ACOUSTIC ANALYSIS OF VOICE IN GERIATRIC POPULATION

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SURESH.T

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MYSORE - 570 006
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TO,

.. .THE NATURE

So Enourmous, Enchanting
and Challenging.

.... TO THE LOVERS OF SCIENCE

Help to create a
***beautiful abode, for* us**

.... TO TEACHERS & PARENTS

Who put their heart and soul
in nourishing budding talents

.... TO ALL OF 'U' CHILDREN

For '*U' the,* Nature belongs to

CERTIFICATE

This is to certify that the dissertation entitled **"ACOUSTIC ANALYSIS OF VOICE IN GERIATRIC POPULATION** " *is the bonafide work in part fulfilment for the degree of Master of Science (Speech & Hearing), of the student with Register No. M 8921.*

Director
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CERTIFICATE

This is to certify that the dissertation entitled

"**ACOUSTIC ANALYSIS OF VOICE IN GERIATRIC POPULATION**"

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.

MYSORE
MAY 1991 **Reg. No. M. 8921.**

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INTRODUCTION

Since time, immemorial man has shown interest in exploring nature and understanding several natural process. Growth of science in this century has accelerated such endeavors. Progress in technology has been immensely helpful in understanding many natural process in human anatomy and physiology, as well as diagnosis and treatment of many diseases.

Interest in voice has been primarily in detection of laryngeal pathology. This led to the development of many methods of analyzing voice. The instrumentation spans from early pitch meters to more recent EGG, stroboscopy and photo-glottography. Computer is the latest addition to this arrmamentorium of voice specialist. It's usefulness in acoustic analysis of speech are being recognized. Computer aided histogram are to most valid and faster method of measuring Fo, especialy in speech (Lass, 1981).

Analysis of voice needs measurable parameters. In 1970's Michel and Wendahl give a set of aerodynamic and acoustic parameters of voice. These were found useful clinically in identifying dysphonics (Michel and Wendahl, 1971; Jayaram, 1976; Hirano, 1981, Nataraja, 1988).

These parameters are also studied in children in order to know the developmental changes in age and sex (Kushal raj, 1983, Rashmi, 1985).

But along with developmental process in children another equally important process of aging has been less documented in voice research.

Information on changes in voice due to normal aging process is important in understanding effect of aging in ,neuromuscular control of speech. "Data on geriatric changes in the neuromuscular control of speech are fragmentary. Very few reports have been published to describe changes in speech motor function that might normally accompany the aging process. Although such changes may be subtle, they could be important in understanding the aging process and diseases that are commonly seen in aged persons" (Kent and Burkard 1981)."

Priliminary attempts have been made in application of acoustic analysis in neurological diseases in the old age, like dysphasia, dysarthria and dyspraxia (Hartman E. 1984; Kent, Netsell and Abbs, 1972; Kent and Rosenbeck, 1975).

/Anatomical and structural changes in larynx associated with aging are documented in literature, which are majorly, vocal cord edema and muscular atrophy. But not much information is available on changes in acoustic parameters of voice as a result of aging.) One has to agree with Fink's statement, "unfortunatity, knowledge in this field is still in an anectidotal stage". Hence the need for the present study was felt.

The present study was attempted as,

- previous investigators have used acoustic parameters to study with voice and developmental changes, and as they have found these parameters useful in describing voice.

- Studying voice changes in aged, are few, and only limited number of parameters are studied like SFF, Fo etc.
- In Indian literature, attempts have concentrated on adults and children and not much on aged or geriatric subjects.

Statement of the problem.

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

The present study therefore, aims at analysing some of aerodynamic and acoustic aspects of the speech of geriatric subjects. 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 range in phonation and in speech, rise & fall time of phonation, speed and extent of fluctuation of frequency and intensity in phonation and fundamental frequency in speech.

Totally 100 subjects, both males and females, age ranging from 35 years to 85 years , were considered for the study. All the subjects were normal in terms of speech, language and hearing.

Three trials of the maximum phonation duration of /a/, /i/, /u/, 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 intensity range

(e) Rise and Fall time.

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

Hence the following parameters were selected for study.

The parameters considered for the study include,

1) Maximum phonation duration.
2) Fundamental frequency in phonation.
3) Fundamental frequency in speech.
4) Frequency range in phonation.
5) Frequency range in speech.
6) Intensity range in phonation.
7) Intensity range in speech.
8) Extent of fluctuation in frequency.
9) Speed of fluctuation in frequency.
10) Extent of fluctuation in intensity.
11) speed of fluctuation in intensity.
12) Rise time of phonation.
13) Fall time of phonation.

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.

Auxillary 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 difference in the fundamental frequency of phonation in males and females with increase in age.

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

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

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

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

IV (b) There is no significant change in the extent of fluctuations in frequency between males and females of the same age group.

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

V (b) There is no significant difference in the speed of fluctuations in frequency of phonation between males and females of the same age group.

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XII (a) There is no significant difference in the rise time of phonation in males and females, with increase in age.

XII (b) There is no significant difference in the rise time of phonation between males and females of the same age.

XIII (a) There is no significant difference in the fall time of phonation in males and females, with increase in age.

XIII (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.

Implication of the study:

This study provides information regarding the changes in 'maximum phonation, fundamental frequency in phonation, fundamental frequency in speech, 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 35 - 85 years.

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 neurological disorders in the aged.
2. In understanding developmental changes in neuromuscular control of voice.
3. In speaker identification.

DEFINITONS :

Maximum Phonation Duration (MPD):

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

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 dB 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 falling time in phonation was defined as the time required for the intensity to decrease from the steady level to 0dB in the final portion of the phonation.

REVIEW OF LITERATURE

Acoustic analysis has been considered as the basic tool in the investigation of voice disordered. It has been considered vital in diagnosis and management of patients with voice disorders.

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-invasive and provides objective, quantitative and non-invasive data.

Further, a clinician will not really know what to expect with a medical diagnosis having a complete physical description of the larynx together with some adjectives like "hoarse" or " rough" until he actually sees the case (Michael and Wendhal 1971). On the other hand, if the clinician receives a report which includes measures of frequency ranges, respiratory function jitter, volume velocity of air flow during sustain phonation etc. in the form of a voice profile, the clinician can then compare these values to the norms of each one of the parameters and thus have a relatively good idea as to how to proceed with therapy even before seeing the patient.

Acoustic analysis acts as an extension of our ears in identifying changes in voice, but also in assessing amount of change and pattern of change in a move objective way.

Objective definition of voice has been a controversy over the past few decades. Some accepted definition are highlighted here. Michael and Wendhal (1971) defines voice as "the laryngeal modulations of the pulmonary air stream, which is then further modified by the configuration of the vocal tract".

Fant (1960) further explains "when describing the production of speech, it should be noted that the source S of the formula P = S.t. is an acoustic disturbance superimposed upon the flow of respiratory air and is caused by a quasi-periodic modulations of the airflow due to the opening and closing movement of the vocal fold.

The vibratory pattern of the vocal folds can be described with respect to various parameters including Fo, regularity or periodicity in successive vibrations, symmetry between 2 vocal folds, uniformity or homogeneity is the movement of differeneet points within each vocal fold etc.

Thus, the nature of Sd generated by the vocal folds can be specified is acoustic and psychoacoustic terms. These psychoacoustic terms are dependent upon the acoustic parameters. Acoustic parameters upon are Fo, intensity, waveform/acoustic spectrum and their time-related variations.

Hence voice is a physical disturbance in air primarily caused by vibration of vocal fold. Then vocal cords can be considered as a vibrator. Hence the acoustic characteristics

of voice depend upon the physical nature of this vibrator or in other words one can explain the changes in acoustic (FF, Intensity, jitter etc) and psychoacoustic (pitch, loudness, timbre) parameters using a set of physical principles.

Myoelastic. aerodynamic theory suggests that tension, mass, and length of the vibrator and air stream from lungs determine the parameters like pitch, loudness and timbre.

Physiology of pitch raising mechanism has been studied intensively. Zemlin (1981) has concluded that changes in mass/tension play a major role in changing the pitch. It can be concluded that the changes in pitch may be due to,

a) Changes in the elasticity of vocal folds.
b) Changes in the subglottal air pressure.
c) A combination of the above.

Larynx is capable of producing a wide range of fundamental frequency in vocal folds can be set into vibrations at difference frequency. This is termed as "pitch range'. Pitch range is defined as the difference between the highest Fo and the lowest Fo that an individual can produce. The larynx has been found to produce from 60Hz to Hz. It is a measure of phonatory capabilities of an individual. Though way of measuring differed, many have attempted to study this parameters, in Singers (Sheela, 74), in dysphonic (Jayaram, 75) and in old age ().

It all indicates better the "range" better the condition of larynx.

Hence, the physical status of vocal folds, muscles, tendons and cartilages which help in changing the tension and elasticity of the vocal fold, responsible for the pitch and loudness, in the result and voice produced. Changes in there can bring about a change is the resultant acoustic or psychoacoustic parameters.

Age related changes in stream of larynx has been studied. They report that structure of larynx undergo ranges in tension, elasticity etc.

Honjo and Isshiki (1985) report marked vocal cord atrophy and edema in their aged male subjects and primarily vocal cord oedema in the aged females. Further they state that there are three major research areas in aging and voice:

1) Comparative listener judgement.
2) Measures of Fo, P.T., aerodynamic and other acoustic and physiological parameters.
3) Inspection of the appearance of the aged larynx.

He conducted a study on 36 Lx of males in age range 65 to 94 years, the result were,

1) Normal cadaveric position was observed in 19%.
2) Bowing of cords and vocal cord sulcus is 80 to 64%.
3) Arrowhead configuration of vocal cord seen in 74%.

4) Arrowhead and cord sulcus increase, with increasing age in contrast with the normal cadaveric and bowing which remains steady.

5) These changes are due to muscle atrophy and a general decline in effeciancy of the glottal value due to senescent changes.

6) Discoloration of the cords (81%) is due to the fatty degeneration and/or keratosis.

7) Changes in mass and glottal efficiency amount for reported increase in hoarseness among older males.

8) Lower, altered anatomical mass and configuration of the nature reported in the study, should result is a lowering of the pitch.

However, compensatory and other factors may interact with the laryngeal constellation, subsequently generating at least perceptually, the higher pitch in males.

Therefore the anatomical changes seen in Lx of older males are,

- decreased circulation
- increased ossification
- Changes in cord lubrication
- diminished aerodynamic support
- alterations in neuromuscular control
- defficiency in feedback
-shifts in endocrine balance.

All of these contribute to changes in phonatory ability.

Kent (1981), summarizes the changes as,

- Ossification and calcification of hyaline cartilages making Lx were rigid which is complete by 65 years (Kitchner, TO, Zemlin, 1968).
- Atrophy of muscles, glands and soft tissues
- Laxity, thinning, bowing of vocal folds.
- Reduction of vascular support
- Changes in mu cusal secretion.

Changes in voice due to old age described in later sections of this chapter. These changes are related to the changes in anatomical structure of Lx climacteric, in males and menopause in females mark the begining of such changes.

Need for measurable parameters of voice led Michael and Wendahl (1971), to describe 12 parameters for assessing the voice and voice disorders. Later Kim (1982) and Yoon(1984) also described some parameters by spectrographic analysis.

These parameters were found to be useful in identifying voice disorders (Nataraja, 88). Some of these parameters low studied for age related changes in children (Kushalraj, 83, Rashmi, 85) and in adults (Vanaja, 86, Gopal 86).

MAXIMUM PHONATION TIME

The measurement of maximum phonation time has been suggested as a clinical tool for evaluating vocal function for the past three decades. Arnold (1955) has stated that "... a good criterion for the general quality of voice immediately available by determining the phonation time". Yanagihara et al (1966) have reported that the efficiency of the vocal function could be demonstrated by evaluating the maximum duration of phonation. Boone (1977) has written that measures of sustained phonation of vowels such as /a/ can provide information about an individuals efficiency in using the respiratory system for phonation. Gould (1975) stated that the maximum phonation time gives an indication of the overall status of laryngeal functioning and of tension in the larynx, and of any neuromuscular disability. A short phonation time with a large air escape suggests a neuromuscular deficit such as laryngeal nerve paralysis.

Several authors have suggested 'norms' for maximum duration of phonation. These norms were found to vary from 10 seconds for consonants in children to 30 seconds for vowels (Arnold, 1955), in normal-voiced individuals. According to Van Riper (1963), normal-voiced individuals should be able to sustain a front, middle and back vowel for atleast 15 seconds without difficulty, while Fairbanks (1960) reported a normal duration of 20 to 25 seconds, clinically MPD values smaller than 10sec should be considered as

abnormal (Hirano,1983). The table 2.1, presents normal values for MPT reported by several investigators. The average is greater for males (25-35 secs) than for females (15-25 secs).

MPT in children has also been studied. A child should have an adequate supply of air and be able to maintain steady phonation sufficient for effective speech communication. The measurement of MPT is an index of this ability (Wilson, 1979).

Westlake and Rutherford (1961) maintained that a child with a normal voice should easily sustain a tone for 20 seconds or longer after a few trials. Olsen, Perez, Burk and Platt (1969) found that average MPT to be 12.8 seconds, for normally speaking boys and girls between 5 and 10 years of age. Bless and Saxman (1970) studied MPT in boys and girls aged 8 and 9 years, and found MPT for girls was 19 seconds and for boys 16 seconds. These results wee contrary to most of the other studies in that, the girls had a longer MPT that 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 time. The difference may reflect the compounding aspects of hoarseness on the duration.

Shigemori (1977) investigated MPT in school children. The MPT was found to increase with age. The difference between males and females was not significant except among the seventh grade children.

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	9.4-26.2

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

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

Cunningham - Grant (1972) reported that MPT for the 6, 7 and 8 year old girls was considerably higher than those found by Launer (1971). However, the 6-, 7- and 8-year old boys fairly well fit into the developmental standard of Launer's boys.

Age	Time (secs)	
	F	M
6	11.7	11.74
7	10.57	11.77
8	15.27	12.97

Table 2.3.: Averaged MPT in seconds for /a/, /i/ and /u/ (Cunningham-Grant, 1972).

Lewis, Casteel and McMohan (1982) found no statistically significant relationship between the length of phonation time and age, using 8- and 10- year olds. Contrary to the above studies, Ptacek et al (1966) found that MPT decreased as a function of increasing age.

This lack of agreement among voice experts has led several investigators to study variables which affect MPT.

Variables investigated include vital capacity and air flow rate (Yanagihara et al 1966; Isshiki et al 1967; Yanagihara and Von Leden, 1967; Beckett, 1971), vocal pitch and intensity (Ptacek and Sanders, 1963; Yanagihara et al 1966; Yanagihara and Koike, 1967), Phonation volume (Yanagihara et al 1966; Yanagihara and Koike, 1967), sex (Ptacek and Sanders 1963; Yanagihara and Von Leden, 1967; Coombs, 1976), age (Launer, 1971, Coombs, 1976), and height and weight (Launer, 1971).

Several researchers have investigated the effect of vital capacity on the Maximum Phonation Time. Yanagihara and Koike (1967) indicated that the air volume available for maximally sustained phonation (that is, phonation volume) varied in proportion to the vital capacity and air available, and this was specific to the sex, height, age and weight of individuals. Additionally, they suggested that longer phonation time is generally related to larger phonation volume. They concluded that maximum sustained phonation is achieved by three physiological factors:

1. Total air capacity available for voice production.
2. The expiratory power.
3. The adjustment of the larynx for efficient air usuage, that is, the glottal resistance.

The results of a study of Isshiki et al (1967) indicated that none of the experimental subjects utilized the total

vital capacity for the production of the longest phonation. The amount of air volume expired during the longest phonation ranged from 68.7 to 94.5% of the subjects vital capacity. Yanagihara and Koike (1967) obtained similar findings with the percentages ranging from 50 to 80% for males and from 45 to 70% for females. Lewis, Casteel and McMohan (1982) found a significant and dominant relationship between vital capacity and the length of sustained phonation of /a/. They also suggested that given twenty trials, the maximum phonation time obtained could reflect utilization of a higher percentage of the vital capacity.

The amount and the kind of training an individual has had, has been considered as yet another variable affecting the duration. Lass and Michel (1969) indicated the atheletes generally do better than non-atheletes and trained singers do better than nonsingers. However, the results obtained by Sheela (1974) were contrary to the above findings. She found no significant relationship between phonation time and trained or untrained singers. The phonation time ranged from 15 to 24 seconds in trained singers and 10 to 29 seconds in untrained singers.

The position of the individual while phonating, has been considered as another factor affecting the measure. Sawashima (1966), however found no significant difference in the MPT in the standing or sitting positions.

Many investigators have specified the number of trails used to obtain maximum duration of phonation; however, most of the studies have been based on three trials (Yanagihara et al 1966; Yanagihara and Koike, 1967; Yanagihara and Von Leden 1967; Launer, 1971; Coombs 1976). Sanders (1963) found MPT with twelve trials and found no difference between the first and the twelth trial.

Stone (1976) indicated that adults demonstrated greater maximum duration of /a/ when fifteen trials were used. Lewis, Casteel and McMohan (1982) have found that the practise of utilizing three trials to determine the MPT is inadequate, for it foes not represent a 'true' measure of the maximum duration. They report that it was not until the fourteenth trial that fifty percent of their subjects produced the maximum phonation and not until the twentieth trial, did all their subjects produce maximum phonation time. The authors believe this finding to be not only statistically significant, but also, more importantly, clinically significant.

Although many researchers have suggested the effect of height and weight to the length of phonation time (Arnold and Luchsinger, 1965; Michel and Wendahl, 1971); Lewis, Casteel and McMohal (1982) found no statistically significant relationship between them. Also Sawashima (1966) reported no significant difference in MPT in the standing and sitting positions.

Ptacek and Sander (1963) appear to be the first to suggest that the maximum duration of phonation may be influence by the frequency and SPL of the phonation. Also, males could sustain phonation longer than females, especially at low frequencies and sound pressure levels. Then as both frequency and SPL increased, the phonation times between males and females tended to become more similar. However, a considerable degree of variability among subjects was still evident in that significant differences existed for frequencies and sound pressure levels for male phonations, but not for female phonations. Conversely, the frequency-sound pressure level interaction was significantly for the females but not for the males. Different results were found by Lass and Michel (1969). They report that for low frequency phonations of both males and females, and for the moderate frequency phonations of the males, there was a general tendency for phonation time to increase as a function of sound pressure level. However, in the high frequency phonations for both males and females, there was a tendency for phonation time to decrease as the sound pressure level increased.

