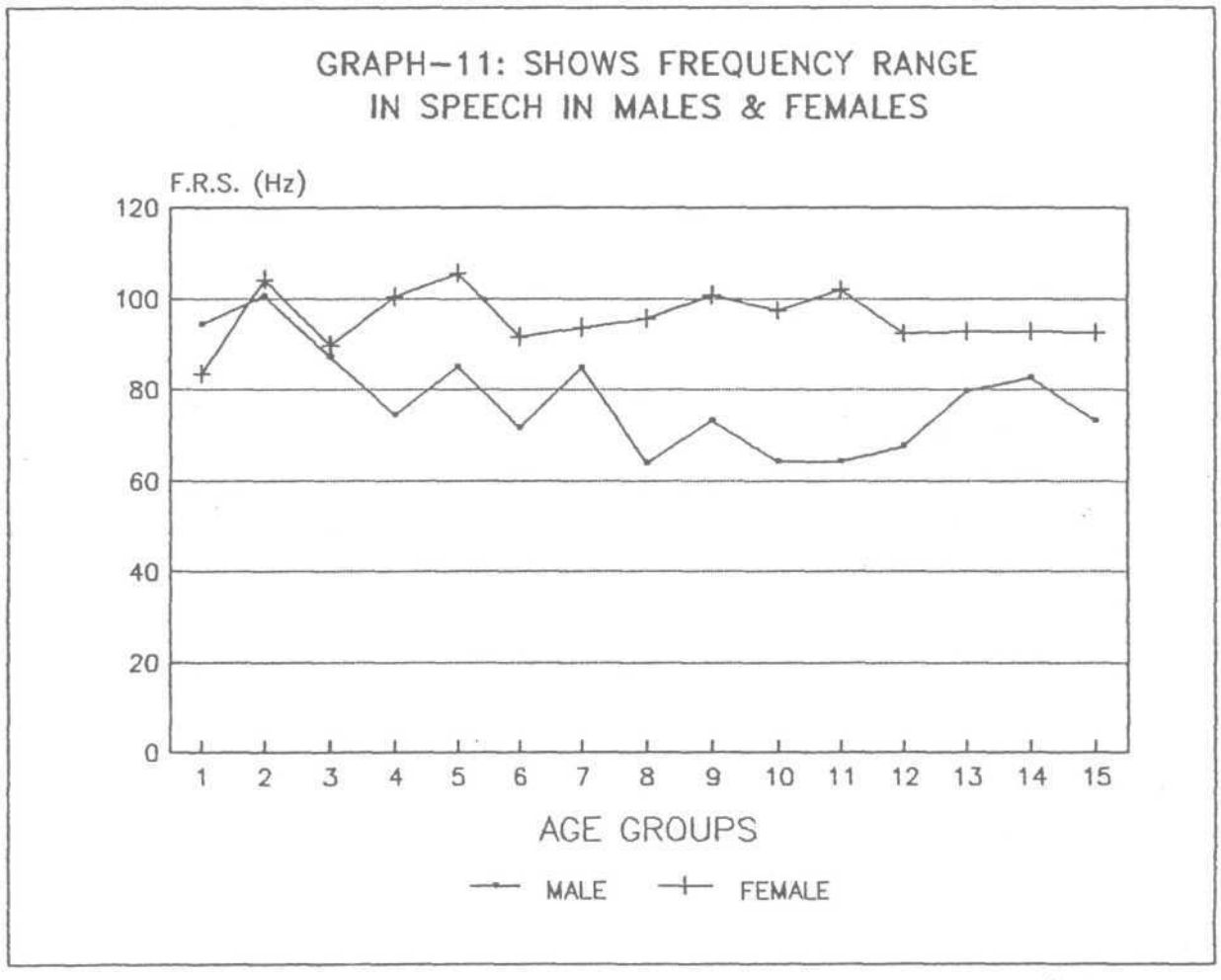


Table-63: Significance difference between different age groups in Frequency Range in speech in males

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	P	A	P	A	P	P	P	P	P	P	P	P	P
8 - 9		A	P	A	P	A	P	P	P	P	P	P	P	P
9-10			A	A	A	A	P	A	P	P	P	A	P	A
10-11				A	A	A	A	A	A	A	A	P	A	A
11-12					A	A	P	A	P	P	P	P	P	P
12-13						A	A	A	A	A	A	A	A	A
13-14							P	A	P	P	P	A	A	A
14-15								A	A	A	A	P	P	A
15-16									A	A	A	A	A	A
16-17										A	A	P	A	P
17-18											A	P	P	A
18-19												A	P	A
19-20													A	A
20-21														A

Table-64: Significance difference between different age groups in Frequency Range in speech in females

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	A	A	P	A	P	A	P	P	P	A	A	A	A
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	A
9-10			a	A	A	A	A	A	A	A	A	A	A	A
10-11				A	A	A	A	A	A	A	A	A	A	A
11-12					P	A	A	A	A	A	P	P	A	A
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	P	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

The test for significance of difference (table 65) shows that age groups 7-8, 10-11 and 11-12 years shows statistically different with its higher age groups. Again age groups 13-14 and 17-18 years shows significant difference with age groups 19-20 to 21-22 years. This could be because they show a slightly lower values than the other age groups.

Hence the null hypothesis stating that there is no significant difference across age groups in males is partly accepted and partly rejected.

Mean and S.D. values of intensity range in females does not show any consistent pattern, and does not show any statistically significant difference between any of age groups as for the Mann-Whitney test which was applied to know the significance difference (table 66).

Hence the null hypothesis stating that there is no significant difference across age groups in females is accepted.

The comparison of males and females shows no significant difference in majority of the age groups. However males show a lower value than females.

Hence the null hypothesis stating that there is no significant difference between age groups in males and females is accepted.

Rashmi (1985) reported gradual insignificant decrease in the range of intensity in males. And in females inconsistent results were found with only few age groups showing difference with reference to higher age ranges than others.

The present study has similar results in case of males, but in females no significant difference was found between the age groups studied.

The results can be summarized as follows:

1) The males show increasing trend in mean values and decreasing trend in S.D. values with age. But females do not show any consistent changes.

2) Male show a lower values than females. However these difference are no significant in majority of age groups.

RISE TIME IN PHONATION

The mean and S.D. of rise time in the phonation of /a/, /i/ and /u/ are represented in tables 67a, 67b & 67c . respectively for both males and females.

The tables 67a, 67b and 67c reveal that the mean and S.D. value for males do not show any consistent patterns of change. This is clearly show in graph-13. The value at 7-8 years for /a/ is lO.lcsec and 2.47, for /i/ it is 10.6csec and 2.58, for /u/ it is 9.5csec and 2.45. The values at 21-22 years for /a/ is 11.2csec and 2.86, for /i/ 12.9csec and 4.08 and for /u/ 12.9csec and 2.02. The table also show that in /a/ and /i/ both younger children and adults show lower values then the rest. In /u/ age groups 7-8yrs, 13-14yrs and 20-21yrs show lower values then the rest.

Table-60c: Mean and S.D. of Intensity Range in Speech (dB) in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	17.80	22.00	24.30	20.70	20.50	27.60	23.90	28.30	25.80	25.40	24.90	26.00	27.30	27.80	29.10
S.D	5.49	4.69	4.74	2.75	4.20	3.60	3.31	2.95	2.74	3.10	2.28	3.74	2.67	2.82	2.85
FEMALES:															
Mean	28.00	26.30	28.90	27.20	28.20	25.90	27.50	28.60	27.00	25.80	27.80	27.70	28.00	29.20	29.30
S.D	2.67	4.03	2.38	3.19	2.97	4.95	3.27	2.95	2.49	3.49	2.82	2.83	3.30	2.20	2.67

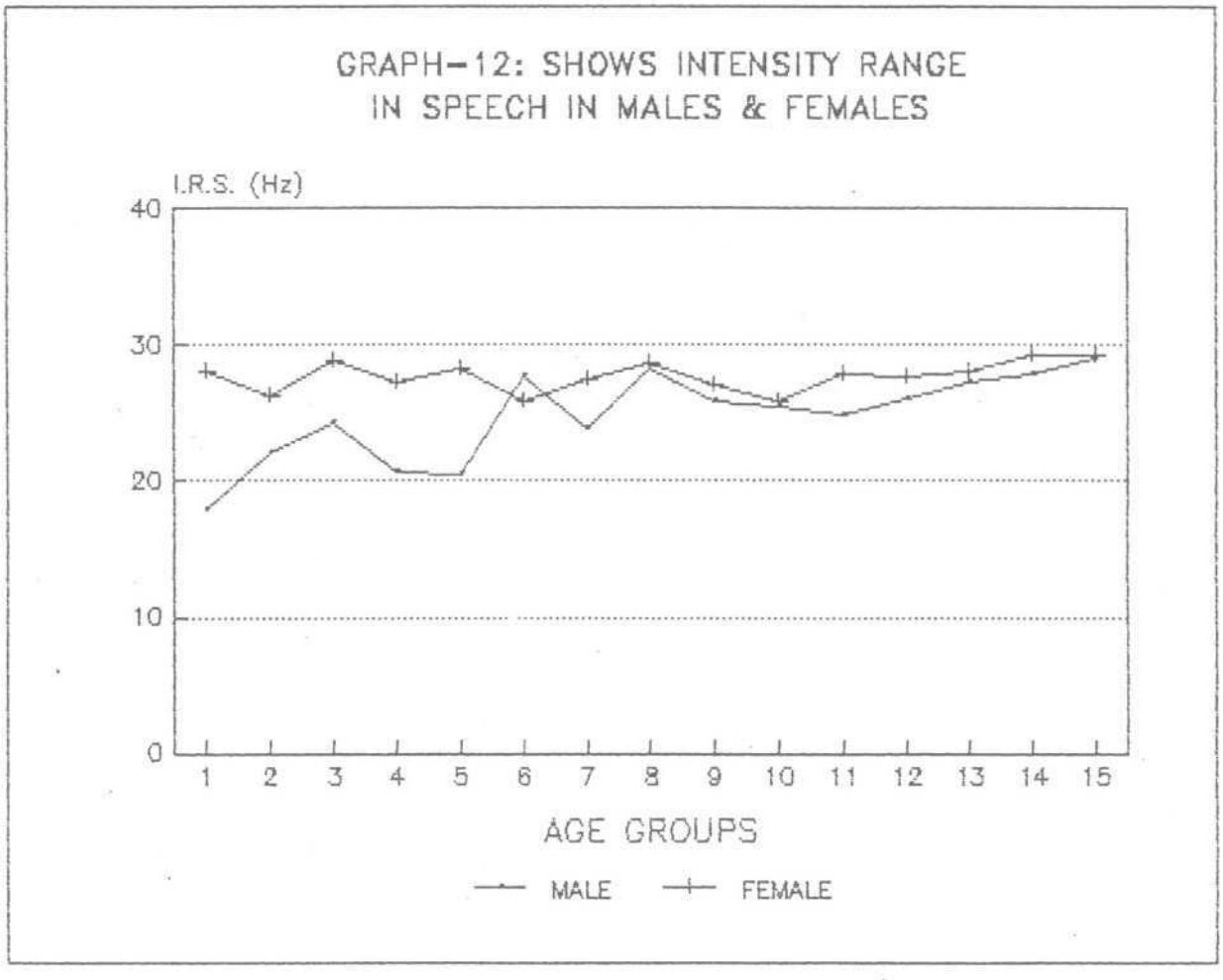


Table-65: Significance of difference between different age groups in tales in intensity range in speech

	8-9	9-10	10-11	H-12	12-13	13-14	14-15	15-1&	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	F	A	A	P	P	P	P	P	P	P	P	P	P
8 - 9		A	A	A	P	A	P	P	A	A	A	P	P	P
9 - 10			a	P	P	A	A	A	A	A	A	A	A	P
10-11				A	P	P	P	P	P	P	P	P	P	P
11-12					P	A	P	P	P	P	P	P	P	P -
12-13						A	A	A	A	A	A	A	A	A
15-14							P	A	A	A	A	P	P	P
14-13								P	P	P	A	A	A	A
15-16									A	A	A	A	A	P
16-17										A	A	A	P	A
17-18											A	P	P	P
18-19												A	A	A
19-20													A	A
20-21														A

Table-66: Significance of difference between different age groups in females in intensity range in speech

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	A	A	A	A	A	A	A
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	A
9-10			A	A	A	A	A	A	A	A	A	A	A	A
10-11				A	A	A	A	A	A	A	A	A	A	A
11-12					A	A	A	A	A	A	A	A	A	A
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

The highest S.D. value for /a/ is 4.28 at 18-19yrs and lowest is 2.4 at 10-llyears. For /i/ the highest is 4.08 at 21-22yrs and lowest is 1.81 at 9-10yrs. For /u/ the highest values is 4.71 at 19-20yrs and lowest values is 1.58 at ll-12yrs. The S.D. values do not show any consistent change with age.