Yanagihara et al (1966) and Yanagihara and Koike (1967) measured the maximum phonation time at three different vocal pitches-low medium and high - in normal adults. Phonation time was reduced at high pitches for both men and women. The figures for men were 28.4 seconds for low pitch, 30.2 seconds

for medium pitch, and 23.7 seconds for high pitch; while those for females were 21.7 seconds for low pitch, 22.5 seconds for medium pitch and 16.7 seconds for high pitch.

Shashikala (1979) studied the maximum phonation time at optimum frequency, +50Hz, +100Hz, +200Hz and -50Hz, and reported that the maximum phonation time was longer at the optimum frequency than at other frequencies, in both males and females, when the optimum frequency was measured using an objective method of locating the optimum frequency as described by Nataraja (1972).

Komiyama and Buma (1973) measured by maximum phonation time taking account of the intensity of the voice. Measurements were made in fortissimo, mesoforte and pianissimo in varying pitches. The results indicated that the "phonation time" in fortissimo showed the minimum value compared with the value of mesoforte or pianissimo phonation in various pitches. They also observed the "phonation capacity" by integration of voice intensity with phonation time and reported that "phonation capacity" was diminished and showed a remarkable decrease in fortissimo phonation during the register transition.

Studies of MPT in geriatric populations is few. Ptaeck (1966) reported decreased MPT in older by 26% in males and 32% in females. Kreul (1972) reported a decrease in MPT of 19%-26% in older subjects. The results are indicated in the table below.

Authour & year	age gp		sex	Results
1. Ptaeck (1966)	younger age group		M	24.6sec
			F	20.9 "
	older age group		M	18.1 "
			F	14.2 "
2. Kreul (1972)	younger age group	/a/		18.2 "
		/i/		18.5 "
		/u/		22.8 "
	older age group	/a/		14.6 "
		/i/		14.6 "
		/u/		15.8 "

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

Arnold (1959) reports that in cases of paralytic dysphonia, phonation time is always shortened to three to seven seconds. He goes on to state that "similar findings were made in 1942 by Ricben (five seconds), in 1937 by Luchsinger (three to fifteen seconds) and in 1952 by Brahm (three to twelve seconds).

Clinically, maximum phonation time values smaller than ten seconds, should be considered abnormal (Hirano, 1981). Sawashima (1966) reported that phonation lengths below fifteen seconds in adult males and below ten seconds in adult females should be regarded as pathological. The table presents values of maximum phonation time in pathological cases, as reported by Shigemori (1977).

An abnormally short maximum phonation time was found in cases of recurrent laryngeal nerve paralysis. The maximum phonation time varies depending on the cord position in recurrent laryngeal nerve paralysis (Shigemori, 1977).

Shigemori (1977) also reported that in the pathological cases, abnormal test findings were most evident in a measure of the maximum phonation time, than in the mean airflow rate or phonation quotient.

Jayaram (1975) reported significantly lower maximum phonation duration in a dysphonic group than in a matched normal group. Further, while a significant difference in maximum duration of phonation was reported between males and females in the normal group, no such difference was evident in the dysphonic group. These results are similar to those reported by Coombs (1976), wherein no significant difference was observed with respect to the maximum duration of phonation, between males and females with hoarseness.

Ptacek and Sanders (1963) appear to be the first to relate the maximum duration of phonation to the perception of "breathiness" . Although none of the voices of their subjects were considered to be non-normal, they were able to divide their subjects into two groups - long phonators and short phonators. When these two groups were judged as to the degree of breathiness from least to most on seven-point scale, they found that the long phonators tended to be judged

as less breathy, than the short phonators. In addition, perceived breathiness decreased as a function of increased intensity, and, high frequency phonations tended to be rated as more breathy, than corresponding low frequency phonations.

Olsen et al (1969) studying children with vocal nodules, age ranging from seven to nine years, reported the mean maximum phonation time to be 10.1 seconds.

Westlake (1962) suggested that a child with cerebral palsy should be able to sustain a sound for a minimum of 10 seconds.

That short phonation times are associated with laryngeal pathology and can be improved by treatment, was shown by Von Leden et al (1967), who reported an increase in phonation time from 1.33 to 14.79 seconds in one case and from 3.91 to 8.66 seconds in another case (both of whom had unilateral vocal fold paralysis), after injecting teflon paste into the affected folds. Michel et al (1968) have also demonstrated an increase of phonation length from 4 seconds to more than 20 seconds as a result of teflon treatment of unilateral vocal fold paralysis.

Shigemori (1977) reported that maximum phonation time is valuable for monitoring the effects of surgical treatment in selected disorders of the larynx, especially in recurrent laryngeal nerve paralysis, and to a certain extent, in cases of sulcus vocalis, nodules, polyps, and polypoid vocal folds.

The rationale for this measure has been given by Arnold (1959) who wrote that "This simple test gives information of the efficiency of the pneumophonic sound generation in the larynx". He further states that "It also demonstrates the general state of the patient's respiratory co-ordination". This statement can be modified to say that this measure can demonstrate the general status of the patient's respiratory co-ordination, but more accurately indicates the relative efficiency of the pneumolaryngeal interaction (Michel and Wendahl, 1971). The measurement of maximum phonation duration is also useful in assessing the phonation quotient and the Mean Airflow rate, which in turn have been found to be important diagnostic and therapeutic indicators.

Thus the measurement of maximum phonation duration, which can be done without equipment, is very useful in diagnosis and treatment of voice disorders. The measurement of this parameter was included in the present study, since no information regarding this with reference to change in age is available particularly on an Indian population.

FUNDAMENTAL FREQUENCY

Voice, the underlying basis of speech, has three major attributes, namely, pitch, loudness and quality.

Pitch is the psychophysical correlate of frequency. Although pitch is often defined in terras of pure tones, it is clear that noises and other aperoidic sounds, have more or

less definite pitches. The pitch of complex tones according to Stevens and Davis (1935) depends upon the frequency of its dominant component, that is, the fundamental frequency in a complex tone. Plomp (1967) states that even in a complex tone, where the fundamental frequency is absent or weak, the ear is capable of perceiving the fundamental frequency based on periodicity of pitch. Emrickson (1959) is of the opinion that the vocal cords are the ultimate determiners of the pitch and that the same general structure of the cords seem to determine the range of frequencies that one can produce.

The factors determining the frequency of vibration of any vibrator are mass, length and tension of the vibrator. Thus, the mass, length and tension of the vocal cords determine the fundamental frequency of voice.

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

There are various objective methods to evaluate the fundamental frequency of the vocal cords. Stroboscopic procedure, pardue pitch meter, High speed cinematography, Electroglottography, Ultrasonic recordings, Stroboscopic laminography (STROL). Cepstrum pitch detection, the 3M plastiform Magnetic Tape viewer, Spectrography, Digi pitch, Pitch computer and the High Resolution signal Analyzer.

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 date 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), Usah 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 is 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 is prominent at puberty. In majority of the cases this change takes place without

appreciable pitch breaks during speech. But in some, 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 on set 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 camed 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 differences of fundamental frequency of speech between 7 and 8 years, or between boys and girls of those age (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 sharply 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 exhibit 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 development 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 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; Rashmi, 1985;).

Among the several types of organic changes recognized leading to vocal involution, the vocal changes noticed during menopause of females and climactene in males are most obvious. 3 major areas are recognised in the research on aging, 1) Comparative listener judgement

2) Measures of F0, MPT, aerodynamics & other acoustic and physiological parameters.

3) Inspection of the appearence of the aged larynx.

Aronson, summarizes number of studies and concludes that senescence affects the larynx by bringingforth changes in its physical structure and neural innervations. Anatomical changes are marked vocal cord atrophy in the aged male subjects and primary vocal cord edema in the aged females (Honjo & Isshiki,).

The studies on Fo in aged males and females are summarised in the table.

Name & year	age gps	para-meter	Results	Conclusion
1) MYSAK.59	geritric	Fo,		-pitch variability & Fo increases with age in males.
2) HOIIIEN & SHIPP, 72	20-29 30-39 40-49 50-59 60-69 70-79 80-89	SFF	120Hz 112Hz 107Hz 118Hz 112Hz 132Hz 146Hz	-lowering of Fo in adult-hood & middle age, increase in SFF in older age gp.
3) ENDEARS,67	Longitudinal study upto 13-15yrs from the starting age.			-Fo increases in males. decreases with age.

TABLE-2.3 results of different researchers on age related changes in Fo in males.

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. On the contrary in old age males show a progressive increase in Fo and females a lowering of Fo, due to senescence and menopausal canges in males and females respectively, the changes in FO in females are more variable.)

The study of fundamental frequency has important clinical implications.

Table-2.4 of results by different investigators on age related changes in Fo and SFF in females

Author	Year	No.	Age	Para meter	Result	Conclusion
1.Abberton	1976	10	20	Fo	242	
2.Fitch & Holbrook	1970	100	18-26	Fo	217	
3.Saxmann & Brook	1967	9	30-40	Fo	189	Increasing in Fundamental Fo of speech at high age
		9	40-50	Fo	196	
4. Stoicheff	1981	21	20-29	SFF &	224	Fo in stable from 20-40, lowering of Fo is seen at 50-59 and maintained at other ages
		18	30-39	"	213.3	
		21	40-49	"	221	
		17	50-59	"	199	
		15	60-69	"	200	
		19	70 & >	"	202	
5.Khtzing	1977	141	20-70	"	193	- Same -
6.Mcglow & Hollien	1963	10	73	SFF	197	Did not find any significant difference in SFF with age
		10	86	SFF	200	
8.Dordain	1967	22	76	SFF	209	
9. P.Krook	1988	35	20-29	SFF &	195.9	SFF tended to decrease with age upto 70yrs. (0.05) and increasing again after 70 (Not significant)
		100	30-39	"	194.7	
		83	40-49	"	190.9	
		83	50-59	"	182.1	
		85	60-69	"	180.9	
		63	70-79	"	187.8	
l0.Hanjo & Issihiki	1980	20	75		177	Correlated laryngoscopic result with Fo

Cooper (1974) has used spectrographic analysis, as a clinical tool to describe and compare the fundamental frequency and hearsencess in dysphonic patients before and after vocal rehabilitation.

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

A study was conducted by Asthana (1977) to find the effect of pitch and intensity variation on the degree of nasality in cleft palate speakers. The results of the study showed that the cleft palate speakers has significantly less nasality at higher pitch levels than the habitual pitch. But the degree of perceived nasality did not change significantly when habitual pitch was lowered.

Most of the therapies of voice disorders are based on the assumption that each individual has an optimum pitch at which the voice will be of a good quality and will have maximum intensity with least expense of energy (Nataraja and Jayaram, 1982). Most of the therapies aim to alter the habitual pitch level of the patients or make the patient to use his optimum pitch (Cowan, 1936; Strother, 1946; West et al 1957; Thurraan, 1958; Anderson, 1961; Greene, 1964; Murphy, 1964; Van Riper and Irwin, 1966).

It is therefore apparent that the measurement of the fundamental frequency of voice has important applications in

both the diagnosis and treatment of voice disorders and also reflects the neuromuscular development in children (Kent, 1976).

FUNDAMENTAL FREQUENCY IN SPEECH

. In daily life, man communicates through speech. An evaluation of the fundamental frequency in phonation, may not represent the true fundamental frequency, used by an individual in speech. Hence, it becomes important to evaluate the speaking fundamental frequency.

The speaking fundamental frequency is estimated subjectively by matching or it is determined objectively with a pitch meter or Digipitch. For more precise measurement, fundamental frequency histograms are obtained with the aid of a computer.

Many investigators have studied the speaking fundamental frequency as a function of age and in various pathological conditions.

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 fremale 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.

Hudson and Holbrook (1981) investigated the mean modal fundamental frequency, in reading, in two hundred, young black adults whose age ranged from 18 to 29 years, and found it to be 110.15Hz in males and 193.10Hz in females. Compared

to a similar white population studied by Fitch and Holbrook (1970), the black population had lower mean modal fundamental frequencies.

The mean speaking fundamental frequency of males, age ranging from 20 to 89 years, indicated that there was a progressive lowering of the speaking fundamental frequency from age 20 to 40, with a rise in level from age 60 through the eighties (Hollien and Shipp, 1972).

A study of the speaking pitch level in two groups of females, between 65 and 75 years and between 80 and 94 years, indicated no significant difference in the pitch level between the two groups. Therefore, speaking pitch level of women probably varies little throughout adult life.

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 no 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.

Investigation of the effects of smoking on the fundamental frequency of adult women was carried out by-Gilbert and Weisman (1974). The results indicated that in the reading condition, fundamental frequency for the smokers was significantly lower than the fundamental frequency for the non-smokers.

Following this study, Stoicheff (1981) controlled the smoking variable and found the speaking fundamental frequency to be higher relative to previous studies. He concluded that the speaking fundamental frequency of adult females is relatively stable until completion of the menopause, when it lowers. This lowered speaking fundamental frequency is maintained in aged women.

Burk and Saxman (1968) reported higher mean speaking fundamental frequency values among female Schizophrenics than that of controls, but the difference was not significant.

Shipp and Huntington (1965) found no significant difference in the mean and median speaking fundamental frequency between laryngitic and post laryngitic voices.

Murry (1978) studying the speaking fundamental frequency characteristics of four groups of subjects, namely, vocal fold paralysis, benign mass lesion, cancer of the larynx and normals, noted that the parameter of mean speaking fundamental frequency failed to separate the normals from the three groups of pathologic subjects.

In a parallel study, Murry and Doherty (1980) reported that along with other voice production measures such as directional and magnitudinal perturbation, the speaking fundamental frequency improved the discriminate function between normal voices and malignancy of the larynx.

Sawashima (1968) reported a rise in mean speaking fundamental frequency in cases of sulcus vocalis and a fall in mean speaking fundamental frequency in cases of polypoid vocal folds and virilism. Very high mean speaking fundamental frequency values result from disturbances of mutation in males.

At present, mean speaking fundamental frequency is measured as a clinical test value (Hirano, 1981).

Thus the review of literature shows that the measurement of fundamental frequency both in phonation and speaking is important in assessing the neuro-muscular coordination, and diagnosis and treatment of voice disorders. Few studies have been carried out to note the changes in fundamental frequency in Indian population with reference to age (Samuel, 1973; Usha, 1978; Gopal, 1980; Kushal Raj, 1983; Rashmi 1985; Gopal 1986; Vanaja 1986). However the information on SFF in old age is limited. Hence, the present study aimed in finding out changes in SFF in old age.

FLUCTUATIONS IN FREQUENCY AND INTENSITY

Perturbations are defined as the cycle-to-cycle variations in period and amplitude. To date, relatively few attempts have been made to measure perturbations in fundamental frequency and intensity, in children, although such a measure may have value in describing the stability of laryngeal control (Lieberman, 1963). Basma, Truby and Lind (1965) proposed that an infant's neurological maturity might be evaluated from such factors as the stability of laryngeal co-ordinations and the mobility of vocal tract components during crying.

Though information on the cycle-to-cycle variations in fundamental frequency and amplitude as a function age are scant, many investigators have found these measures to be useful in describing the voice characteristics of both normal and pathological speakers (Koike, 1969, 1973; Hollien, Michel and Doherty, 1973; Murry and Doherty, 1977; Smith, Weinberg, Feth and Horii, 1978; Horii 1979, 1980). This irregularity in vibration has been implicated as a physical correlate of rough or hoarse voices (Mathes and Miller, 1947; Bowler, 1964; Colerman, 1960, 1969, 1971; Moore and Thomson, 1965; Wendahl, 1966; Isshiki 1966; Michel, 1966; Coleman and Wendahl, 1967; Yanagihara, 1967; Takashi and Koike, 1975; Hirano et al 1977; Deal and Emanuel, 1978).

Hollien, Michel and Doherty (1973) using sustained vowels, obtained measures of frequency perturbation similar

to those of Lieberman (1961) which they called the jitter factor. This jitter factor (JF) was defined as the cycle-to-cycle period variations relative to the average speaking fundamental frequency. They suggested that when vocalization other than sustained phonation is used to examine the cycle-to-cycle variations is period, the perturbations may possibly be due to involuntary and/or learned phonatory behaviour associated with meaningful speech patterns produced by the speakers. As sustained phonation reduces the variability due to learned speech patterns and eliminates the differential loading of the glottis related to changes in vocal tract " configuration, a more valid assessment of the frequency perturbations associated with laryngeal behaviour may be obtained using only sustained phonation. Horii (1979) further cautions against the use of connected speech due to the random perturbation associated with "mechano-physiologic" limitations of the glottal source which may accompany such samples. …. However, Hammarberg et al (1968) analyzed the amplitude and period variations that occur in connected speech and obtained a representative sample of voice qualities.

Many authors have complied normative data for shimmer and Jitter. Horii (1979) reported an average shimmer of 0.39dB for vowels /a/, /i/ and /u/. However, in a later study Horii (1980) and Wilcoxon and Horii (1980) noted Jitter and/or shimmer differences among different vowels. Wilcox

and Horii (1980) found that /u/ was associated with significantly smaller jitter (0.55%), than /a/ or /i/ (0.68% and 0.69% respectively). Studying older subjects, Horii also found both jitter and shimmer to be smallest for /u/, intermediate for /i/ and greatest for /a/. On the other hand, a trend towards greater jitter for high vowels than low vowels was reported by Johnson and Michel (1969) who examined twelve English vowels. Zeralin (1962) reported a significantly greater jitter for /a/ than /i/. Horii (1982) found no significant difference in either shimmer or jitter values between eight English vowels and obtained an average jitter value of 0.75% and an average shimmer value of 0.17dB.

However, in a recent study, Sorenson and Horii (1983) found the jitter and shimmer values to differ for the three vowels /a/, /i/ and /u/. The mean directional jitter factor was 49.3% with a range of 34.6% (men /u/) to 62.7% (women /i/), while the average directional shimmer factor was 59.7% with a range of 43.5% (men /i/) to 72/6% (women /u/). Directional factors for shimmer were on the average, 10% higher than directional factors for jitter.

They also reported that for both the groups (men and women), /u/ had the highest directional jitter factors, /a/ was the lowest and /i/ was intermediate. The vowel /i/ had the highest shimmer factor for the men and /a/ was intermediate. For the women, the results of these two vowels were reversed.

The magnitude jitter values for the men and the magnitude shimmer values for the women followed the same pattern as the directional factors. The female magnitude jitter and the male magnitude shimmer, however, did not follow the patterns of the directional factors. Their analysis also indicated that the magnitude values and the directional factors can vary independent of each other. In other words, the magnitude factors and the directional factors do not necessarily have the same pattern.

Research has shown that the intensity, the fundamental frequency level and the type of phonatory initiation and termination are some factors which affect the jitter magnitude in sustained phonation (Moore and Von Leden, 1958; Jacob, 1968 Koike, 1973; Hollien et al 1973).

Koike (1973) observed differences in the perturbation values for the initiations of the vowel (soft versus breathy) and suggested that different mechanisms are responsible for the two onsets.

Shimmer, in any given voice is dependent at least upon the modal frequency level, the total frequency range, and the sound pressure level relative to each individual voice (Michel and Wendahl, 1971). Ramig (1980) postulated that shimmer and jitter values should increased when subjects are asked to phonate at a specific intensity, and/or as long as possible. White head and Emanuel (1974) found vocal fry

productions were perceived to be relatively rough compared to the modal register phonations and manifested elevated spectral noise levels, comparable to those associated with simulated abnormally rough phonations. This is explained by Wendahl (1963, 1966) and Colerman (1969) who indicated that when two audible complex waves manifest equal amounts of wave aperiodicity, the wave the higher fundamental frequency will tend to be heard as least rough. At comfortable vocal intensity and fundamental frequency, however, normal speakers appear to have average jitter of 1% or less during the middle portions of phonation. For example, Jacob (1968) reported a median value of 0.6%. Hollien et al (1973), Koike (1973) and Horii (1979) found an average jitter of about 0.5% for male adult speakers.

Horii (1980) found a significant correlation between shimmer and jitter supporting the notion that similar sets of physical forces (such as vocal fold tension, mass, length and subglottal pressure) underlie the regulation of the individual fundamental period and intensity of laryngeal sounds.

In addition, jitter and shimmer has been applied to the early detection of laryngeal pathology (Lieberman 1961; 1963), defined pitch perturbation as the difference in periods of adjacent glottal pulse and suggested that what he termed "the pitch perturbation factor", that is, the

percentage of discrete perturbation exceeding 0.5 msce, might be a useful index in detecting a number of laryngeal diseases.

Hecker and Kruel (1971) suggested that there might be, in addition to the pitch perturbation factor, a "directional perturbation factor", which he defined as the algebraic sign, or rate of progression, rather than simply the absolute magnitude of difference between glottal periods. Applying this criterion, he reported a significantly higher "directional perturbation factor" in pathologic speakers than those in normal speakers. The magnitudinal perturbation factor of Lieberman, on the other hand, did not differentiate the two conditions. However, Koike (1973) obtained lower mean magnitude perturbation in normal voices than in pathologic voices.

Koike (1969) showed that a relatively slow period modulation of vowel amplitude was observed in patients with laryngeal neoplasms. He reasoned from this that the measurement and analysis of such modulation might be useful in assessing laryngeal pathology.

Crystal and Jackson (1970) measured both the fundamental frequency and amplitude perturbations of voices 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 tumor and laryngeal paralysis was possible.

The perturbation factors, both directional and magnitudnal, during sustained vowels, are significant in discriminating normal talkers from those with laryngeal cancer (Murry and Doherty, 1980).

Von Leden and Koike (1970) found a significant correlation between subjects with various laryngeal diseases (Laryngitis, edema, myasthenia laryngis, bilateral adductor paralysis, unilateral paralysis, nodule, hematoma, cyst granuloma benign neoplasms, multiple papilloma, intrinsic and extrinsic carcinoma, senile, spastic and psychosomatic dysphonia) and different types of amplitude modulations and affirmed the potential value of short-term perturbations in the acoustic signal for diagnostic purposes. Their data suggested four different types of amplitude modulations, which in turn correlates with clinical groupings.

Kitajina and Gould (1976) studied the vocal shimmer during sustained phonation in normal subjects and patients with laryngeal polyps and found the values 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 was 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.

Sorenson, Horii and Leonard (1980) pointed out that the average jitter was significantly greater under anesthesia than under normal conditions, and that the jitter difference was more prominent at high frequency phonation, indicating that high frequency phonations are more dependent on laryngeal mucosal feedback.

Smith et al (1978) analyzed the voice of esophageal speakers and indicated that the magnitude of vocal jitter present in the vowels was substantially larger than that in normal speakers, and speakers with laryngeal/vocal disturbance.

Considerable caution must be taken in interpreting these data, however, because gross changes in wave periods (upto an octave in extent) were reported to be characteristic not only of pathologic voices, but also of vocal recordings taken from adolescent boys and girls, preadolescent children of both sexes, and from postmenarchal females (Fairbanks et al 1949; Curry, 1940; Duffy, 1958).

The fluctuations in frequency and intensity in a given phonation sample may indicate the physiological (Neuromascular) or pathological changes in the vocal

mechanism. No information regarding these two variables 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 hours. 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/, /x/, /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. 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).

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.

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.

Coleraan 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/cm^2) 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 terras 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.

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 terras of intensity on each syllable were seen in the speech of the normal subject.

Not much information is available regarding the changes in the range of intensity in old age. However, on similar lines as fundamental frequency variability, it may be hypothesized that the variability in intensity increases with age. Thus it will be interesting and useful to investigate the intensity variation leading to determination of range in Speech of geriatric population in a Indian population. The data may be helpful in understanding changes in laryngeal control with age. This further can be compared with clinical data on various voice disorders.

RISING AND FALLING TIME OF PHONATION

Imaizumi et al (1980) while investigating the possibility of utilizing a sound spectography for a multidimensional analysis of pathological voices, measured the rising time and falling time of sustained vowels as two of the parameters, among the nine acoustic parameters studied. These two parameters were measured on an amplitude display. The rising time was defined as the time required for the increase in overall amplitude from a value of 10% of the steady level to 90%. The falling time was defined as the

time span required for the decreases from 90% to 10% of the steady level.

Birren (1956) in evidence of importance of such measures says, "the systematic study of age changes in speed of response and timing appears to be one of the most advantageous ways of exploring the nature of age changes in behaviour and the aging nervous system.

There are few studies on age related changes on these parameters. Rashmi reported a gradual decrease in rise time and a gradual increase in fall time in the age range studied (4yrs to 15yrs). Vanaja (1986) studied these parameters in age range 16-65yrs and reported no significant changes.

Howell and Rosen (1983) measured the rise times of voiceless affricates and fricatives, when the test material occurred in sentences, in isolated words and in isolated nonsense syllables. The rise times of affricates were significantly shorter than those of fricatives. Rise times varied with the type of test material and for all types of material were significantly longer than those reported by Gerstman (1957). They also pointed out that because rise time varies with the type of test material, no auditory sensitivity at a single rise time value can be responsible for the perceptual distinction between voiceless affricates and fricatives.

Many pathological conditions are more apparent during the transitional phases of phonation, including the onset and the termination of phonation and hence of speech. In this connection further extensive clinical and basic research is required (Hirano, 1981). Further studies have reported that the initiation and termination of voice in stutterers are delayed (Miller, 1977, Basu, 1979). Inspite of the fact that these measurements are very simple and important, it is surprising to note there are only few attempts to note changes in parameters with age and in different pathological conditions (Rashmi,1985; Gopal, 1986; Vanaja, 1986). It was, therefore decided to investigate these aspects in the present study in different age groups of the Indian population.

METHODOLOGY

The study was aimed at studing the age related changes in phonatory abilities of geriatric population. The following parameters were found to be useful in differentiating normals and dysphonics. Age related changes of these parameters, in children and adults have been studied earlier. Hence these parameters were included in the present study.

1) The maximum duration of phonation
2) The fundamental frequency of phonation
3) The speaking fundamental frequency
4) Frequency range in phonation
5) Frequency range in speech
6) " or intensity " " "
7) Intensity range in phonation
8) Intensity range in speech
9) Extent of fluctuation is Fo in phonation
10) Speed of fluctuation is intensity of phonation
11) Extent of fluctuation is intensity of phonation
12) Speed of fluency in frequency of phonation
13) Rise time of phonation
14) Fall time of phonation

Subjects: Subjects, both males and females with age range between 35-85yrs were randomly selected for the study. The elderly population were selected from on old age home.

The criteria for the selection of speech was the absence of any speech, or respiratory problem with no observable deformities of the nasal, oral or pharyngeal cavities and with no incapicating hearing loss or major cardiae problem. Only literates were selected for the study.

10 male and 10 female subjects were included for each decade studied and hence a total of 100 subjects were considered for the study.

Test Material:

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

Three Kannada sentences were selected for the analysis of their speech.

1) Idu pa:pu, 2) Idu ko:ti & 3) Idu Kempu banna

The 3 sentences were selected for the study to enable comparison with other studies as by Gopal (1986), Nataraja (1988)

Data Collection

The data was collected in 2 steps.

Step I: Here the maximum phonation duration was recorded. The instructions were given as below,

"Take a deep breath and say /a/ as long-as you can. Do not breath is the middle" . This was demonstrated before the subject phonated. Three trials of each phonation were recorded.

Step II: Here speech samples were recorded. Instructions were given as,

"Now I will say three sentences. Repeat each sentences 3 times".

Then the investigator spoke the 3 sentences (idu, pipu), (idu ko;ti) and (idu kerapu banna) and the repetitions by subjects were recorded.

The recordings were done using a portable phillips tape recorder with an external microphone.

Analysis

Tape recorded samples were utilized to analyze the parameters.

1. Maximum phonation Duration of vowels:

The recorded samples of phonation of vowels were played back. And measurement was done using a Stop watch. It was carried out for all 3 vowels and for all 3 trials. And the maximum values, in seconds, for each of the vowel was considered as MPD for the vowel, for that subject.

2. Measurement of fundamental frequency of phonation

Measurement was carried out for all 3 vowels using the setup given below.

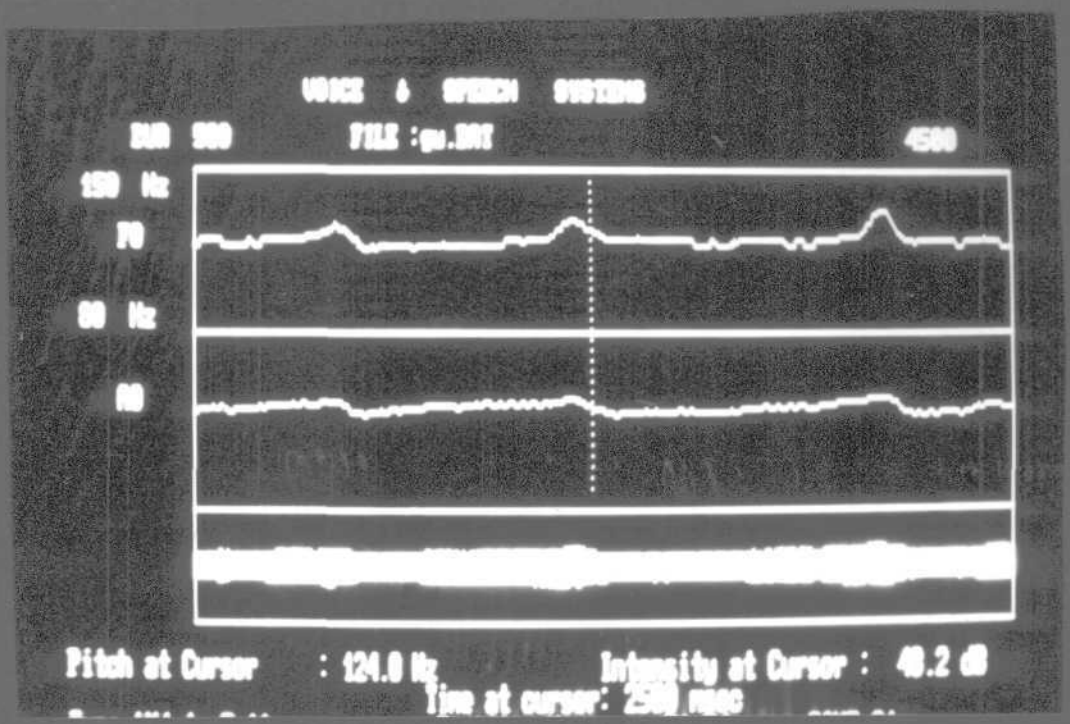
The tape recorded speech samples were digitized at 8000Hz sampling frequenc7 using 12 bit (ADC). Analog to digital converter and having antialaising filter at 3.5KHz "VSS-DATA ILN" program was used to digits. A PC-AT 386 computer having Intel 80386 as CPU and Intel 80387 as NDP with 16MHz clock speed used in this digitization 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-INTON3" programme was used to extract F0 and related measurements. The extracted Fo values were used to calculate the following parameters using PC-AT computer,

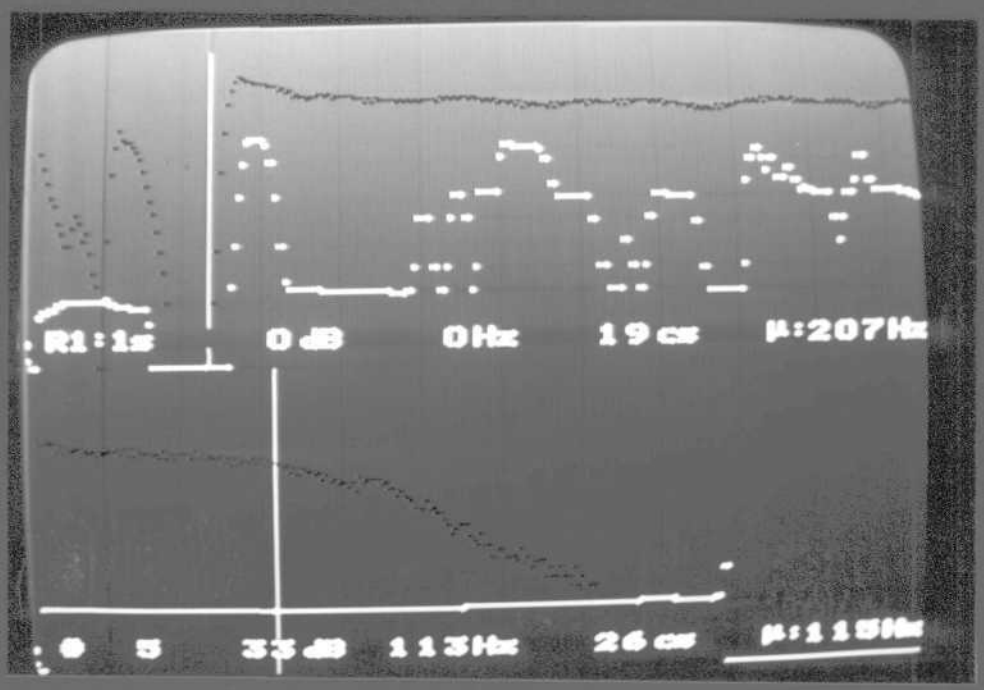
- Fundamental Frequency of phonation.
- Frequency range of phonation.
- Intensity range of phonation.

- Extent of fluctuation of Fo in phonation
- Speed of fluctuation of Fo in phonation
- Extent of fluctuation of Fo intensity in phonation
- Speed of fluctuations of intensity in phonation.

SET UP FOR THE ANALYSIS OF Fo AND RELATED PARAMETERS



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

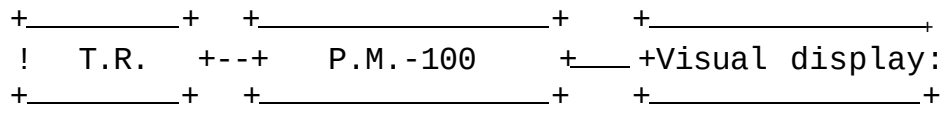


DISPLAY OF RISE TIME AND FALL TIME IN PHONATION

Results were directly read from the visual display from the screen.

3. Fundamental Frequency in speech

This was measured using the set up.



Recorded sample of speech is 3 sentences were selected. The time duration of PM-100 was set to 9 second. Then the sentences were fed to PM-100 and the mean Fo value was directly read from the visual display.

4. Frequency range in speech

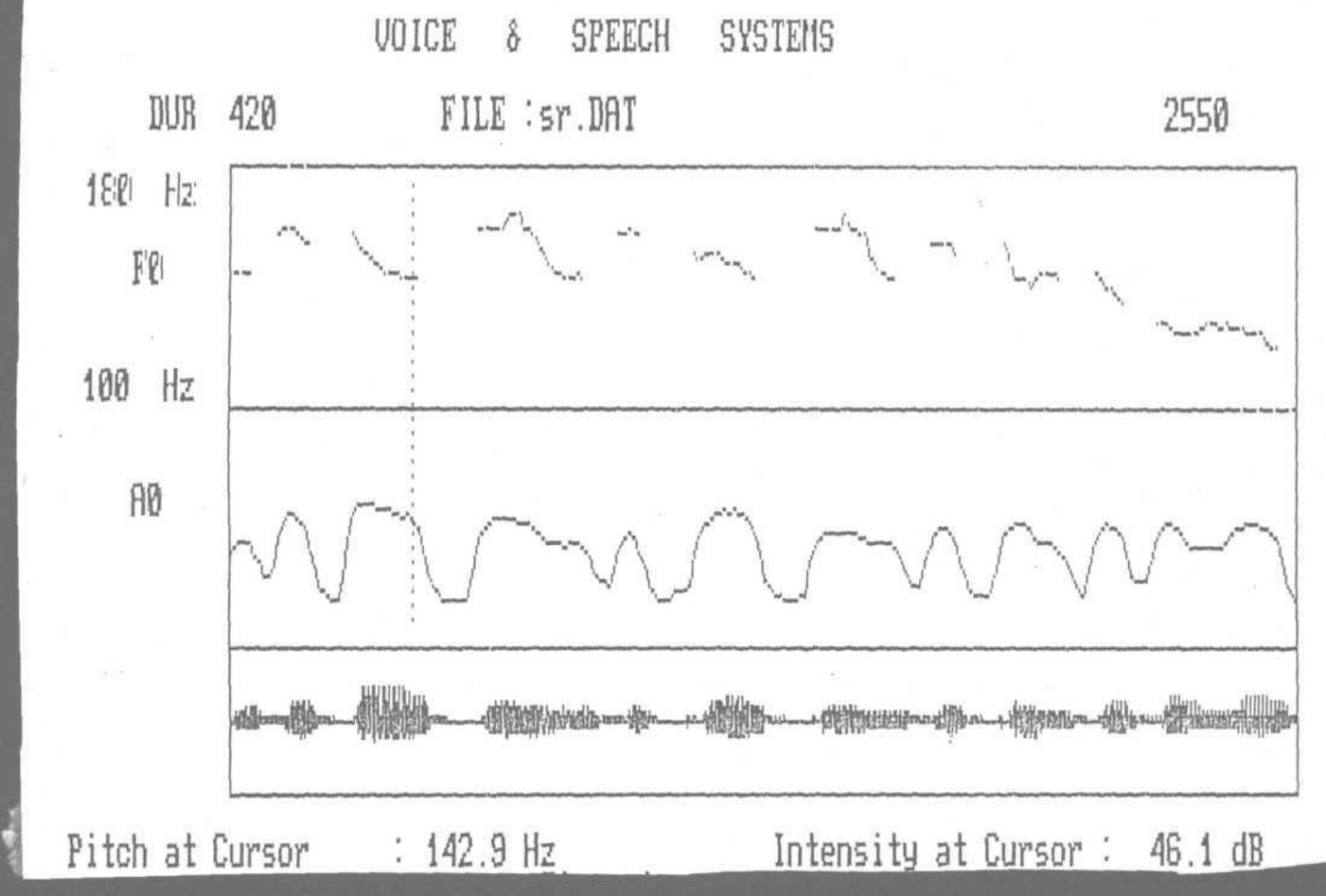
The same sample selected for analysis 3 was used. The minimum Fo level and maximum Fo level were determined by moving the cursor along the fo curve in both the screen. Range was computed as the difference between the 2 measurement.