The test of significance show (tables 68, 69 & 70) no consistent significant changes for /a/. For /i/ the group 14-15 years is significantly different with lower age groups, but not with the higher age groups. The group 9-10yrs shows significant difference with age group 14-15yrs and above. The values of /u/ show a similer picture to that of /a/.

Thus the null hypothesis stating that there is no significant difference in Rise time of phonation in males across age group is partly accepted and partly rejected.

The mean values for females also show a variable picture in all the three vowels. The age group 8-9yrs show higher values in both /a/ and /i/, both in terms of mean and S.D. values. The lower values are found in age group 20-21yrs for all the three vowels.

The test of significance of difference for rise time in phonation shows scattered findings across age groups studied for all the three vowels.

Thus the null hypothesis stating that there is no significant difference in Rise time in phonation as function age in females is partly accepted and partly rejected.

Inspection of table-81 shows that there is no significant difference between males and females for vowel /a/ at any of the age groups except the age group 16-17yrs. For vowel /i/ significant difference between males and females were found only in the age groups 10-llyrs, 16-17yrs and 17-18yrs. For vowel /u/ again significant difference only in age groups 16-17yrs, 17-18yrs and 21-22yrs.

Thus the null hypothesis stating that there is no significant difference between males and females with respect to the rise time in phonation of vowel is accepted.

The results can be summarized as follows:

1) a) There is no significant difference change in rise time in phonation of /a/ and /u/ in males.

   b) In vowel /i/ age group 14-15yrs show significantly difference higher values than the lower age group. Similarly age group 9-10yrs shows significantly lower value than the rest.

2) In females the rise time in phonation decreases gradually with age.

3) Significant difference in male are present in age group 16-17yrs for /a/, 10-llyrs, 16-17yrs and 17-18yrs for /i/

and 17-18yrs, and 21-22yrs for /u/. In all these age groups females show lower value.

The low values of rise time found in younger age groups and found in males may indicate increase laryngeal control as well as respiratory system adjustments made more development neuromuscular system, thus building up subglottal pressure required for phonation. The higher values in rise time across the age group 13-14yrs to 17-18yrs may indicate that disruption in laryngeal control and coordination between respiratory and phonatory system seen in adolescence. Similarly higher rise time found in age range of 9-10yrs, 10-llyrs and ll-12yrs. In females may be due to onset of puberty.

FALL TIME IN PHONATION

The mean and S.D. values of fall time in phonation for /a/, /i/ and /u/ are presented in tables 74a, 74b & 74c respectively, for both males and females.

The inspection of tables 74a, 74b and 74c indicates that the fall time shows an increasing trend as a function of age which is clearly evident in graph (14). The S.D. values also shows increasing trend. These value are in contrast with rise time.

Table-67a: Mean and Standard Beviation of the rise time in phonation of /a/ in tales and females

	7-8	8-9	9-10	..10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	iO.iO	?.00	8.97	10.20	13.23	10.00	11.10	12.00	13.14	12.10	11.20	14.50	9.60	9.80	11.20
S.B	2.47	2.58	2.60	2.94	2.40	3.02	4.12	3.94	3.37	2.69	2.70	4.28	5.46	3.36	2.86
FEMALES:															
Mean	9.8	14.30	10.90	11.80	12.30	9.90	11.60	9.60	10.50	8.30	9.50	11.77	11.00	8.10	10.30
S.B	2.78	4.19	1.79	2.53	3.59	4.01	3.57	2.67	3.14	3.27	1.27	4.33	2.75	1.29	3.42

Table-67b: Mean and Standard Beviation of the rise time in phonation of /i/ in mtales and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MLES:															
Mean	10.60	10.50	8.97	10.33	11.00	9.90	11.00	14.00	13.10	12.2')	13.40	12.00	9.80	8.80	12.90
S.B	2.58	3.24	t.ai	3.00	2.71	2.77	3.59	2.98	4.04	3.89	3.78	3.43	3.77	3.46	4.08
FEMALES;															
Mean	8.10	12.40	11.60	13.00	11.80	10.60	11.50	11.20	11.20	9.10	9.90	15.20	10.70	9.50	10.60
	2.50	3.10	3.10	2.40	1.87	3.66	3.34	3.43	2.62	2.29	2.02	5.55	1.64	2.68	4.30

Table-67c: Mean and Standard Deviation of the rise time in phonation of/u/ in tales and fetales

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	?.50	10.50	10.10	11.73	12.60	10.10	9.50	12.80	13.90	12.90	14.60	12.00	12.20	9.60	12.90
S.D	2.45	3.03	2.33	3.68	i.58	2.85	2.06	3.65	2.96	3.82	2.80	2.98	4.71	4.35	2.62
FEMALES;															
Mean	9.70	12.10	10.30	12.50	11.70	10.90	10.70	10.40	11.80	9.40	9.70	12.39	10.80	9.10	10.30
S.D	1.89	3.03	3.06	2.59	2.93	2.51	3.50	3.44	2.78	3.31	1.49	4.62	2.15	3.11	3.40

Table-68: Significance of difference between different age groups in risetime in phonation for /a/ in tales

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	A	A	A	P	A	A	P	A	A	A
8 - 9		A	A	P	A	A	P	P	P	A	P	A	A	P
9 - 10			A	P	A	A	P	P	P	A	P	A	A	A
10 - 11				P	A	A	A	P	A	A	P	A	A	A
11 - 12					P	A	A	A	A	A	A	P	P	A
12 - 13						A	A	P	A	A	P	A	A	A
13 - 14							A	A	A	A	A	A	A	A
14 - 15								a	A	A	A	A	A	A
15 - 16									A	A	A	P	P	A
16 - 17										A	A	A	A	A
17 - 18											A	A	A	A
18 - 19												P	P	A
19 - 20													A	A
20 - 21														a

Table-69: Significance of difference between different age groups in rise time in phonation for/i/ in tales

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	P	A	A	P	A	A	A	A
8 - 9		A	A	A	A	A	P	A	A	A	A	A	A	A
9 - 10			A	A	A	A	P	P	P	P	P	A	A	P
10 - 11				A	- A	A	P	A	A	P	A	A	A	A
11 - 12					A	A	P	A	A	A	A	A	A	A
12 - n						A	P	P	A	A	A	A	A	A
13 - 14							P	A	A	A	A	A	A	A
14 - 15								A	A	A	A	P	P	A
15 - 16									A	A	A	A	P	A
16 - 17										A	A	A	A	A
17 - 18											A	P	P	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														P

Tabie-70: Significance of difference between different age groups in rise time in phonation for . in Malees

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	A	A	P	P	P	P	A	A	A	P
8 - 9		A	A	A	A	A	A	P	A	P	A	A	A	A
9 - 10			A	P	A	A	A	P	p	p	A	A	A	P
10 - 11				A	A	A	A	A	A	A	A	A	A	A
11 - 12					P	P	A	A	A	P	A	A	P	A
12 - 13						A	A	P	P	P	A	A	A	p
13 - 14							P	P	P	P	A	A	A	P
14 - 13								A	A	A	A	A	A	A
15 - 16									A	A	A	A	P	A
16 - 17										A	A	A	A	P
17 - 18											P	A	p	A
18 - 19												A	A	A
1? - 20													A	P
20 - 21														

Table-71: The significance of difference between different age groups in rise time in phonation of /a/ of females

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	P	A	A	A	A	A	A	A	A	A	A	A	A
8 - 9		p	A	A	P	A	p	P	p	P	A	P	A	P
9 - 10			A	A	A	A	A	A	P	A	A	A	A	A
10 - 11				A	A	A	A	A	p	P	A	A	A	A
11 - 12					A	A	A	A	P	P	A	A	A	A
12-13						A	A	A	A	A	A	A	A	A
13 - 14							A	A	P	A	A	A	A	A
14 - 15								A	A	A	A	A	A	A
15 - 16									A	A	A	A	A	A
16 -17										A	A	P	A	A
17 - 18											A	A	A	A
18 - 19												A	p	A
19 - 29														A
20 - 21														A

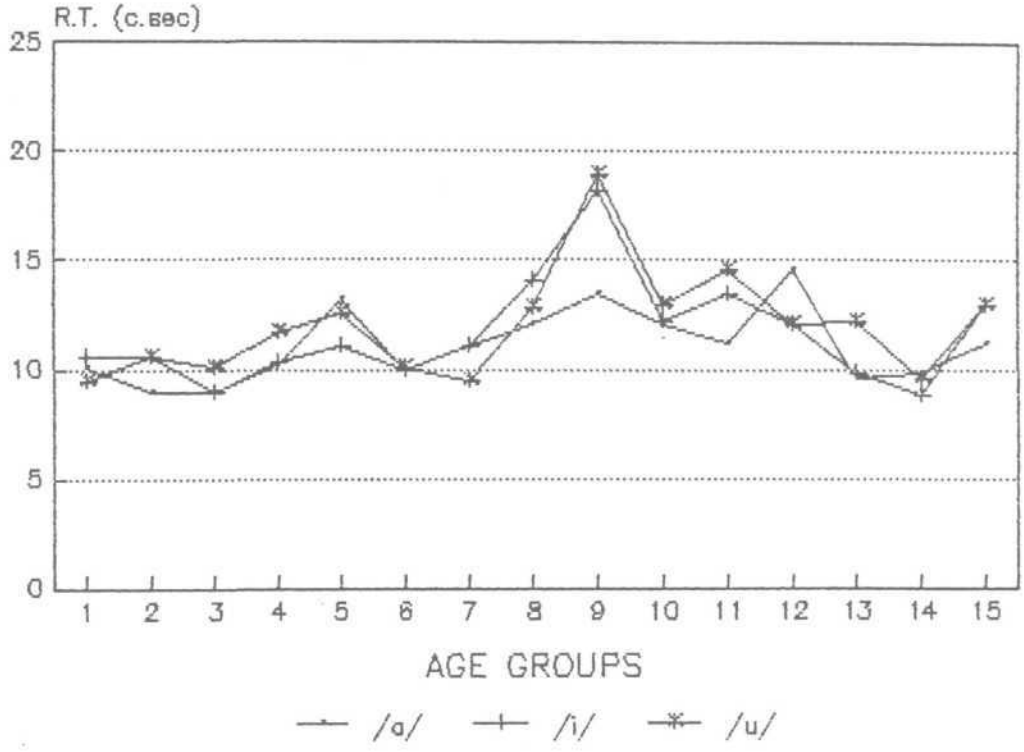
Tabte-72: The significance of difference betMeen different age groups in rise tiaein phonation of /i/ of feaaies

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17.	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A		A	A	A	A	A	A	A	A
8 - 9		A	A	A	A	A	A	A	P	P	A	A	P	A
9-10			A	A	A	A	A	A	A	A	A	A	A	A
10-11				A	A	A	A	A	A	P	A	P	P	F
11-12					A	A	A	A	P	P	A	A	P	A
12-13						A	A	A	A	A	P	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	A	P	A	A	A
15-16									A	A	P	A	A	A
16-17										A	P	A	P	A
17-18											P	A	A	A
18-19												P	P	P
l9-20														A
20-21														A

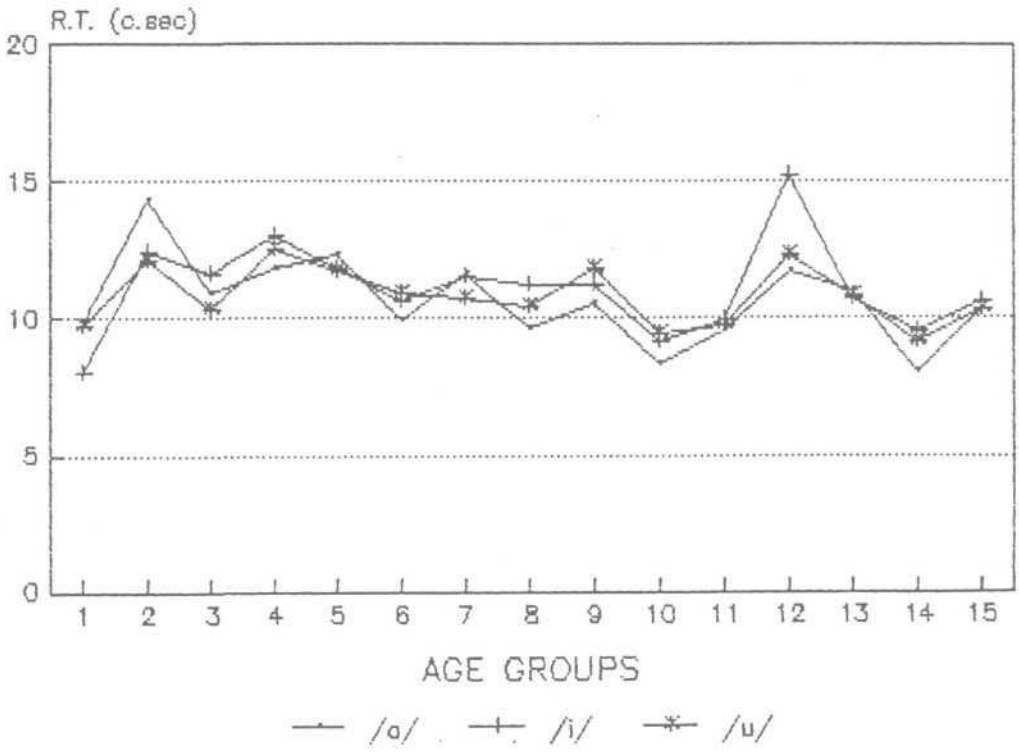
Tabte-73: The significance of difference between different age groups in rise time in phonation of /u/ of females