5. Intensity. Range in speech

The same sample and set up as in analysis 3 was used. The maximum and minimum values was noted down on visual display by moving the cursor along the intensity curve. The difference of these 2 gives the range of intensity is speech.

6. **Rise time and fall time in phonation.**

For this phonation of 3 vowels were selected and measurement was done using the set up in analysis 3. The



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

initial sample was fed to the upper half of the display and final segment was fed to the bottom half of the display.

The rise time in centiseconds was noted by moving the cursor on intensity curve from the point where it begin to the point of steady state the difference in time between these two points is rise time.

Fall time was measured similarly, by moving the cursor to the end of steady state signal and to the last point of the curve. The difference in values is time scales between these 2 points gives fall time.

Same procedure was carried out for all 3 vowels and for all 3 trials to compute rise time and fall time.

RESULTS AND DISCUSSION

The study was aimed at examining the variations in the below listed parameters, as a function of age and sex in the age range 35 to 85 years.

1. The maximum phonation duration of vowels.
2. The fundamental frequency in phonation.
3. The fundamental frequency in speech.
4. Speed of fluctuation in frequency of phonation.
5. Extent of fluctuation in frequency of phonation.
6. Frequency range in phonation.
7. Frequency range in speech.
8. Speed of fluctuation in intensity of phonation.
9. Extent of fluctuation in intensity of phonation.
10. Intensity range in phonation.
11. Intensity range in speech.
12. Rise time in phonation.
13. 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

The mean values, S.D. values of the age groups studied are shown in the tables la, lb & lc.

In males, there is a decrease in mean Maximum phonation duration (MPD) values, from 18.1sec at 35-45 years to 9.55sec at 75-85 years, in the phonation of /a/. In the phonation of /i/ the decrease is from 19.15sec at 35-45yrs to 9.58sec at 75-85yrs age group. In the phonation of /u/ mean MPD decreases from 19.5sec at 35-45 years to 9.957sec at 75-85 years.

The S.D. values do not show a consistent change with age for /a/ (2.233 at 35-45 years and 2.05 at 75-85 years). Vowel /i/ and /u/ also shows same trend, except for 75-85 years age group, which shows slightly higher variability than others (/i/ - 3.351 and /u/ - 3.351).

Mann-Whitney 'U' test was applied to know the significance difference between the age groups studied. It revealed that, in vowel /a/, there is a significant drop xn the mean values at the 45-55 years age group and again at the age group 65-75 years after which the decrease is not significant. A slight increase in 55-65 years is statistically not significant. vowel /i/ and /u/ also shows similar results. Thus there is a gradual decrease in MPT

values with age, in case of males.

In females, there is a decrease in maximum phonation duration with age, from 17.55sec at 35-45yrs to 8.40sec at 75-85yrs age group, for vowel /a/. For vowel /i/ there is a decrease from 18.55sec at 35-45yrs to 7.66sec at 75-85yrs age group. And for vowel /u/, there is a decrease in MPD, from 18.58sec at 35-45yrs to 8.334 at 75-85yrs age group.

The SD values do not show consistent change with age for /a/ (3.32 at I group and 3.439 at V group). But in vowel /i/ and /u/ the value at 75-85yrs(V group) show a lesser value from the 35-45yrs (2.628 for /i/ and 1.52 for /u/).

Administration of Mann-Whitney test to findout the significance of difference reveals that there is no significant differences are found when a group is compared with the immediate higher group for the vowel /a/, hence indicating a gradual decrease in values with age. Vowel /i/ and /u/ do not show significant difference between 55-65yrs and 65-75yrs only, indicating a more rapid change in mean . values with age.

Hence the null hypothesis stating that there is no significant difference in males and females in maximum duration of phonation with age group is rejected.

Comparisons of males and females, in terms of maximum duration of phonation, reveal that, in vowel /a/ slightly lower values are found in female groups. Age group 45-55 shows higher SD and range in females than in males. The same

is observed in 75-85 years age group.

S.D. values of males show higher values than that of females in vowel /i/. In vowel /u/ only 75-85 years age group show lower SD values than that of males.

The significance of difference between males and females at each age group shown in table 40 , reveal that there is no difference between males and females in any age group.

Hence the null hypothesis stating that there is no difference between males and females in maximum duration of phonation at each age group is accepted.

The decrease in MPD reported here is reflated by Ptacek, 66, Kruel, 72. However values found here are lower than those western population. Furthermore they have reported a significant difference between males and females, which was not supported by this present study.

However, study by Vanaja, 1986, shows similar results between age groups 16 to 65 years. The mean values reported in the present study in 35-45, 45-55, 55-65 are slightly higher than that reported by Vanaja, 1986. She also reports no significant differences between males and females.

It is also interesting to note that when compared with norms by Nataraja, 88, the mean values and S.D. values in all age groups of males found in the present study are lower. But except for 75-85 years all age groups show mean values in the range specified by the study by Nataraja (ll-30sec).

Table: 1. Showing Mean, S.D. and Range of MPD in Males and Females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
1a.	Mean	18.10	13.55	14.72	11.33	9.55	17.55	15.314	12.503	10.622	8.404
	S.D.	2.233	2.266	2.365	2.389	2.05	3.32	2.68	2.219	4.166	3.439
(a)	Min.	15.00	10.00	11.50	9.00	7.00	14.00	12.00	9.51	0.55	6.00
	Mix.	21.00	16.00	18.00	16.00	13.00	24.00	21.00	15.40	15.38	15.63
1.b.	Mean	19.15	14.8	14.711	10.657	9.58	18.55	15.226	12.90	11.38	7.66
	S.D.	3.00	2.057	2.946	3.275	3.351	3.166	2.501	1.963	2.69	2.628
(i)	Min.	15.00	12.00	10.00	7.58	5.00	14.50	12.60	9.89	7.25	5.32
	Mix.	23.00	18.00	19.00	18.00	15.44	25.00	21.00	16.91	16.94	11.84
1.C.	Mean	19.50	14.95	14.539	11.19	9.957	18.55	15.904	13.291	11.635	8.334
	S.D.	2.87	1.786	2.76	2.376	3.351	2.948	2.713	2.894	2.719	1.52
/u/	Min.	15.00	13.00	11.50	8.00	5.00	14.50	13.00	8.90	7.25	6.99
	Mix.	23.00	19.00	21.00	15.00	14.73	24.00	24.00	19.61	16.32	10.61

Table-2: Significance of difference age groups of males on MPD

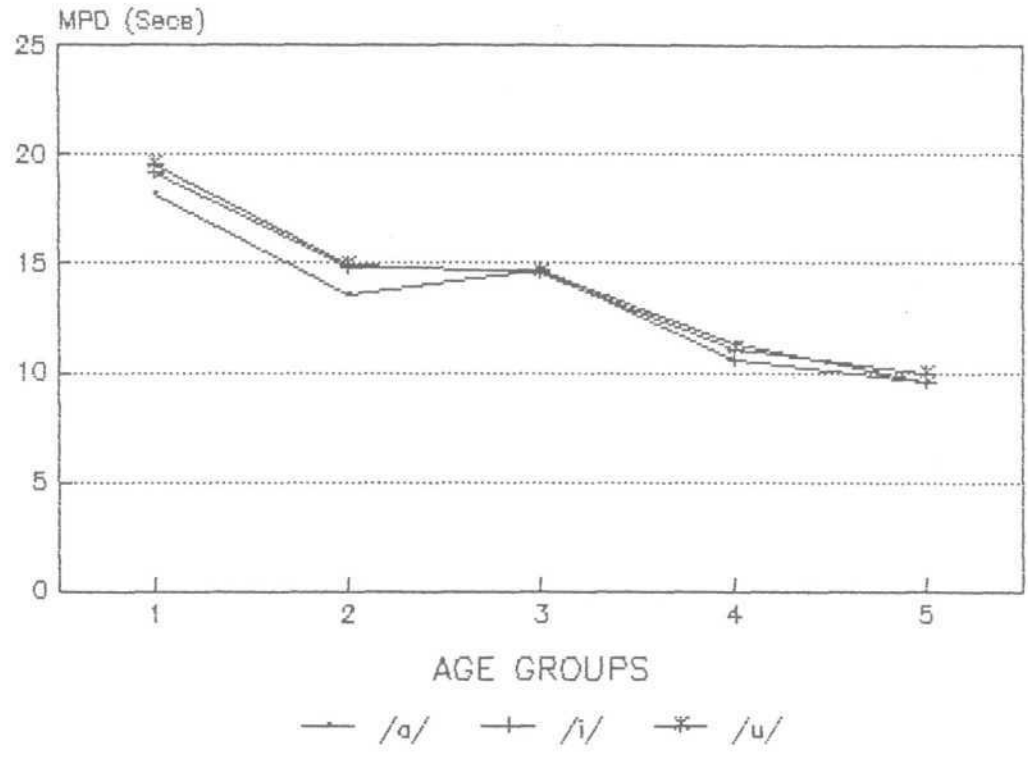
	45 55	55-65	65-75	75-85
35-45	P	P	P	P
45-55	-	**P**	P	P
55-65	-	-	P	P
65-75	-	-	-	A

Table-3: Significance of difference age groups of females on MPD

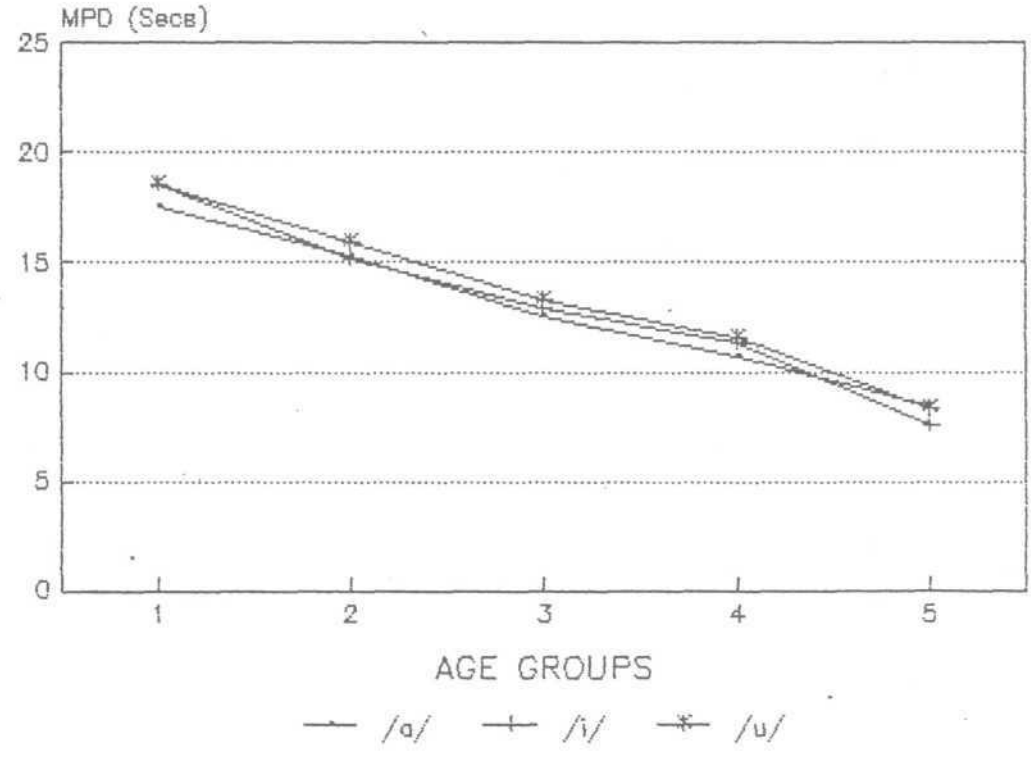
	45 55	55-65	65-75	75-85
35-45	**P***	P	P	P
45-55	-	P	P	P
55-65	-	-	A'	P
65-75	-	-	-	P

* A -> not significant at 0.05 level.
* P -> significant at 0.05 level.

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



GRAPH-2: SHOWS PHONATION DURATION OF /a/, /i/ & /u/ IN FEMALES



MPD in females is similar to the mean values reported by Nataraja (1988) in the younger age groups, 35-55yrs. But in older age groups the mean MPD is lower.

The results can be summarised as,

1. In males and females maximum phonation duration decreases as a function of age.
2. Males and females did not differ significantly in mean maximum phonation duration at all age groups.

FUNDAMENTAL FREQUENCY IN PHONATION

The fundamental frequency in phonation for all the three vowels was analyzed as described in chapter III. The results of the measurement are presented in the Table-4a,4b & 4c.

The examination of these tables and graph-3 shows that, MFo in males show a slow and gradual increase in Fo in phonation with age, in all the 3 vowels. The lowest Fo is seen in the age group 35-45. (/a/ - 122.83H, /i/ - 121.66H and /u/ -119.23H) which increases to 145.47Hz, 152.42Hz and 151Hz for /a/, /i/ and /u/ respectively by 75-85 years.

However, for the /a/ and /i/ the highest values of mean and S.D. are present in the age group 55-65 years. For /u/, mean values at 55-65 years shows an increase but it is less than that of 75-85 years.

The inspection of mean values (graph-4) for females reveals that the decrease in Fo is gradual for all the three vowels. Vowel /a/, however shows an increase in Fo again in the age group 75-85 years. The S.D. values do not show much change with age.

Table 5 showing significance of difference between the age groups in terms of Fo, indicates that in males for /a/ lower age groups 35-45 and 45-55 do not show significant difference with each other.

Age group 55-65 years shows significant difference with all age group except 75-85 years. Age group 75-85 years show significant difference with the lower age groups 75-85 and 45-55 years.

Vowel /i/ also shows similar trend, except that age group 75-85 years show significant difference with 55-65 years also. Vowel /u/ shows more clear significant increase with age as shown in the table 5.

For females, (table 6) the values reveal that there is a significant but gradual decrease in Fo in phonation, for all the vowels in the age range studied. However this change in Fo is not significant statistically when each age is compared with the next higher age groups.

Comparisons in mean Fo in phonation between males and females show that significant differences exist between males

and females in terras of mean Fo at all age groups, in all the three vowels. However, in /i/, age group 75-85 years do not show significant differences between males and females(table 40).

Thus the hypothese that "there is no significant difference in the fundamental frequency of phonation in males and females with increase in age" and "there is no significant change in the mean fundamental frequency of phonation between males and females of the same age group". are rejected.

The results can be summarized as follows:

(l) Males in general show an increase in Fo with age.

a) Vowel /a/ shows gradual increase as immediate age groups do not show significant differences. Vowels /i/ and /u/ shows more rapid increase with age.

b) Age group 55-65 years show higher values than others.

c) Variability in Fo in phonation in males increases with age.

2) Females show a decrease in Fo with age.

a) Vowel /a/ shows a sudden significant decrease at 45-55yrs followed by a gradual decrease there after. Immediate age groups do not show significant differences except for 35-45 and 45-55 years.

b) Vowel /i/ also shows similar trend as /a/.

c) Vowel /u/ also shows more gradual decrease, as immediate age groups do not show any significant differences.

d) Variability in Fo, in females, do not show much changes with age.

3) Males and females show significant difference at all age groups, in terms of mean Fo, except for /i/, in which, age group 75-85 years shows no significant differences between males and females in MFo.

The results of the earlier studies with western population are shown in tables I and II. All studies show an increase in MFo with age in males.

Endears et al (1967), in a longitudinal study of 15 years reports an increase in MFo with age. The present study also reports similar results.

No studies in Indian population is available in geriatric age groups. Vanaja (1986) and Nataraja (1988), reports no change in MFo in the age range 16 to 65 and 16 to 45 respectively. The present study also shows similar results between 35 to 55yrs in vowel /i/ and /u/.

As Fo changes in males are associated with climacteric period occurring around 55-60 years, the significant changes could only be seen after this age group (Mysak, 57, Hollien and Shipp, 72). In the present study though age group 55-85 years in general shows higher value than the lower age groups, age group 55-65 years shows higher value than 65-75 years. Hence, it is possible that along with age factor, climacteric changes have contributed for the increase in MFo.

Table: 4- Indicating the Mean and S.D. of Fo in phonation in males and females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
4.a	Mean	122.833	123.10	150.633	125.50	145.47	219.033	190.80	184.40	168.20	176.33
	S.D.	12.555	13.781	23.802	16.911	21.05	14.499	16.22	22.676	23.759	14.30
/a/	Min.	138.00	103.66	126.00	99.66	130.66	194.33	172.67	145.00	135.33	152.00
	Mix.	106.32	144.66	187.00	149.33	191.66	242.66		220.33	205.33	189.33
4.b.	Mean	121.66	128.60	145.06	131.80	152.42	228.30	200.53	190.90	176.06	177.14
(i)	S.D.	11.39	13.02	22.97	16.86	18.28	17.11	17.10	22.91	24.25	14.49
	Min.	107.66	101.33	123.33	101.33	135.66	195.00	177.00	66.00	211.00	143.00
	Mix.	137.33	147.33	197.00	149.33	189.33	250.61	220.33	153.33	211.16	201.00
4-C.	Mean	119.23	127.10	144.43	134.13	151.09	222.86	202.10	185.56	179.76	180.47
	S.D.	7.53	16.37	32.59	16.67	19.21	21.72	19.33	24.747	25.78	16.98
(u)	Min.	108.00	103.66	10.500	103.66	138.00	193.66	172.33	135.66	140.00	156.00
	Mix.	131.66	162.66	221.33	149.66	189.66		225.66	210.33	220.33	207.00

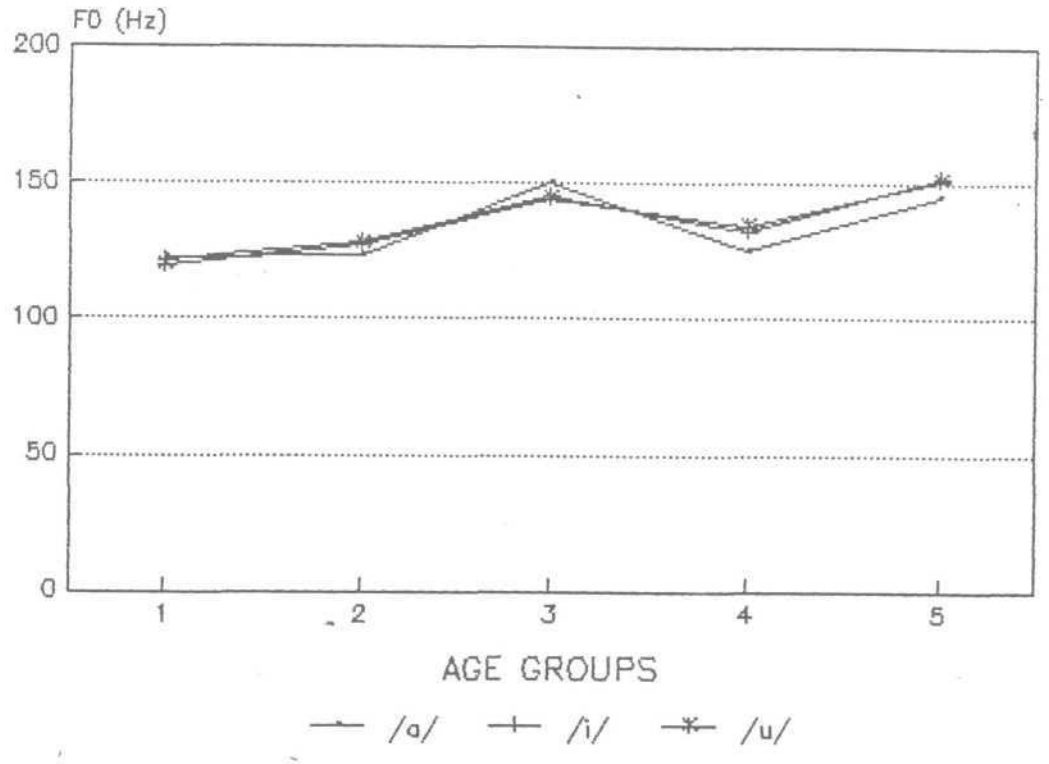
Table-5: Significance of different age groups of males on fundamental frequency of phonation

	45 55	55-65	65-75	75-85
35-45	A	**P**	A	**P**
45-55	-	**P**	A	**P**
55-65	-	-	P	A
65-75	-	-	-	A

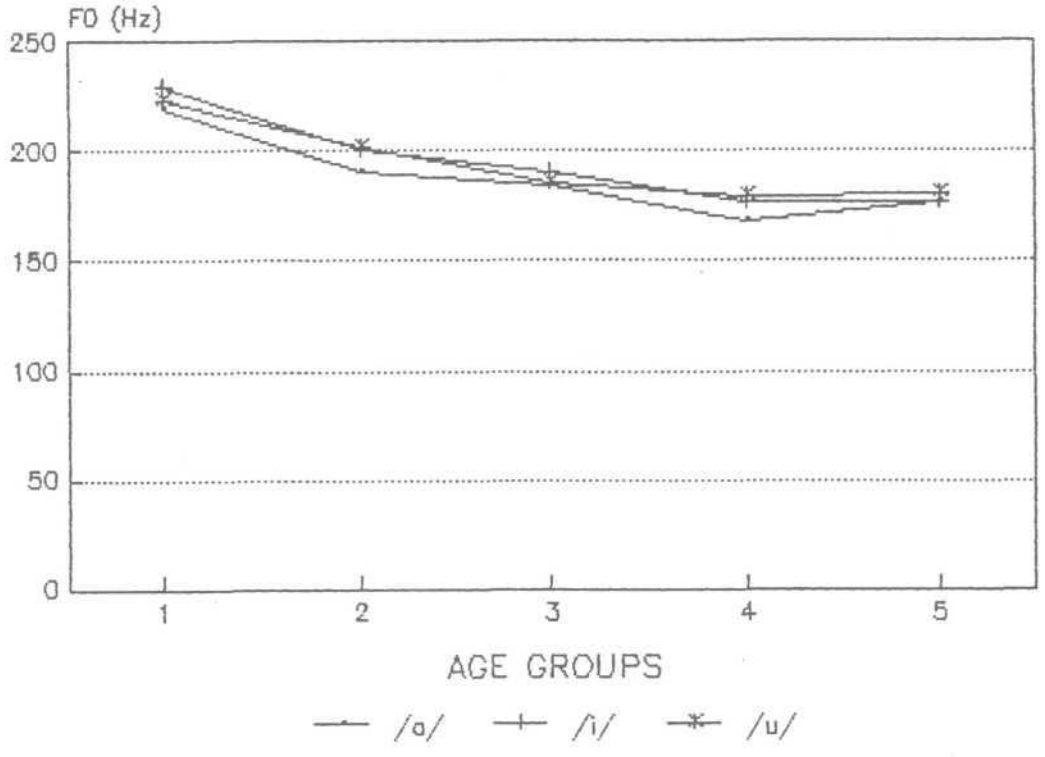
Table-6: Significance of difference age groups of females on fundamental frequency of phonation

	45-55	55-65	65-75	75-85
35-45	**P**	P	P	P
45-55	-	A	P	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:3 SHOWING F0 IN PHONATION
/a/, /i/ & /u/ IN MALES



GRAPH-:4 SHOWS F0 IN PHONATION
/a/, /i/ & /u/ IN FEMALES



The results with reference to the female groups studied are similar to reports by Stoicheff, 81, Kitzing 79, Honjo and Isshiki, 80. However Saxmann and Brook (1967) reported an increasing trend again at higher age, which was found only in case of /a/, in the present study, and not in other two vowels.

Thus it can be concluded that, in general, males after 45 years of age show an increase in Fo in phonation with increasing age where as female counterparts show a decrease in Fo in phonation with increasing age.

(FREQUENCY RANGE IN PHONATION")

Tables 7a, 7b, 7c and graphs 5 & 6 presents the results of analysis of phonation in terras of frequency range i.e the difference between maximum and minimum Fo seen during the phonation of /a/, /i/ & /u/.

The inspection of table shows that, in males, for vowel /a/, the frequency range in phonation of age groups 65yrs and above are higher than mean values in the age range 35 to 55 years. The S.D. also shows a similar trend. The higher mean S.D. value is 17.952Hz and 9.244Hz (75-85 years) and lowet is 8.76Hz and 1.905Hz at 45-55 years.

For vowel /i/ and /u/ the results are similar. The highest mean values of /i/ is 19.524Hz at 75-85 years and lowest is 3.49 a 45-55 years. The S.D. value is highest at 65-75 years (10.50Hz) and lowest at 45-55 years (3.49Hz).

The highest mean value for /u/ is 15.428Hz at 75- 85 years and lowest at 45-55 years (8.427Hz). The S.D. value is highest a 65-75 years (12.23Hz) and lowest at 3.668 at 45- 55 years.

The mean values also show an increasing trend in older subjects and a slight decreasing trend for adults in all 3 vowels (graph-5).

The test of significance applied indicates, (table-8)

1) for both /a/ and /i/ the significant difference is seen only between 75-85 years and other age groups.

2) for /a/, the change is significant only between 75-85 years and adult group in 35-45 years and 45-55 years.

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

In females, the age group 75-85 years show the highest value i.e, 30.762Hz for /a/, 25.38Hz for /i/ and 36.238Hz for /u/. The lowest is 13.46Hz at 55-65 years for /a/ and 11.33Hz at 45-55 years for /i/ and 11.9Hz at 35-45 years for /u/. The SD values show a similr picture.

Like in males, the older group show an increasing trend, where as the younger group shows a slight decrease in both mean and SD values.

The Mann-Whitney test 'U' applied for significance of differnece shows that, (table- 9)

1) for /a/ the age group 75-85yrs shows significant difference between from 35-45 years and 45-55 years.

2) Whereas phonation of /i/ do not show any significant difference across the age group studied.

3) for /u/, the age group 75-85 years is significantly differenct from all other age groups.

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

Comparisons between mean and S.D values of males and females shows that, in vowel /a/ females have higher mean values at all age groups, and the difference is significant at 45-55yrs and 75-85yrs. Vowel/i/ and /u/ also shows significant differences between all age groups except between 55-65yrs and 65-75yrs.

The variability is more in females than in males at all age groups, in all three vowels as shown in table 40.

Hence the null hypothesis stating that there is no significant difference between males and females in frequency range in phonation at each age group is rejected.

The results can be summarized as,

1) In males, the older subjects shows a higher values then adult age group, for all 3 vowels.

2) But however, the difference is significant only for 75-85 years and other age groups is /a/ and /i/ and between 75-85 years and adult age group.

3) Females, also show similar trend as in male.

4) But significant difference is present only between 75-85 years and groups for /a/, and between 75-85 years and all others for /u/ for /i/ do not show any significant difference.

5) Thus significant vowel effect is seen in both males and females.

6) Females show higher values than males.

Very few studies have been carried out an this parameter, as majority have concentrated on MPFR capabilities (Sue Ellen Linville, 1987, Harry et al 1971). They report changes in such capability over age, like reduced high frequency end in MPFR in elderly. Changes in middle aged women was attributed to menophause (S.E Linville, 1987) and that in elderly, to the anatomical and structural changes.

PFR was studied by Nataraja (1988) in an attempt to differentiate normal and dysphonics using acoustic parameters. He reported that both mean and range were greater in female group than in male.

Table:7.Showing Frequency range in phonation (Mean, S.D. and Range) of males and females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
7a.	Mean	9.067	8.967	10.967	11.23	17.952	19.80	14.96	13.46	16.80	30.762
	S.D.	2.204	1.905	6.089	4.962	9.244	26.03	9.55	5.558	8.087	25.57
(a)	Min.	4.33	6.33	5.00	5.33	8.33	7.33	7.33	6.33	8.66	8.66
	Mix.	11.66	12.00	21.00	21.00	35.66	93.33	11.33	25.00	32.33	75.00
7-b.	Mean	9.167	8.967	10.23	13.50	19.524	12.30	11.33	14.466	13.867	25.381
	S.D.	3.922	3.49	5.742	10.501	8.799	2.86	2.66	7.57	7.921	20.77
(i)	Min.	6.33	6.00	3.33	6.33	11.00	7.66	7.33	6.66	4.33	7.33
	Mix.	17.66	17.66	18.33	41.33	36.66	15.00	16.66	28.66	31.00	64.66
7-c.	Mean	8.80	8.427	9.30	12.70	15.428	11.90	12.20	14.966	15.266	36.238
(u)	S.D.	3.85	3.668	4.56	12.233	8.232	1.982	1.008	9.932	7.756	28.747
	Min.	5.00	14.667	3.33	5.00	8.66	9.33	10.66	6.00	6.33	12.00
	Mix.	17.00	17.667	16.66	45.00	31.33	14.66	14.33	38.66	28.33	85.33

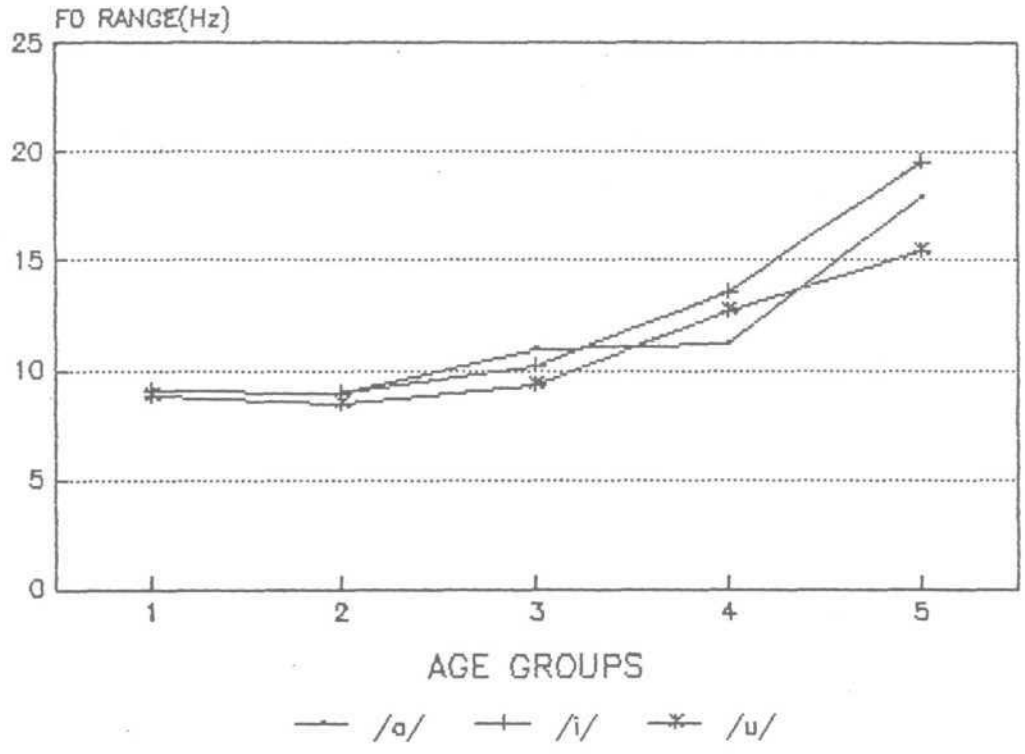
Table-8: Significance of difference age groups of males on range of Fo of phonation (PFR)

	45 55	55-65	65-75	75-85
35-45	A	**A**	A	P
45-55	-	**A**	A	P
55-65	-	-	A	P
65-75	-	-	-	P

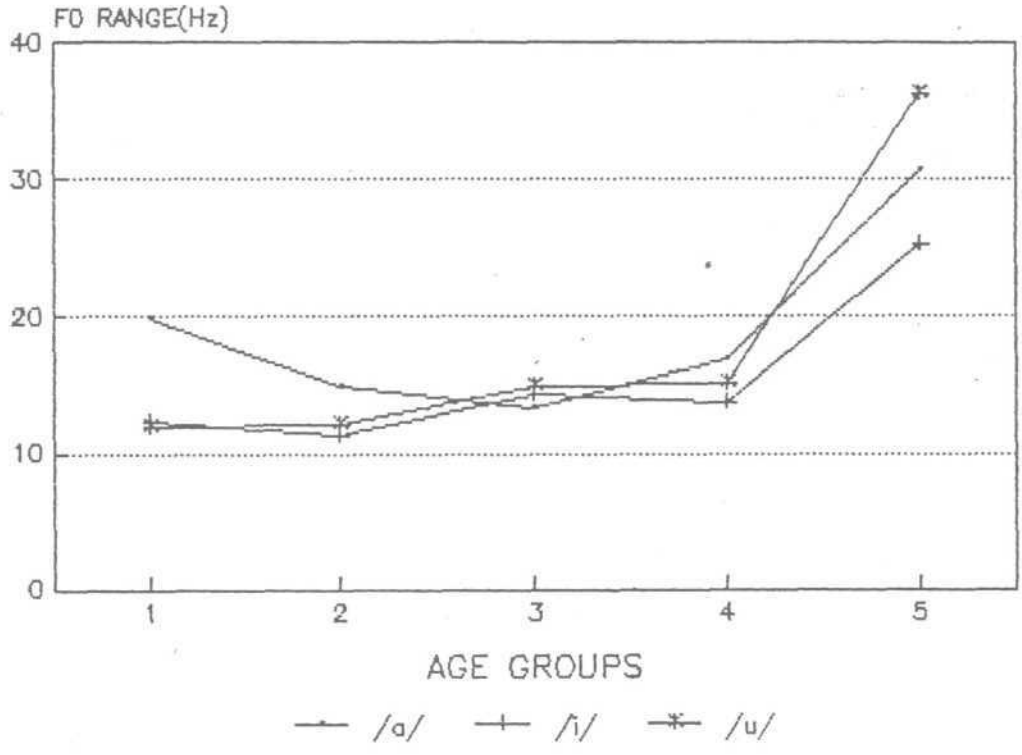
Table-9: Significance of difference age groups of females on range of Fo of phonation (PFR)

	45 55	55-65	65-75	75-85
35-45	A	A	A	P
45-55	-	A	A	P
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:5 SHOWING F0 RANGE IN PHONATION
/a/, /i/ & /u/ IN MALES



GRAPH-:6 SHOWING F0 RANGE IN PHONATION
/a/, /i/ & /u/ IN FEMALES



INTENSITY RANGE IN PHONATION

Table and graph presents the results of analysis of phonation in terms of intensity range i.e the difference between maximum and minimum intensity level seen during the phonation of /a/, /i/ & /u/.

The inspection of table reveal that,

In males, /a/ do not show much change in mean values of intensity range with age. The mean value at 35-45 years is 5.26dB and S.D 1.34 and at 75-85 years is 6.286dB (mean), and 1.568 (SD).

For the vowel /i/ the mean value at 35-45 years is 5.13dB and S.D 2.36 and at 75-85 years is 7.38dB (mean), and 7.24 (SD). Vowel /i/ shows that age groups 55-65yrs and 65-75yrs shows a slightly lower values compared to adults, and 75-85 years which shows the highest i.e,7.381. Vowel /u/ shows similar result.

The Mann-Whitney 'U'test was applied to know the significance difference between age groups, a) for vowel /a/ the age group 55-65 shows a significalty lower values than other age group (b) for /i/ & /u/, both age groups 55-65 years and 65-75 years show a significant difference from other age group.

In females, the mean value do not show any systematic change in /a/ and /i/. But vowel shows a gradual increase in

mean values from 3.83dB at 35-45 years to 6.286dB at 75-85 years.

The SD values for /a/ is lowest at 35-45 years (0.834) and highest 65-75 years (4.669), for /i/, at 65-75 years (3.775) and for /u/, lowest in again at 35-45 years (0.633) and highest at 55-65 years (3.278).

The Mann-Whitney[v] 'U' test shows that, majority of the groups do not vary significantly . Only age groups 35-45 years and 45-55 years and 35-45 years and 65-75 years show a significant difference in /a/, /i/ and /u/ do not show any significant difference.