	8-9	9-10	10-11	11-12	12- 13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	A	A	A	A	A	A	A	A	A
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	A
9-10			A	A	A	A	A	A	A	A	A	A	A	A
10 -11				A	A	A	A	A	P	P	A	A	P	P
11-12					A	a	A	A	A	A	A	A	A	A
12-13						A	A	A	A	A	A	A	A	A
13-14							A	A	A	A	A	A	A	A
14-15								A	A	A	A	A	A	A
15-16									a	P-	A	A	A	A
16-17										A	A	A	p	A
17-18											A	A	A	A
13-19												A	A	A
19-20													A	A
20*21														A

GRAPH-13: SHOWS RISE TIME IN PHONATION
OF /a/, /i/ & /u/ IN MALES



GRAPH-13: SHOWS RISE TIME IN PHONATION
OF /a/, /i/ & /u/ IN FEMALES



The highest mean value for /a/ is 12.9 at 19-20yrs and the lowest is 7.5 at 9-10yrs. The highest S.D. value is 4.15 at 19-20yrs and the lowest is 2 at 7-8yrs. It can also be seen that age group 12-13yrs, 13-14yrs and 16-17yrs show slight decrease in mean values. For vowel /i/ the highest value is 11.7csec at 17-18yrs and lowest is 6.3 at 9-10yrs. The highest S.D. value is 4.77 at 21-22yrs and the lowest in 1.93 at ll-12yrs. There are also groups 12-13yrs and 13- 14yrs show a lower value. For vowel /u/ the highest mean value is 13.6 at 21-22 years and the lowest 7.4 at 8-9yrs. The highest S.D. values is 4.43 at 21-22yrs and the lowest in 1.59 at 7-8yrs.

As seen in graph-14 the vowel /u/ shows a consistent and gradual increase in fall time of phonation with age.

The test for significance of difference was applied and the result of it are shown in table 75, 76 and 77. In vowel /a/ younger children and older children upto 13-14yrs show significant difference with adult age groups 19-20 and above. Also age group 15-16yrs shows significant difference with the age groups 12-13yrs and below except 8-9yrs age groups 14-15yrs to 17-18yrs. The adult age groups do not show any significant difference. Similar trend is also seen in vowel /i/. In vowel /i/ age group 10-llyrs do not show significant difference with only other age groups.

In vowel /u/ also younger children and older children upot 13-14yrs show significant differences with adult age groups.

Age groups 14-15yrs, 15-16yrs and 17-18yrs show significant difference with young children age groups but not with adult age groups.

Thus null hypothesis stating that there is no significant difference in fall time across the age groups for male is partly accepted and partly rejected.

In females the mean and S.D. values show an increasing trend with age for all the three vowels as observed in males evident in the graph-14.

The test for significance however show that age groups 17-18yrs and above show a significant difference with the age groups 13-14 and below for /a/, the age group 9-10 shows a significant difference with the age group 15-16 and above. In case of /i/ age groups 7-8yrs, 9-10yrs, 12-13yrs and 13-14yrs shows significant difference with the age groups 14-15yrs and above. For /u/ age groups 14-15yrs, 15-16 years and 17-18yrs and above show a significant difference with the lower age groups.

Comparison between males and females shows that there is no significant difference in majority of age groups in terms of fall time of phonation. Hence the null hypothesis stating

that there is no significant difference in fall time between males and females is accepted.

In summary it can be stated that both males and females show increase in fall time with the age in all the three vowels. Males show a sudden increase in fall time at the age range 14-15yrs (for /a/ & /i/) and females at the age range 8-9yrs which corresponds to the onset of puberty. No significant difference is found in fall time of phonation between males and females. This study is with an agreement with reports made Rashmi (1985). This result can be considered as reflecting the increased neuromuscular control with age. This parameter apears to be useful in diagnosis of respiratory or laryngeal system or the neuromuscular control over these systems.

Table-74a: Mean and Standard Deviation of the fall time in phonation of /a/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	8.00	9.00	7.10	9.50	8.80	7.70	7.80	10.30	11.90	9.30	10.30	1D.-20	12.90	11.10	12.40
S.D	2.00	2.58	3.48	4.25	2.64	3.36	2.09	2.95	4.12	2.79	2.71	3.36	4.15	3.67	3.50
FEMALES;															
Mean	8.00	11.30	8.90	9.80	9.00	8.83	10.40	9.60	7.60	10.60	12.40	12.40	13.20	13.10	15.90
S.D	2.62	4.16	2.92	2.25	3.91	3.91	2.84	2.67	2.84	3.2j	2.97	4.62	1.99	4.51	6.38

Table-74b: Mean and Standard deviation of the fall time in phonation of/i/ in males and females

	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
HALES:															
Mean	7.27	8.20	6.30	9.10	9.80	6.80	7.30	10.80	9.90	9.60	11.70	11.50	9.70	10.80	11.40
S.D	2.89	3.79	2.67	3.57	1.93	1.99	1.34	3.53	2.50	3.89	3.82	2.80	2.31	2.62	4.77
FEMLES:															
Mean	A. 80	12.00	8.60	10.00	9.40	8.60	11.10	8.60	9.30	11.70	12.10	15.50	13.00	16.10	14.67
	1.62	6.46	3.02	1.76	1.59	3.24	1.52	3.17	4.45	3.13	1.29	4.92	2.05	3.00	3.30

Table-74c:Mean and Standard deviation of the fall time in phonation of/u/ in males and females

	7-S	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
MALES:															
Mean	7.57	7.40	7.50	8.00	9.00	8.29	9.00	11.40	11.30	9.80	11.20	11.60	10.70	11.30	13.60
S.D	1.59	5.27	2.37	1.23	1.15	3.01	2.54	3.47	2.87	3.82	3.52	1.35	3.13	1.33	4.43
FEMALES:															
Mean	8.10	11.40	8.00	11.10	9.40	7.20	10.00	8.70	9.30	10.50	il.?0	14.10	12.80	14.70	12.50
S.D	2.51	3.98	2.11	2.18	2.22	2.44	3.46	3.74	3.36	2.01	2.35	5.57	1.40	3.89	2.35

Table-75: The significance of difference between different age groups in Fall time in phonation of /a/ in Males

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	A	A	A	A	P	A	P	A	P	p	p
8 - 9		A	A	A	A	A	A	A	A	A	A	P	A	P
9-10			A	P	A	A	A	P	P	P	F	P	p	P
10-11				A	A	A	A	A	A	A	A	A	A	P
11-12					A	A	A	p	A	A	A	p	A	P
12-13						A	A	P	A	P	A	P	P	p
13-14							P	A	A	P	A	p	P	P
14-15								A	A	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	P	P	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-76: The significance of difference between different age groups in Fall tiae in phonaticn of /i/ in males

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	6	A	P	P	A	P	P	p	P	P
8 - 9		A	A	A	A	A	A	A	A	P	p	A	A	P
9-10			A	A	A	A	p	p	P	P	P	P	P	P
10-11				A	A	A	A	A	A	A	A	A	A	A
11-12					P	P	A	A	A	A	A	A	A	A
12-13						A	P	P	A	P	P	A	p	P
13-14							P	F	A	p	P	P	P	P
14 -15								A	A	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	A	A
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-77: The significance of difference between different age groups in fall timein phonation of /u/ in aaies

	8-7	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	A	P	A	A	p	P	A	P	P	P	P	P
8 - 9		A	A	A	A	A	P	P	A	P	P	P	p	P
9 -10			A	P	A	A	P	P	A	P	P	P	P	P
10 -11				a	A	A	P	P	p	P	p	P	P	P
11-12					A	A	A	p	A	A	P	A	P	A
12-13						A	p	p	A	A	P	A	P	P
12-14							A	A	A	A	P	A	P	p
14-15								A	A	A	A	A	A	A
15-16									A	A	A	A	A	A
16-17										A	A	A	A	P
17-18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

Table-78: The significance of difference between different age groups in Fall time in phonation of /a/ in females

	8-9	9-10	10-11	11-12	13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7- 8	A	A	A	A	A	A	A	A	A	P	p	P	P	P
8- 9		A	A	A	A	A	A	p	A	A	A	A		P
9 -10			A	A	A	A	A	A	A	p	A	P	p	P
10 -11				A	A	A	A	A	A	P	A	P	A	P
l1-12					A	A	A	A	A	p	A	p	P	P
12-13						A	A	A	A	P	p	p	P	P
13-14							A	P	A	A	A	p	A	P
14-15								A	A	P	P	P	P	P
15-16									A	P	p	P	P	P
16-17										A	A	P	A	P
17 -18											A	A	A	A
18-19												A	A	A
19-20													A	A
20-21														A

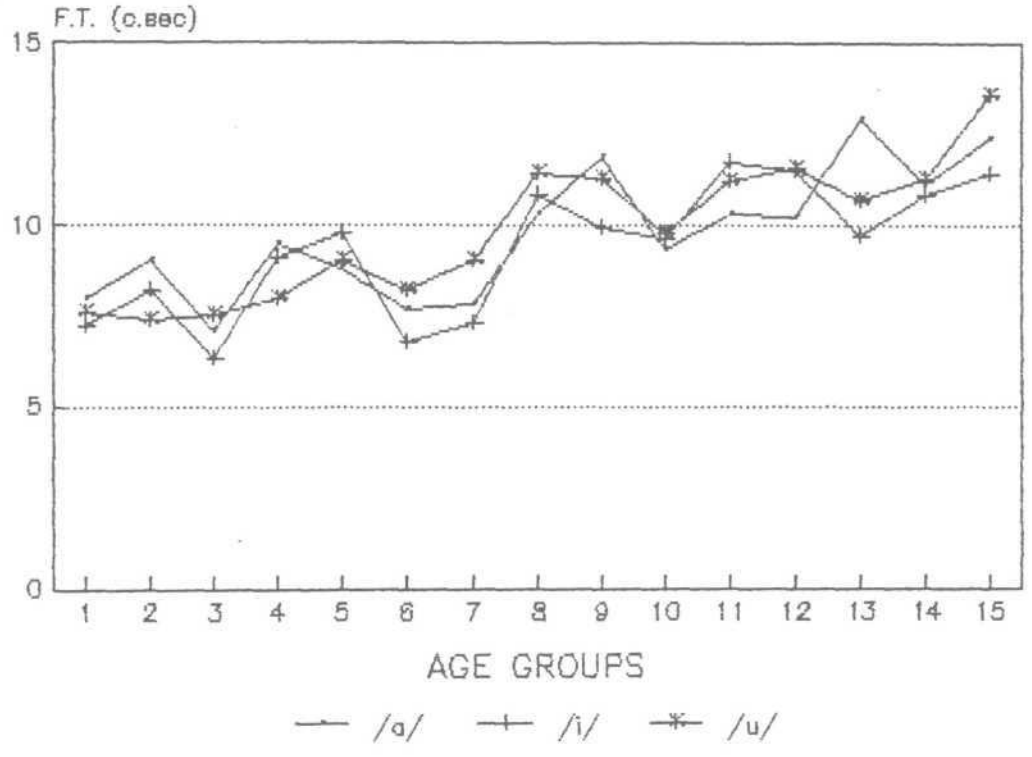
Table-79: The significance of difference between different age groups in Fall time in phonation of /i/ in females

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	P	A	P	P	A	A	A	A	P	P	P	P	P	P
8 - 9		A	A	A	A	A	A	A	A	A	A	A	A	A
9 - 10			A	A	A	A	A	A	A	P	P	P	P	P
10 - 11				A	A	A	A	A	A	P	P	P	P	P
11 - 12					A	P	A	A	P	P	P	P	P	P
12 - 13						P	A	A	P	A	P	P	P	P
13 - 14							A	A	A	A	P	P	P	P
14 - 15								A	P	P	P	P	P	P
15 - 16									A	A	P	P	P	P
16 - 17										A	P	A	A	P
17 - 18											A	A	P	P
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

Table-80: The significance of difference between different age groups in Fall time in phonation of /u/ in females