No study which reports intensity range in phonation in geriatric subjects are available to compare. Nataraja (1988), has studied this parameters with a similar definition in normal adults and dysphonics. He reported that no significant difference between the age groups studied in 16-45 years and also between males and females. The mean values for normal male adults were 3.8dB and for females 4.18dB. The mean values reported in the present study is higher than the mean values of normal adults reported by Nataraja (1988).

Table: Showing the values of range of intensities (Mean, S.D. and Range) for males and females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
10(a)	Mean	5.366	6.226	4.226	6.266	6.286	3.80	6.201	5.366	7.166	5.571
	S.D.	1.341	1.967	1.654	3.059	1.568	0.834	2.747	2.613	4.669	3.089
(a)	Min.	3.00	4.00	2.33	1.326	5.00	2.66	3.016	2.00	4.00	2.33
	Mix.	7.00	10.00	8.33	12.66	9.33	5.00	11.66	11.66	19.66	10.33
10.b.	Mean	5.133	5.70	3.766	3.953	7.381	5.066	5.066	5.033	5.833	5.142
	S.D.	2.368	1.55	2.228	1.48	7.241	0.913	1.16	3.214	3.775	1.772
(i)	Min.	2.66	3.66	1.66	1.20	3.33	3.33	3.66	2.33	2.66	2.33
	Mix.	10.33	8.33	9.33	6.33	23.66	6.66	7.66	13.66	14.66	7.66
10.c	Mean	4.366	5.33	3.96	3.86	5.00	3.83	4.33	4.466	5.133	6.286
	S.D.	0.908	1.937	3.444	1.536	1.71	0.633	1.176	3.278	2.251	2.927
(u)	Min.	3.00	2.00	2.00	0.986	3.00	2.66	2.66	2.33	2.33	3.33
	Mix.	6.333	9.33	13.66	6.00	8.33	4.33	6.33	13.33	8.33	10.33

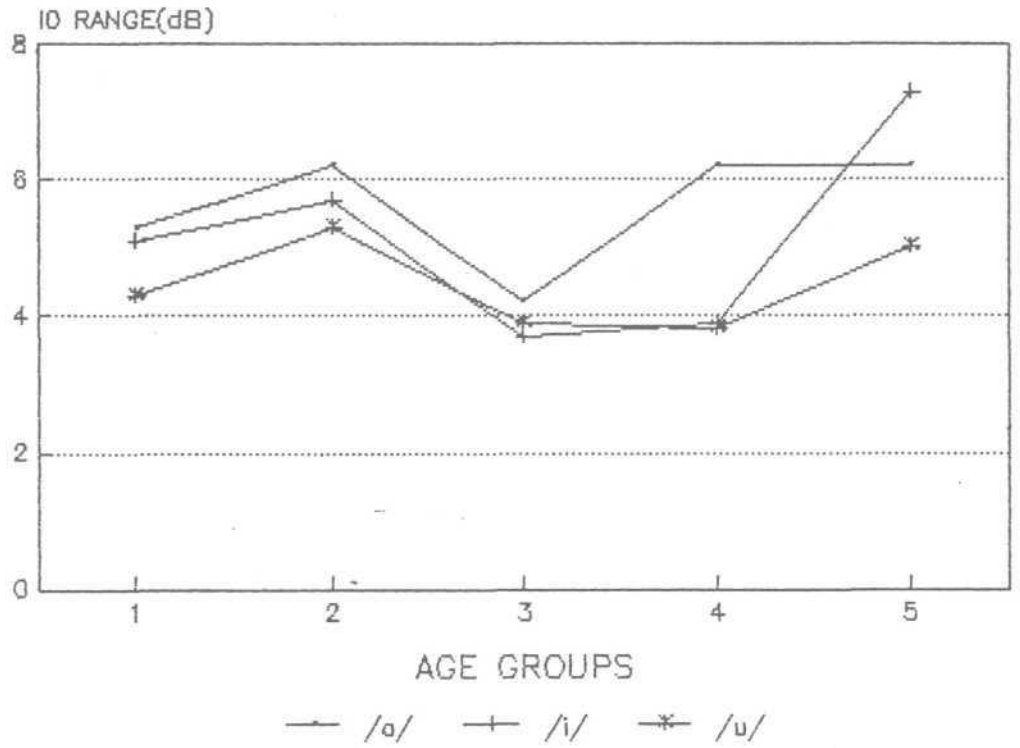
Table-11: Significance of difference age groups of males on range of intensity in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	A
45-55	-	P	P	A
55-65	-	-	A	P
65-75	-	-	-	A

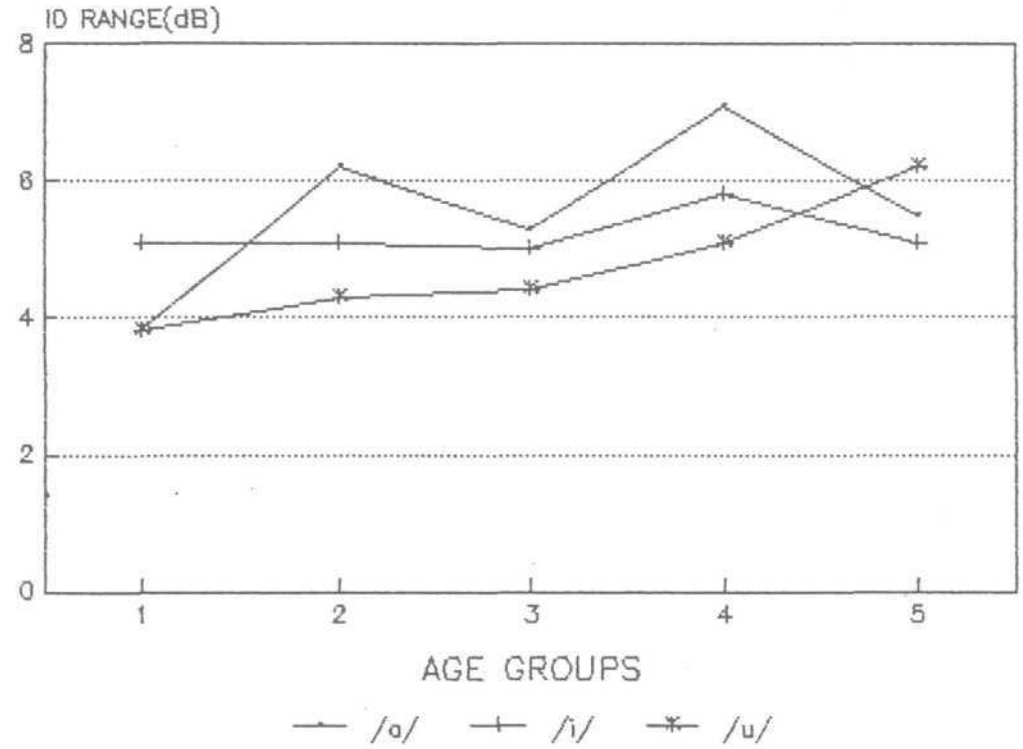
Table-12: Significance of difference age groups of females on range of intensity in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	A
45-55	-	A	A	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:7 SHOWING IO RANGE IN PHONATION
/a/, /i/ & /u/ IN MALES



GRAPH-:8 SHOWING IO RANGE IN PHONATION
/a/, /i/ & /u/ IN FEMALES



EXTENT OF FLUCTUATION IN FREQUENCY

The mean and S.D. values are shown in table 13a,b & c. The mean values show a gradual increase with age for /a/. Except that age group 55-65 years show a slightly low value. The mean value of /i/, shows that the age groups 65- 75 and 75-85 years show a higher value than other age groups. The Mean values of /u/, shows that age group 75-85 years shows a higher value than others and age group 55-65 years show a lower value.

The SD values show a slow increase with age for /a/ and /i/ with 33-45 showing lowest value for /a/ (0.508) and 75-85 years showing highest value (1.851), for /i/ lowest value is 0.724 at 45-55 years and highest at 75-85 years (2.735), for /u/, there is ano such trend but lowest value is at 75-85 years (0.3422) and highest at 45-55 years (0.495).

The test of significance applied shows that, in /i/ the age groups 65-75 and 75-85 show a significantly higher values from the rest. In /u/, the age group 75-85 shows significant difference with 45-55 years' and 55-65 years and with 35-45 years and 65-75 years at a lower value in 0.6 and 0.57 respectively. In /a/, the age groups 35-45 and 75-85 years shows a significant difference and no other age group shows any significant difference (table-14).

Hence the null hypothesis stating that there is no significant change in the extent of fluctuations in frequeny of phonation of the vowels with increase in age in males is partly accepted and partly rejected.

Inspection of female data reveals that there is not much change in mean value across the age groups. /a/ shows a slight decrease at the age group 55-65 years. /i/ shows a slight increase in mean values at 55-65 yeas and 75-85 years /u/ also shows similar increase.

The S.D. values correlate with mean values in /a/, in /i/ and /u/ age group 55-65 and 75-85 years an increase.

The Mann-Whitney test applied reveals that (table-15) in /a/ only age group 55-65 years shows a significant difference with 45-55 years and 65-75 years. In /i/ age group 75-85 years shows a significant difference with 45-55 years group and 65-75 years group. In /u/ no age group shows any significant difference. Hence the null hypothesis stating that there is no significant change in the extent of fluctuations in frequeny.of phonation in females with increase in age is partly accepted and partly rejected. Comparisons of mean and S.D values between males and females shows that in /a/ females show higher mean values than males at all age groups, in /i/ very little differences in mean values are found, males show a slight lowering at 55-65 yrs age group while females show an increase at the same age group and in /u/ mean values show very little differences.

Mann-Whitney test was applied to know the significance of difference which shows no significant differences between males and females at all age groups (table 40).

No studies are available in geniatric subjects with similar difinition of parameter. Nataraja (1988) has shown

Table: Showing extent of fluctuation in frequency (Mean, S:D. and Range) of males and females

13.

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
13.a	Mean	3.445	3.579	3.289	3.796	4.598	4.126	4.321	3.541	4.962	4.648
	S.D.	0.508	0.546	0.783	0.622	1.851	1.33	1.562	0.591	2.579	1.492
(a)	Min.	2.633	2.19	2.156	2.62	3.513	2.182	3.556	2.183	3.166	3.168
	Mix.	4.26	4.109	4.326	4.643	8.699	7.823	8.743	4.47	11.666	7.13
13.b.	Mean	3.469	3.694	3.461	4.208	4.169	3.959	3.732	4.104	3.659	4.893
	S.D.	0.793	0.724	1.001	1.138	2.775	0.765	0.420	0.789	0863	1.551
(i)	Min.	2.336	2.313	0.703	2.136	3.82	2.488	3.186	2.98	1.552	3.578
	Mix.	5.023	4.823	4.252	6.396	4.56	4.803	4.45	5.461	4.947	8.062
13.c	Mean	3.395	3.506	3.055	3.658	4.312	3.628	3.909	7.818	3.659	6.55
	S.D.	1.035	0.495	1.259	1.200	0.342	0.736	1.032	3.772	0.863	7.167
(u)	Min.	2.276	2.665	0.34	2.116	3.716	1.899	2.81	2.246	1.552	3.341
	Mix.	5.65	4.383	7.471	6.275	4.683	4.225	6.536	14.563	4.947	22.776

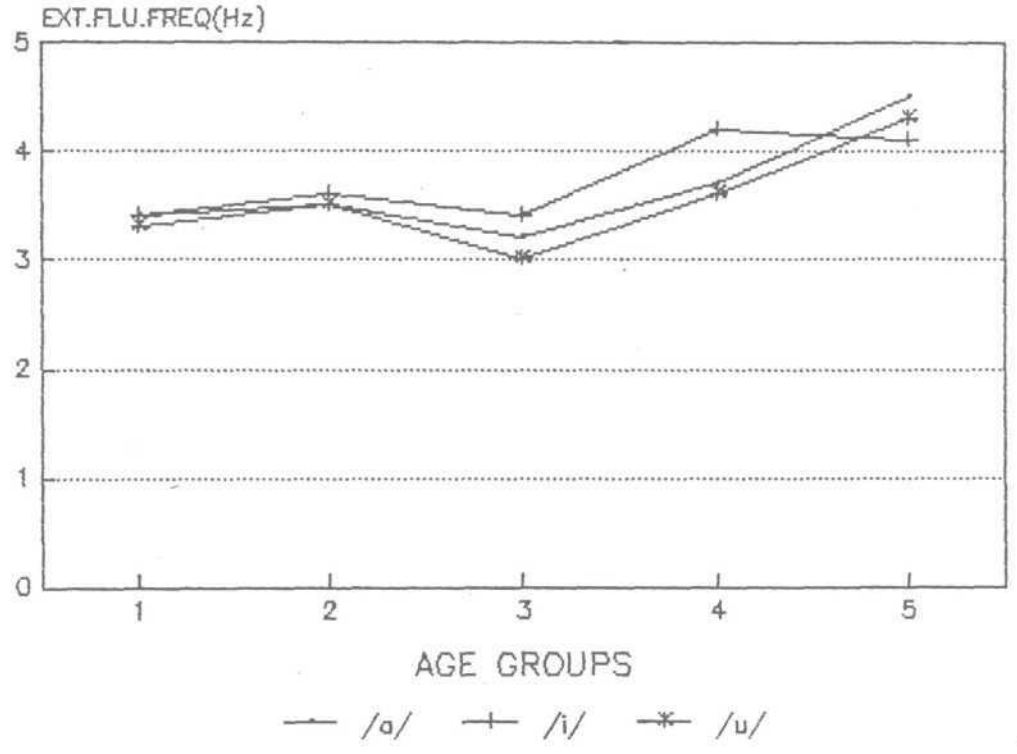
Table-14: Significance of difference age groups of males on extent of fluctuations in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	**P**
45-55	-	A	A	A
55-65	-	-	A	A
65-75	-	-	-	A

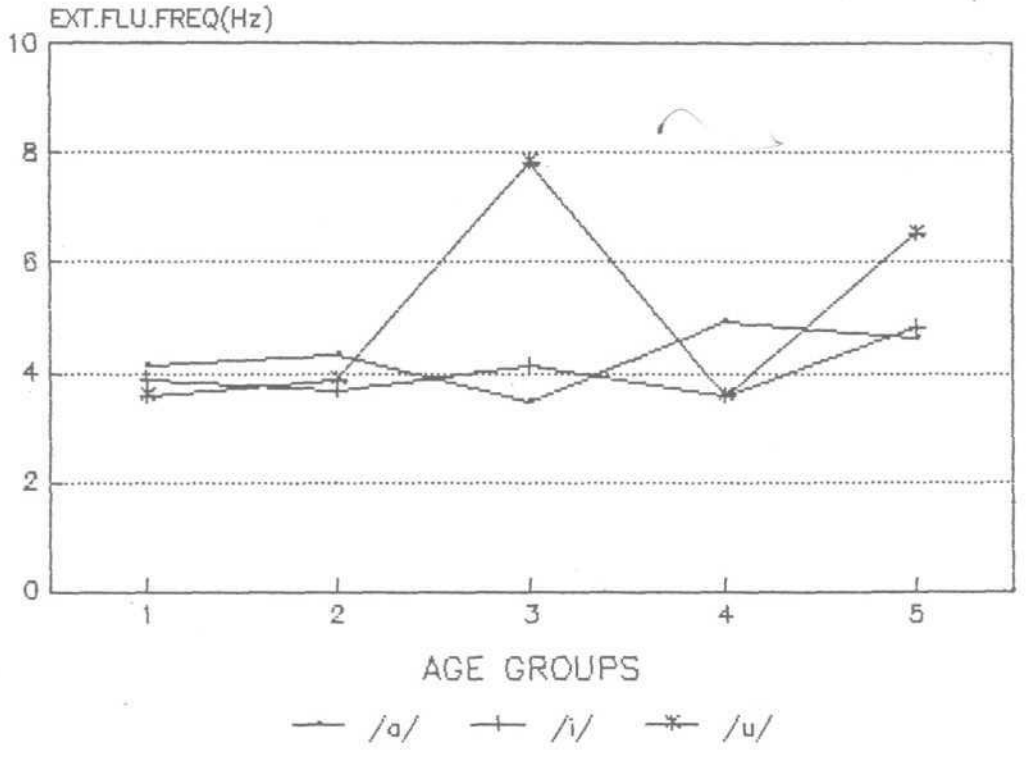
Table-15: Significance of difference age groups of females on extent of fluctuations in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	A
45-55	-	P	A	A
55-65	-	-	P	A
65-75	-	-	-	A

GRAPH-:9 SHOWING EXT.OF FLU.IN FREQ.
/a/, /i/ & /u/ IN MALES



GRAPH-:10 SHOWING EXT.OF FLU.IN FREQ.
/a/, /i/ & /u/ IN FEMALES



that extent of fluctuation did not change with age between 16 to 45 years reported a mean value of 3.86 for males and 3.56 for females. The present study also reported the same with mean age ranging from 3.54 to 4.59 from lowest to highest age group for /a/.

SPEED OF FLUCTUATION IN FREQUENCY

The mean, SD values are listed out in table 16a,b & c. Graph 11 & 12 shows the mean values in males and females in different age groups.

Inspection of values for males groups, shows the following: 1) The older age groups 65-75 yers and 75-85 years shows a greater values than the other age group, for all 3 vowels.

2) The S.D. value show an increase, trend with age for /a/ and /i/. In /u/ also such as trend in present but age group 65-75 years shows highest value.

These values are in contrast with extent of fluctuations values which showed no consistent change with age.

The Mann-Whitney 'U' test (table 17) revealed the following:

- The age group did not show significant differences when compared with immediate higher group.
- In the phbnation of /a/ & /i/, significant differences between age group 75-85yrs and other age groups were present.
- In /u/ significant differences were found only between 35-45yrs. 55-65yrs and 75-85yrs.

Hence the null hypothesis stating that there is no significant change in the speed of fluctuations in frequeny of phonation of the vowels with increase in age in males is rejected.

Examination of results of analysis of speed of fluctuation in frequency, in female age groups reveals that,

- For vowel /a/ age group 35-45yrs show lowest mean and S.D values i.e,4.49 and 1.936 respectively. It also shows a rapid increase between 35-45 and 45-55yrs age group and thereafter very small increase in mean values is found.

For vowel /i/ age group 35-45yrs shows lowest mean & S.D i.e, 3.69 and 1.30 respectively. the highest value is found in the age group 75-85yrs i.e., 12.74 and 11.83 respectively. there is a rapid increase in mean values from age group 35-45yrs to 55-65yrs as evident in graph 12. There is a slight decrease at the age group 65-75yrs followed by an increase again at 75-85yrs age group.

for /u/ shows a similar trend, however the values are higher than /a/ at age groups 55yrs and above. The highest mean and S.D are 13.02 and 9.55 at the age group 75-85yrs and lowest mean and S.D are 3.96 and 1.80 at 35-45yrs.

The Mann-whitney'U' test was applied to know the significance of difference between age groups. It showed that the age group 35-45yrs shows statistically significant difference with all other age groups. No other age groups show statistically significant differences (table-18).

Hence the null hypothesis stating that there is no significant change in the speed of fluctuations in frequeny of phonation of the vowels with increase in age in females is partly accepted and partly rejected.

Mean values of speed of fluctuation in frequency of phonation in males and females were compared (table 40). Wich shows that,

In /a/ age groups 35-45yrs to 55-65yrs show significant differences between males and females.

In /i/ significant differences are present between males and females in all age groups except 75-85years.

In /u/ significant differences are present in all the age groups.

Hence the null hypothesis stating there is no significant differnce between males and females across age groups is partly accepted and partly rejected.

Table: Showing the values of speed of fluctuation (Mean, S.D. and Range) for males and *l6* females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
16.a	Mean	2.544	2.444	2.74	4.002	7.252	4.491	7.224	7.818	7.453	7.956
	S.D.	1.00	1.149	2.52	3.303	3.044	1.936	3.491	3.772	5.978	4.171
(a)	Min.	1.04	0.86	0.52	0.749	2.976	2.052	4.08	2.246	1.596	3.991
	Mix.	4.572	4.60	7.47	10.536	10.69	7.486	14.38	14.56	22.873	16.268
16.b	Mean	2.862	2.542	2.89	3.068	7.563	3.699	7.967	12.369	11.64	12.738
	S.D.	0.935	1.587	2.296	2.83	3.738	1.305	8.756	8.05	11.089	11.83
(i)	Min.	1.606	0.33	0.295	0.997	3.547	1.268	2.411	2.908	1.41	2.409
	Mix.	4.273	5.68	6.488	8.996	14.575	5.177	30.04	28.85	34.336	37.653
16.c.	Mean	2.269	2.644	2.241	3.495	4.99	3.962	6.087	8.202	11.078	13.027
	S.D.	0.781	1.517	1.757	4.104	3.51	1.804	3.932	4.773	9.458	9.55
(u)	Min.	0.496	0.914	0.024	0.415	2.473	1.307	1.62	3.463	1.05	3.794
	Mix.	3.213	5.643	5.16	11.55	11.584	7.283	13.92	18.326	27.763	29.446

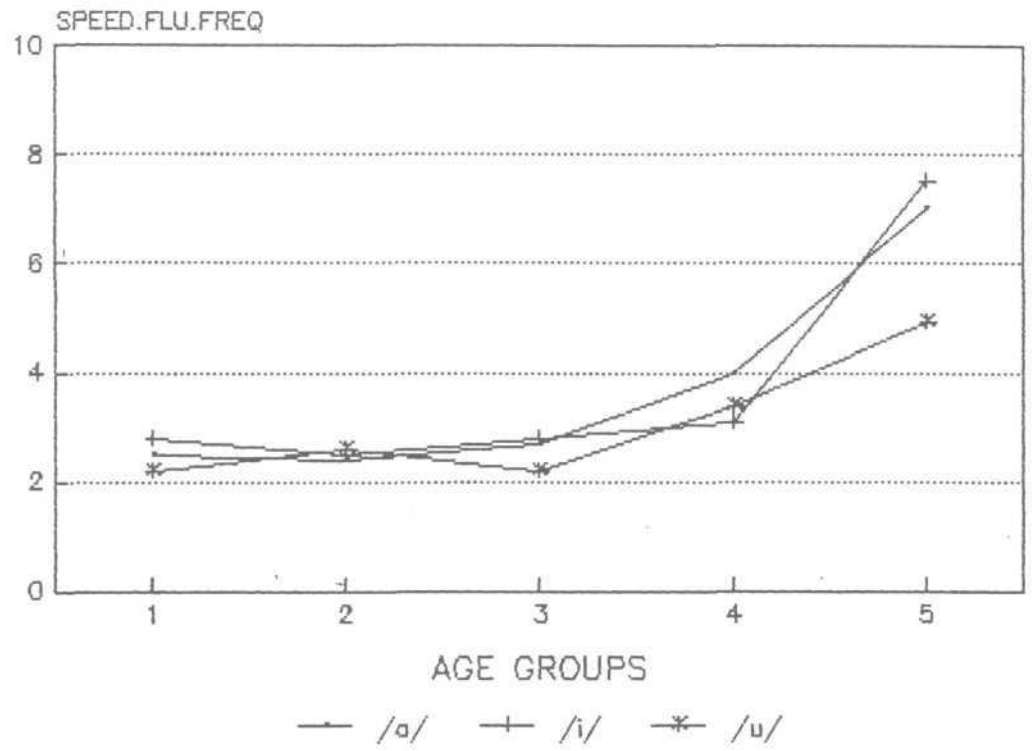
Table-17: Significance of difference age groups of males on speed of fluctuations in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	P
45-55	-	A	A	P
55-65	-	-	A	**P**
65-75	-	-	-	P

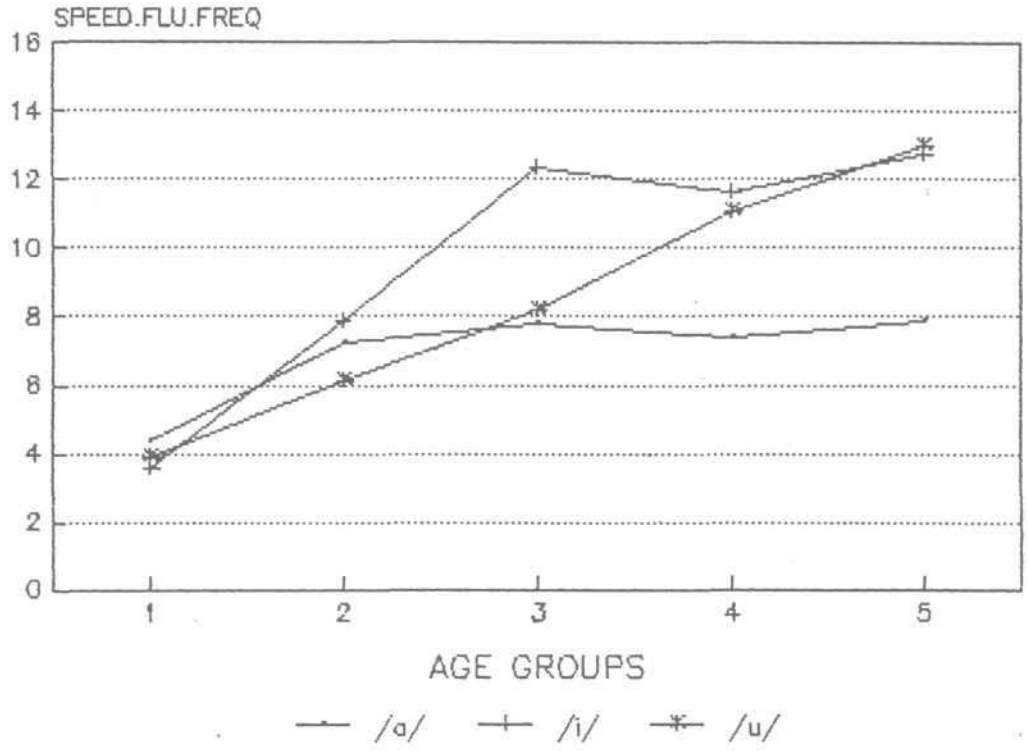
Table-18: Significance of difference age groups of females on speed of fluctuations in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	P	A	P
45-55	-	A	A	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:11 SHOWING SPEED OF FLU.IN FREQ.
/a/, /i/ & /u/ IN MALES



GRAPH-:12 SHOWING SPEED OF FLU.IN FREQ.
/a/, /i/ & /u/ IN FEMALES



In general males and females show significant differences across age groups studied for vowel /i/ and /u/.

As in the case of extent of fluctuation in frequency the research reports are available only normal adults and dysphonics. The results of earlier studies in normal adults are given below.

Investigators	Male		Female	
	Mean	S.D.	Mean	S.D.
Kim (1982)	6	8	128	5.7
Nataraja (1988)	6.2	4.53	618	4.1

The mean values of the present studies are well with in the range specified by different investigators. However the present study shows that higher age group show a significant difference with younger age groups.

EXTENT OF FLDCTDATION IN INTENSITY IN PHONATION

It is one of the measures of stability of laryngeal control. This measure has been found useful in differentiating normals and dysphonics.

The results of the analysis of this parameter are given in the table 19 a, b and c.

The inspection of the table, for /a/, in males reveals the lowest value at the age group 55-65 yrs and the highest at the age group 65-75 yrs. The S.D is lowest at 55-65 yrs and highest at the age group 75-85 yrs. In general the older age groups show higher values than the younger age groups.

The highest mean value for /i/ is at the age group 75-85 yrs (2.379) and the lowest mean value is 55-65 yrs (1.419). Similarly in vowel /u/, the highest mean value is at 45-55 yrs (1.95) and the lowest is at the age group 55-65 yrs (.713).

The S.D values do not change much with age. Age group 55-65 yrs show lowest values in both /a/ and /u/.

In majority of the age groups mean extent of fluctuation in intensity, range between 0 & 4 dB.

Mann-Whitney 'U' test was applied to know the significance of difference across age group. It reveals that in /a/ age group 55-65 yrs shows significantly lower values than its higher age groups i.e. 65-75 yrs, and 75-85 yrs. Similarly age group 45-55 yrs show significantly lower values than the age group 65-75 yrs. In /i/ significant differences are present only between age groups 55-65 yrs and 75-85 yrs. In /u/ age group 55-65 years shows significant difference with all other age groups except 75-85 years.

Hence the null hypothesis stating that there is no significant change in the extent of fluctuation in intensity in phonation of the vowels with increase in age in males is accepted.

Generaly age group 55-65 yrs show significantly lower values than the rest.

Examination of table-19 shows that, in females, in the phonation of /a/ the highest mean value is 2.39 at 65-75 yrs and the lowes is 1.32 at 35-45 yrs. In the phonation of /i/ the highest value is 2.6 at 75-85 yrs and the lowest mean value is 1.51 at 35-45 yrs. In the phonation of /u/ the highest value is 2.29 at 75-85 yrs and the lowest is 1.08 at 35-45 yrs.

Older age groups show slightly higher values than the other age groups. Also range of values show that majority of age groups range within 0 to 3 dB.

Mann-Whitney 'U' test was applied to know the significance of difference between different age groups in females (table-21) which shows that in vowel /a/ significant differences are present between age groups 35-45 yrs and 45-55 yrs. In the vowel /i/ significant differences are present between the age group 75-85 yrs and all other age groups except with age groups 55-65 yrs. In vowel /u/ significant differences are present between 35-45 yrs and 75-85 yrs.

Hence the null hypothesis stating that there is no significant change in the extent of fluctuation in intensity in phonation of the vowels with increase in age in males is accepted.

Comparision between mean extent of fluctuation in phonation between males and females shown in table-40,

-in the vowel /i/ significant differences are not found in any age groups.

-in the vowel /a/ significant differences are found in the age group 45-55 yrs.

-in the vowel /u/ significant differences are found in the age group 35-45 yrs.

Generaly females show lower mean values than males.

Hence the null hypothesis stating that there is no significant change in the extent of fluctuation in intensity in phonation between males and females in all age groups is accepted.

The results can be summaried as :

1: In both males and females the extent of fluctuation in intensity in phonation do not change with age.

2. Significant differences between males and females are not found.

Vanaja (1986) reported that fluctuation in intensity in the initial and final segments increased with age in both males and females. Significant differences between males and females in terms of fluctuations in intensity were not found.

In the present study however a slight decrease at 55-65 yrs was present. Age groups after 55 years showed slightly higher values than others. But consistent change with age was not found.

TABLE: 19 Mean, S.D. & Range of Extent of fluctuation in Intensity, in Males and Females.

		MALES					FEMALES			
	AGE GROUPS	35-45	45_55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
19.a	Mean	2.395	1.65	1-318	3.116	2.64	1.322	2.48	1.78	2.39	2.03
	S.D.	1.11	1.034	0.981	1.14	1.29	1.18	0.95	1.167	1.02	1.42
(a)	Min.	0.52	0	0	1.32	1.072	0	0.683	0	1.02	0
	Max.	4.00	3.289	3.237	5.66	4.6	3.573	3.386	3.29	3.48	3. 4
19.b	Mean	1.60	1.81	1-42	1.54	2.38	1.515	1.75	2.45	1.56	2.63
(i)	S.D.	1.38	1.058	1-338	1.52	0.916	0.798	1.067	2.28	1.014	0.86
19.c	Min.	0	**0**	**0**	0	1.06	0.817	0	0	0	1.06
(u)	Max.	4.176	3.42	4.48	5	3.95	3.32	3.22	7.8	3.34	3.41
	Mean	1.34	1.95	0.713	1.929	1.374	1.087	1.49	1.28	1.74	2.29
	S.D.	0.708	0.967	1.419	1.346	1.21	0.91	1.24	1.137	1.45	1.3
	Min.	0.721	0	0	0	0	0	0	0	0	0
	Max.	2.9	3.29	4.55	3.66	3.27	2.366	3.21	3.37	3.32	3.86

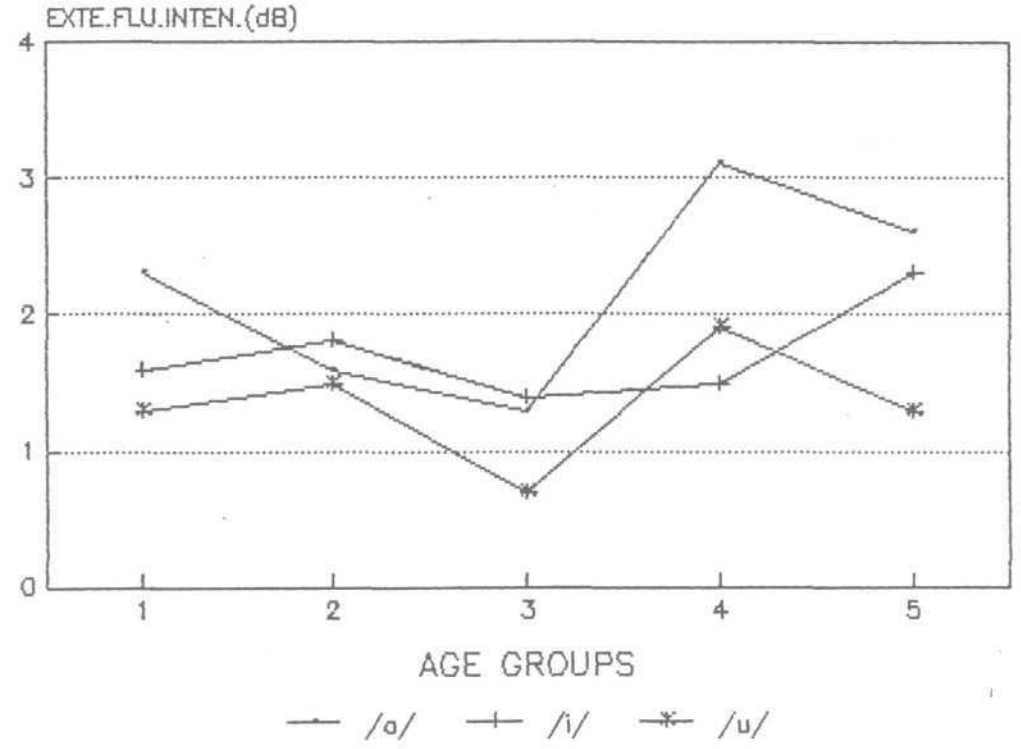
Table-20: Significance of difference age groups of males on extent of fluctuations in Intensity of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	A
45-55	-	A	A	A
55-65	-	-	P	P
65-75	-	-	-	A

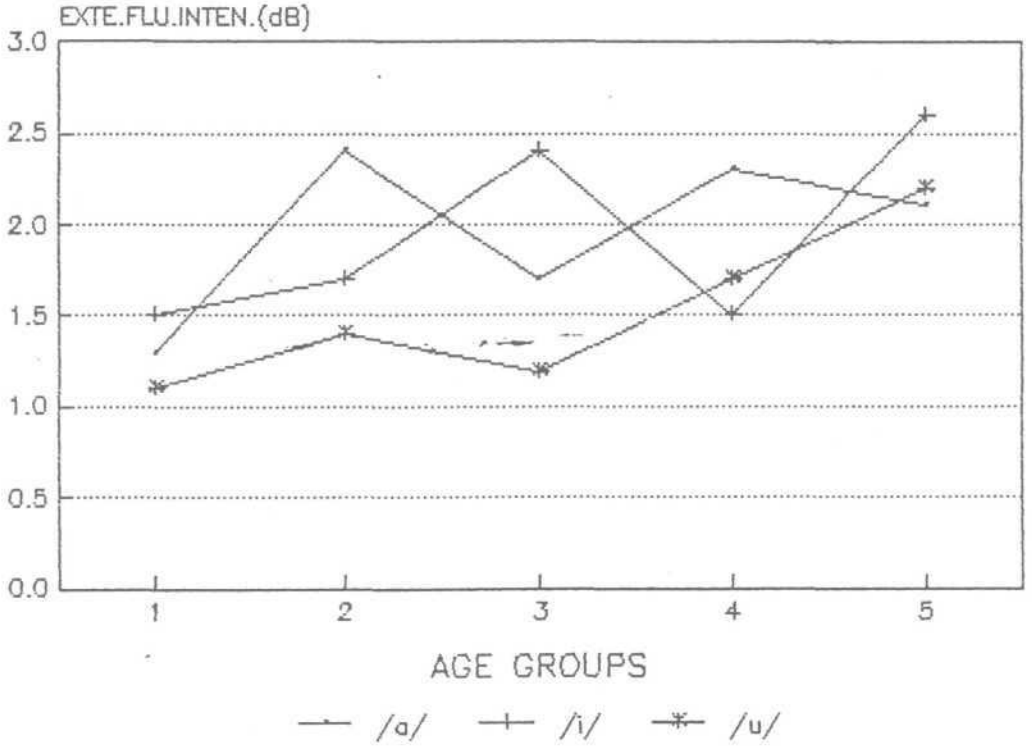
Table-21: Significance of difference age groups of females on extent of fluctuations in Intensity of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	A	P
45-55	-	A	A	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:13 SHOWING EXT.OF FLU.IN INTEN.
/a/, /i/ & /u/ IN MALES



GRAPH-:14 SHOWING EXT.OF FLU.IN INTEN.
/a/, /i/ & /u/ IN FEMALES



SPEED OF FLUCTUATION IN INTENSITY

The definition of this parameter first given by Kim (1982). It was later modified used in analysis of normal and dysphonic voice by Nataraja,1988.