	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
7 - 8	A	A	P	A	A	A	A	A	P	P	P	P	P	P
8 - 9		P	A	A	P	A	A	A	A	A	A	A	A	A
9 - 10			P	A	A	A	A	A	P	P	P	P	P	P
10 - 11				A	P	A	A	A	A	A	A	P	P	P
11 - 12					A	A	A	A	A	P	P	P	P	P
12 - 13						A	A	A	P	P	P	P	P	P
13 - 14							A	A	A	A	A	P	P	A
14 - 15								A	A	P	P	P	P	P
15 - 16									A	A	P	P	P	A
16 - 17										A	A	P	A	A
17 - 18											A	A	A	A
18 - 19												A	A	A
19 - 20													A	A
20 - 21														A

GRAPH-14: SHOWS FALL TIME IN PHONATION OF /a/, /i/ & /u/ IN MALES



GRAPH-13: SHOWS FALL TIME IN PHONATION OF /a/, /i/ & /u/ IN FEMALES

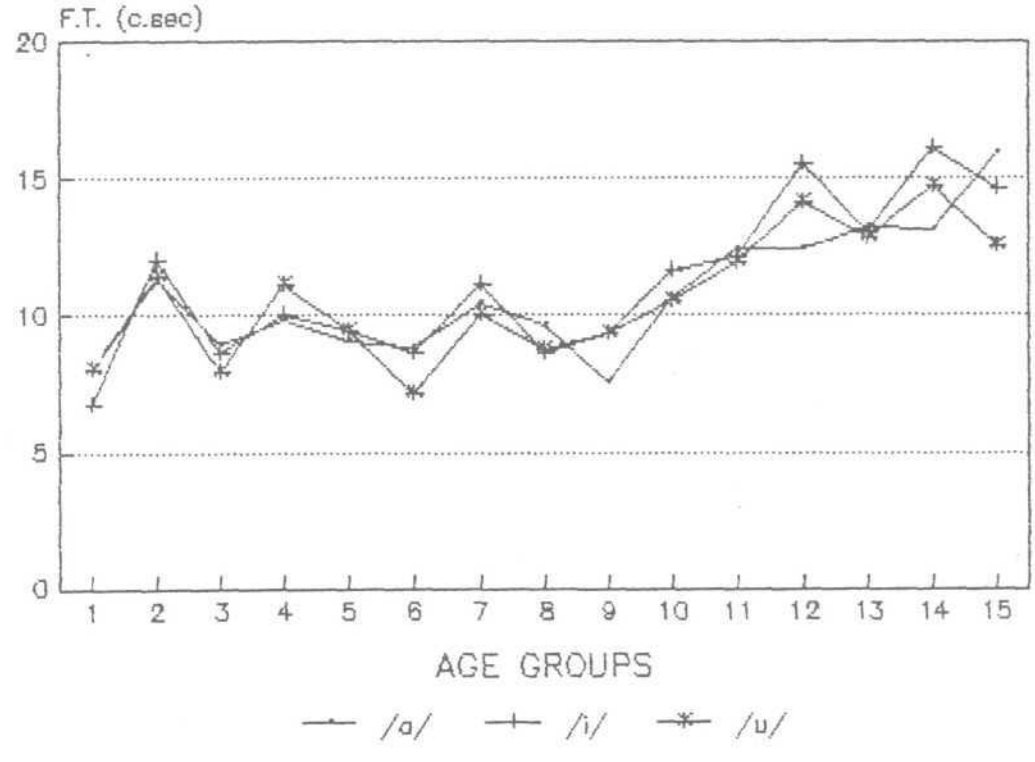


Table: showing significant difference across sex (Males and females)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1 Vs 1	A	+	A	P	A	A	A	A	A	A	P	A	P	A	P	P	P	P	A	A	P	A	A	A	P	A	A	A	A	A	A	A	A	P
2 Vs 2	P	A	A	A	A	A	A	P	A	P	A	P	A	A	A	P	A	A	A	A	A	A	A	A	P	A	A	A	P	P	A	A	A	
3 Vs 3	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	P	A	A	A	A	A	A	A	A	P
4 Vs 4	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	A	A	A	P	A	A	A	A	P	A	A	P	P
5 Vs 5	P	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	P
6 Vs 6	A	A	A	A	A	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	A
7 Vs 7	A	A	A	A	A	A	A	A	P	P	A	P	A	P	A	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A
8 Vs 8	P	A	A	A	A	P	A	A	A	A	A	P	A	P	A	P	P	P	A	A	A	A	A	P	P	P	P	A	A	A	P	A	P	A
9 Vs 9	P	A	A	A	P	A	A	A	P	P	A	P	P	A	A	A	A	A	A	A	P	P	P	A	A	A	A	A	A	A	P	P	P	A
10 Vs 10	P	P	P	A	A	A	A	P	A	A	A	P	P	P	A	A	A	P	P	A	A	P	P	P	P	A	A	A	P	A	A	P	P	A
11 Vs 11	P	A	A	A	A	A	A	A	A	A	A	P	A	P	A	A	A	A	P	A	A	P	A	P	A	A	A	A	P	A	A	P	P	P
12 Vs 12	P	A	P	A	A	A	A	A	A	A	A	P	A	P	A	A	A	A	P	A	P	A	A	P	A	A	A	A	A	A	P	P	A	
13 Vs 13	P	A	P	P	A	A	A	A	A	P	A	P	A	P	A	A	A	A	P	P	P	P	P	A	A	A	A	A	P	P	P	A		
14 Vs 14	P	P	A	P	A	A	A	A	A	A	A	P	P	P	A	A	A	A	P	A	P	P	P	A	A	A	A	A	P	A	P	A	A	
15 Vs 15	P	P	P	A	A	A	A	A	A	P	P	P	A	P	P	A	A	P	A	P	A	P	A	P	P	A	A	A	P	A	A	P	P	A

COLUMN NO:- PARAMETER

1, 12 & 21 - MF$_0$
2, 13 & 22 - PFR
3, 14 & 23 - PFS
4, 15 & 24 - PFX
5, 16 & 25 - PIR
6, 17 & 26 - PIS
7, 18 & 27 - PLX
8, 19 & 28 - RT
9, 20 & 29 - FT
10, 21 & 30 - MPT
31 - S/Z RATIO
32 - SFF
33 - SFR
34 - SIR

1 → 7-8 yrs, 2 → 8-9 yrs, 3 → 9-10 yrs, 4 → 10-11 yrs, 5 → 11-12 yrs, 6 → 12-13 yrs, 7 → 13-14 yrs, 8 → 14-15 yrs.
9 → 15-16 yrs, 10 → 16-17 yrs, 11 → 17-18 yrs, 12 → 18-19 yrs, 13 → 19-20 yrs, 14 → 20-21 yrs, 15 → 21-22 yrs.

SUMMARY AND CONCLUSIONS

Speech is comlex activity involving various muscles of respiration, phonation, articulation and resonation. The end product of this neuromuscular activity is an ascoustic signal i.e. speech. Speech and voice is known to change with age and maximum co-ordination between different subsystems of speech is achieved by adulthood. The importants of acoustic analysis in studying this developmental changes in neuromuscular activity in speech is highlighted in following statement by Kent (1976) "The past twe decades have been witness to an increasing application of acoustic analysis to the study of speech development in children . . . . These acoustic features on various aspects of speech production indicates that the acuracy of motor control improves with age untill adult like performance is achieved at about ll-12years, somewhat after the age at which speech sound acquisition is usually judged to be complete.

Availability of sophasiticated methods of measurement like digitization and computer have enabled speech scientist to study developmental changes in voice in large number of children.

The acoustic analysis to study the speech development in children has been found to be useful in early indentification diagnosis and treatment of various speech and language disorders.

Hence the present investigation included some of the parameters which were earlier recomended by earlier investigators. They are,

1. The maximum phonation duration of vowels.
2. The maximum duration of /s/ and /z/ and the S/Z ratio.
3. The fundamental frequency of phonation.
4. The speaking fundamental frequency.
5. Speed of fluctuation in frequency of phonation.
6. Extent of fluctuation in frequency of phonation.
7. Frequency range in phonation.
8. Frequency range in speech.
9. Speed of fluctuation in intensity of phonation.
10. Extent of fluctuation in intensity of phonation.
11. Intensity range in phonation.
12. Intensity range in speech.
13. Rise time in phonation.
14. Fall time in phonation.

These parameters were studied in sample of three hundred subjects (children and adults) age ranging from 7-22 years who were normal interms of their speech, language and hearing.

Data on the maximum duration /a/, /i/, /u/ and /s/, /z/ along with the repetition of three Kannada sentences 'idu pa:pu', 'idu ko:ti' and 'idu kempu banna' were recorded. Each subject was given three trials.

The duration of vowels and the fricatives were measured using a stop watch, the longest of which was considerd as the maximum phonation duration.

These samples were digitized by using ADC and fed to computer (PC-AT) to obtain the fundamental frequency of phonation, Frequency range, Intensity range, Speed & Extent of fluctuations in frequency and intensity in phonation.

The same samples were fed to the pitch analyzer (PM 100) to measure the rise and fall time in phonation. Three kannada sentences were fed into pitch analyzer for the analysis of SFF, frequency range and intensity range in speech.

Thus the results for all the parameters were obtained for all the 300 subjects. The obtained values were then tabulated and subjected to statistical analysis to determine the mean, S.D and significance of difference. Mann-Whitney 'U' test was applied to know the significance of difference.

After the statistical analysis, the following conclusions were drown.

I) **Maximum phonation duration:**

1) The MPT of vowels increases as a function of age in both males and females.

2) There is no significance difference in MPT of vowels, between males and females, across the age range studied.

3) The MPT of /i/ is greatest followed by /a/ and /u/.

II) S/Z Ratio:

1) S/Z ratio remains constent throught the age range studied.

2) There is no significant difference in the S/Z ration between males and females.

III) Fundamental frequency of phonation:

1) In males, there is a towering of Fo with advancing age upto the age of 15 years, after which there is a marked decrease in the fundamental frequency.

2) In females there is a gradual decrease upto the age of 12 years after which there is little change in Fo with age.

3) A significance difference in fundamental frequency of voice between males and females is observed after the age of 15 years only.

4) The fundamental frequency of /i/ is the highest followed by /u/ and finally /a/ has the lowest fundamental frequency of the three vowels studied.

IV) Speed of fluctuation in frequency of phonation:

1) Males and females show a significant decreases in the mean and S.D. values with age.

2) No significant difference speed of fluctuation in frequency between males and females observed in younger age group, upto age group 14-15 after which the significant differences were found.

V) Extent of fluctuation in frequency of phonation:

1) The extent of fluctuation in phonation in males decreases with age.

2) In females there is no consistent significant change in extent of fluctuation in frequency of phonation with age.

3) There is no significant difference between males and females with reference to extent of fluctuation in frequency of phonation.

VI) Speed of fluctuation in intensity:

1) Males show significant decrease in speed of fluctuation in intensity with age.

2) Females also show a decrease with age but more gradual than that of males.

3) Males show significantly highest speed of fluctuation in intensity than that of females in lower age groups only.

VII) Extent of fluctuation in intensity of phonation:

1) Age groups 17-18 years and above show a significantly lower age values than other age groups.

2) Females do not show any consistent change with age.

3) No significant difference is found between males and females in the age range studied.

VIII) Frequency range in phonation:

1) In males the frequency range in phonation decrease gradually with age.

2) In females the decrease in frequency range in phonation is more gradual than in males.

3) The significant difference in frequency range between males and females are present in adult age groups only.

IX) Intensity range in phonation:

1) Both males and females show a gradual decrease in intensity range with the age.

2) Males show higher intensity ranges at 13-14years age groups and females show in the age group 8-9 and 9-10yrs.

X) Speech in fundamental frequency:

1) In case of males gradual change in SFF as a function of age upto age of 15 years, at which age 3 sudden decrease in the speaking Fo is observed.

2) Incase of females there is a gradual change in the SFF in females with increase in age.

3) The SFF of males and females is not significantly different upto 15yrs. A significantly lower speaking FF is present in the males after 15yrs when compared to females.

XI) Frequency range in speech:

1) Males show significant decrease in frequency range in speech with increasing age.

2) In females no significant change is observed.

3) Siginificant, difference between males and females are not present.

XII) Intensity range in speech:

1) Males show increase in intensity range in speech.

2) Female do not show any consistent changes.

3) There is no significant difference in intensity range of speech between males and females.

XIII) Rise time:

1) There is no significant change rise time for both males and females.

2) There is no significant difference in rise time between males and females.

XIV) Fall time:

1) Both males and females show increase in fall time with age.

2) Males show a sudden increase in fall time at the age range 14-15yrs (for /a/ and /u/) and females at the age range 8-9yrs.

3) No significant difference is found in fall tiem of phonation between males and females.

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