The Results are tabulated in table 22 a,b & c.

The examination of /a/ shows that there is a decrease in values from 35-45 years age group to the 55-65 years age groups, which has the lowest value (0.54Hz). After this again there is an increasing trend. The S.D. values do not show much changes.

The /i/ shows, again lowest values in 55-65 years. The S.D. values again do not show much changes with age.

The /u/ shows progressive decrease in mean values with age (from 1.426 at 35-45 years age group to 0.322 at 75-85 years). The S.D. values show a decreasing trend with age except at 55-65 years which shows higher value (1.36).

The inspection of mean values of speed of fluctuation in intensity with reference to females shows that

- in /a/ there is an increasing trend with age except at 55-65 years which shows the lowest value which is similar to males (0.446).

- in /i/ also it shows an increasing trend with age, again with a slight decrease at 55-65 years (0.555).

- in /u/ it shows a clear increasing trend with age, even S.D. shows an increasing trend with age.

The table showing the significance of difference shows that, age group 55-65 years is significantly different from others and no other group shows significant difference. In /u/, age 35-45 years shows significant difference with the rest. The lower age groups do show significant difference with the older age groups.

Thus the hypotheses stating that " There is no significant difference in the sp,eed of fluctuations in intensity of phonation in males and females with increase in age" and " There is no significant difference in the speed of fluctu-ations in intensity of phonation between males and females of the same age group" have been partly accepted and partly rejected.

The results can be summarized as :

1. In males the speed of fluctuation in intensity varies systematically with age only in the phonation of /u/.
2. Also age group 55-65yrs shows significantly lower values in all the three vowels.
3. In females increasing mean values with age is present in all the three vowels.
4. Vowel /u/ shows the lowest values in females.
5. Males and females differ significantly in terms of speed of fluctuation in intensity in the age groups 35-45 yrs to 55-65 yrs.

Table: Showing the values of speed of fluctuation of intensity (Mean, SD and Range) for 22 males and females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
22.a	Mean	1.438	1.005	0.54	1.176	1.050	0.450	1.184	0.446	2.716	1.860
	S.D.	0.7442	0.854	0.792	1.011	0.6705	0.784	1.251	0.422	4.330	1.702
(a)	Min.	0.332	0.000	0.000	0.180	0.4983	0.000	0.083	0.000	0.496	0.000
	Max.	2.356	3.049	2.730	3.326	2.223	2.566	4.096	1.80	19.82	3.86
22.b	Mean	0.746	0.8289	0.435	0.424	0.8976	0.3528	0.734	0.555	0.618	1,021
	S.D.	0.709	1.093	0.913	0.628	1.140	0.442	0.945	0.504	0.924	0.924
(c)	Min.	0.000	0.000	0.000	0.000	0.166	0.077	0.000	0.000	0.000	2.932
	Mix	2.056	3.794	3.003	1.426	3.426	1.579	3.126	1.176	3.096	0.206
22.c	Mean	1.426	0.872	0.514	0.415	0.322	0.098	0.331	0.377	0.703	1.226
	S.D.	1.401	0.729	1.36	0.43	0.271	0.091	0.441	0.423	0.819	0.934
(u)	Min.	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mix	5.01	2.603	4.37	1.426	0.76	0.204	1.416	1.34	2.603	2.363

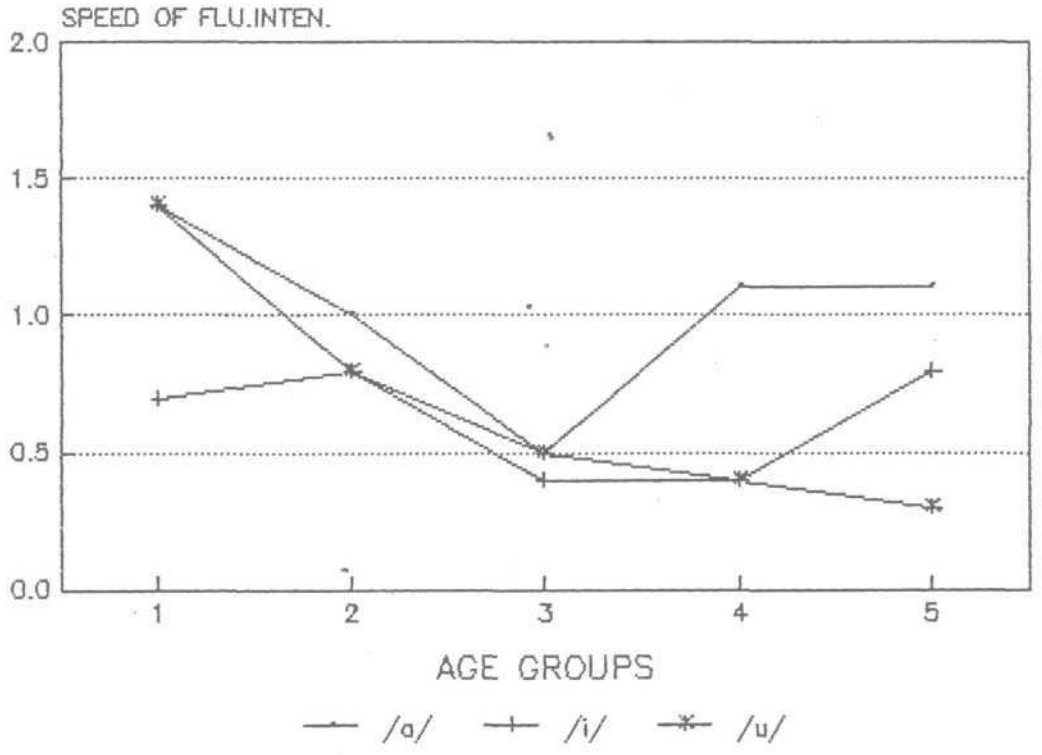
Table-23: Significance of difference age groups of males on speed of fluctuations in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	P	A	A
45-55	-	P	A	A
55-65	-	-	A	P
65-75	-	-	-	A

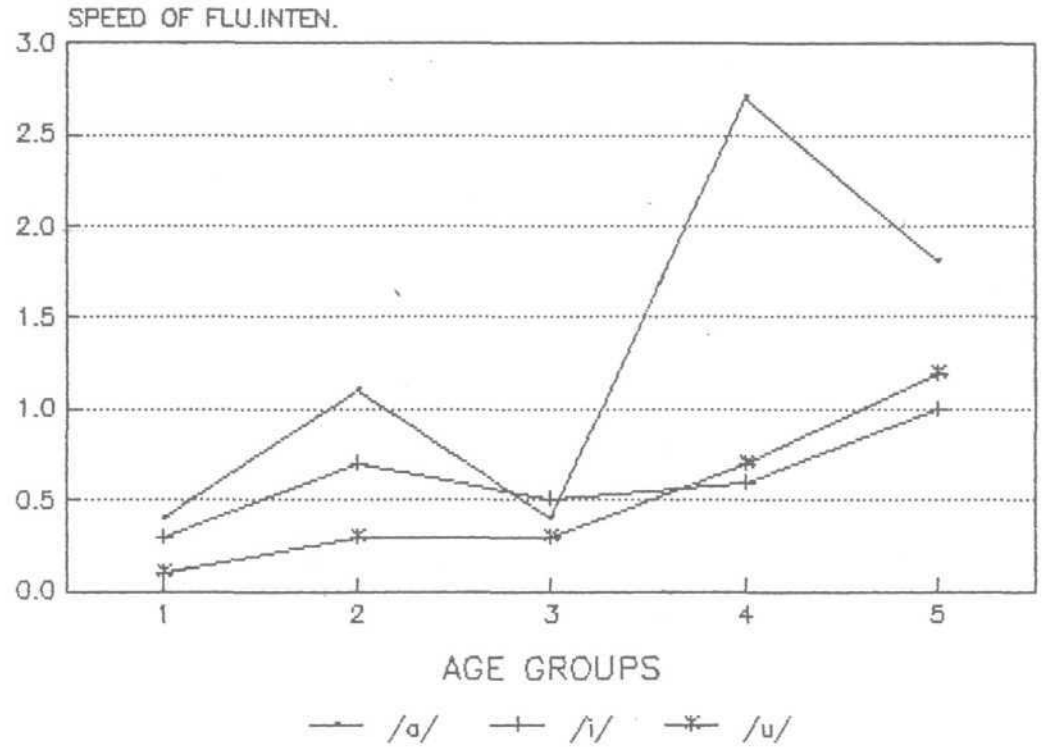
Table-24: Significance of difference age groups of females on speed of fluctuations in Fo of phonation

	45 55	55-65	65-75	75-85
35-45	A	A	P	P
45-55	-	A	A	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:15 SHOWING SPEED OF FLU.IN INTEN.
/a/, /i/ & /u/ IN MALES



GRAPH-:16 SHOWING SPEED OF FLU.IN INTEN.
/a/, /i/ & /u/ IN FEMALES



RISE TIME OF PHONATION

The examination of values in tables 25 a,b & c and graphs 17 & 18 reveals that, .

In males there is a gradual increase in rise time value with age for /a/, mean value increase from 7.766 at I group to 26.43 at V group.

For /i/, it increase from 7.33 at I group to 20.476 at V group, for /u/ it increase from 6.966 at I group to 27.05 at V group. However in /u/, IV group shows a lower value (15.03) than III group (17.23) and V group (27.05).

Mann-Whitney test for significance of difference shows that though there is increase in values with age, the immediate groups 35-45 and 45-55 years, 55-65 years and 65-75 years shows a significant difference. Other age group show significant difference at 2nd succssive group and above.

Hence the null hypothesis stating that there is no significant change in the rise time in phonation of the vowels with increase in age in males is rejected.

Females also show a trend similar to males. There is increase in RT value with age. for /a/ from 11.16 at .35-45 years to 27.66rasec at 75-85 years, for /i/, from 13.166msec at 35-45 years to 25.286msec at 75-85 years and /u/, 8.30msec at 35-45 to 26.09rasec at 75-85 years. The highest SD value is at the age group 75-85 years and lowest at 35.45 years age level.

65 years. However the present study found a step wise increase in rise time in the age groups 35 to 85 years. Males and females did not show any significant difference was supported by Vanaja (1986) and Nataraja (1988) in normal adults.

Varios investigators have reported rise time in normal adults. Yoon et al (1984) have found the rising time varying from 5.2centisec, to 11.1 centisec. Kim et al (1982) reports a mean rise time of 10.95sec and S.D of 2.89 centisec. Nataraja (1988) reports a mean of 8.39centisec and 9.56 centisec and a S.D of 1.99 and 2.68 for males and females respectively. The present study also shows similar results in age range 35 to 45yrs. The later age groups showed a progressive increase. The S.D values are higher in all age groups tanh reported by previos investigators.

Rashmi (1985) from a study of children reported a progressive decrease in rise time which marked the development of adequate control over laryngeal and respiratopry system. It can be seen that geriatric subjects show a marked increase from ault value, in contrast to children. This may indicate the difficulty in timing and adjusting phonatory and respiratory systems in geriatric population. The results can be summarised as,

1. In both males and females the rise time in phonation increases with age. 2. Significant differences between males and females in rise time in phonation are not found in any age group.

Table: Showing Mean, S.D. and Range of values of rise time of phonation for males and females

25

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
25.a	Mean	7.766	12.00	13.40	21.76	26.43	11.16	15.13	16.2	23.6	27.66
	S.D.	3.624	1.227	3.427	8.49	17.80	9.589	9.50	7.254	11.65	18.68
(a)	Min.	3.33	10.00	9.33	5.33	8.66	3.66	5.00	8.00	12.33	6.00
	Mix.	14.33	13.66	27.00	34.66	63.00	37.33	39.33	33.33	51.33	63.00
25.b	Mean	7.33	12.733	17.76	21.80	20.476	13.166	11.40	19.10	24.00	25.286
	S.D.	3.446	2.72	3.702	11.06	11.967	8.753	4.69	8.649	6.91	10.386
(i)	Min.	4.00	9.66	11.00	7.33	8.00	6.66	3.00	7.66	16.33	8.00
	Mix.	14.00	19.00	21 .33	36.33	42.33	37.33	19.00	34.33	36.33	42.33
25.c	Mean	6.966	12.16	17.23	15.03	27.05	8.30	11.73	16.36	14.50	26.09
	S.D.	3.237	0.933	8.43	5.64	13.90	2.40	5.135	3.81	6.55	13.69
(u)	Min.	4.00	10.33	9.66	7.66	12.33	4.33	3.66	9.66	8.66	10.00
	Mix.	13.00	13.66	36.66	24.66	52.66	10.66	23.33	22.66	30.66	52.66

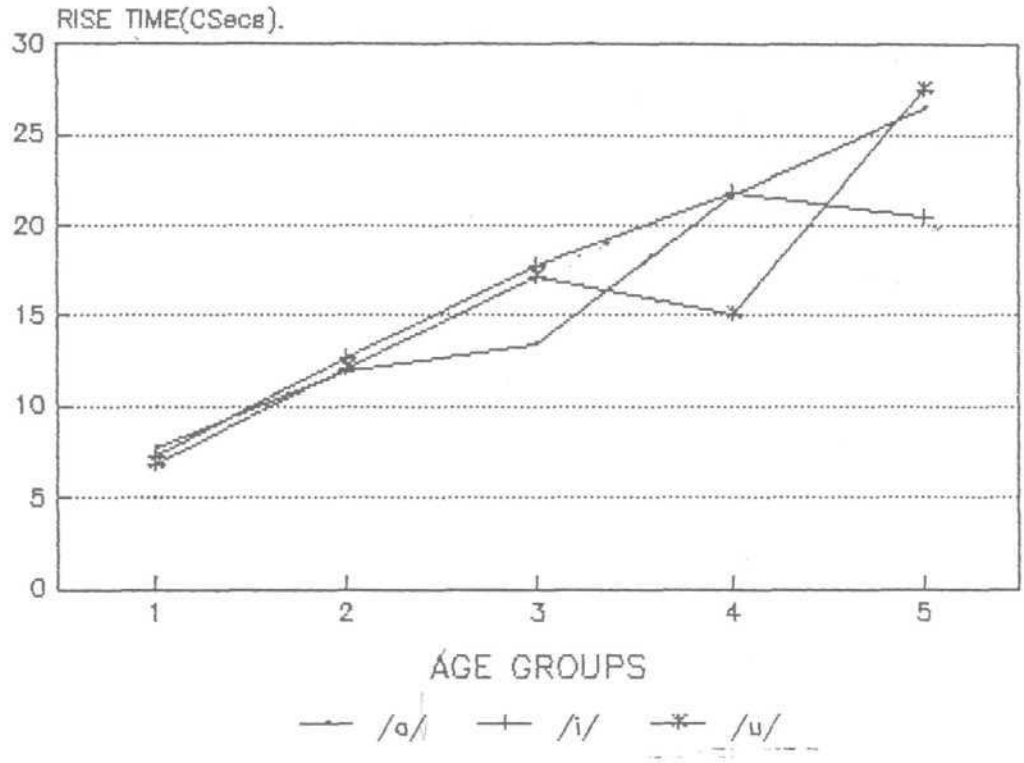
Table-26: Significance of difference age groups of males on rise time in phonation

	45 55	55-65	65-75	75-85
35-45	**P**	P	P	P
45-55	-	A	P	P
55-65	-	-	P	P
65-75	-	-	-	A

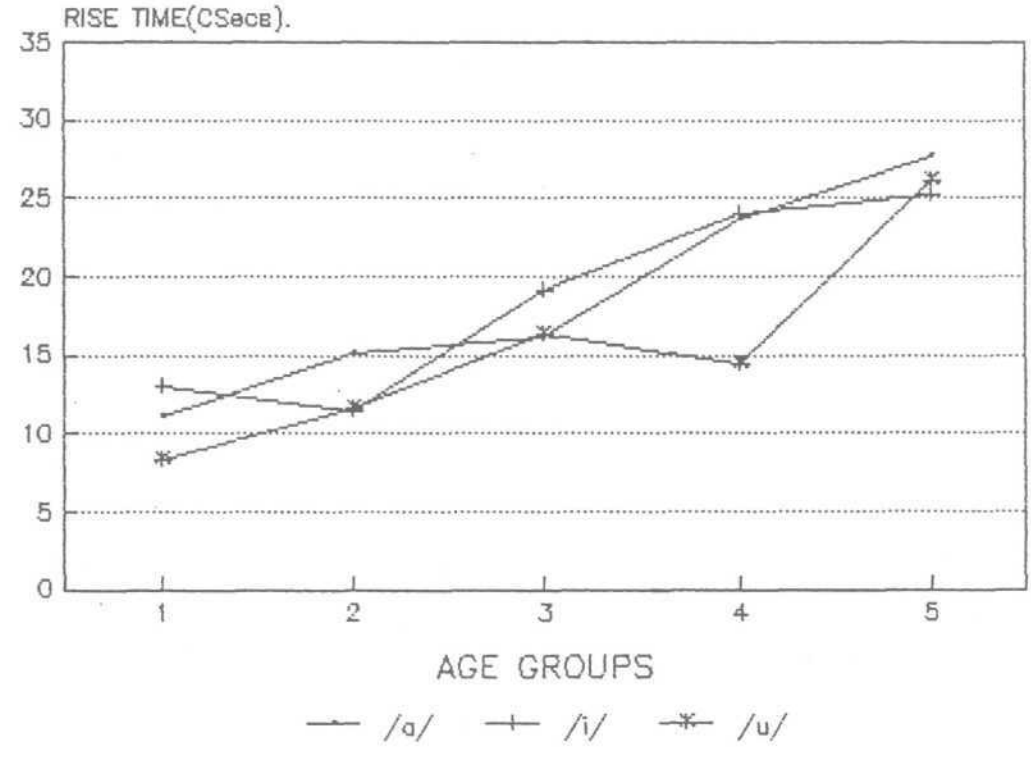
Table-27: Significance of difference age groups of females on rise time in phonation

	45 55	55-65	65-75	75-85
35-45	A	P	P	P
45-55	-	A	P	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:17 SHOWING RISE TIME IN PHONATION
/a/, /i/ & /u/ IN MALES



GRAPH-:18 SHOWING RISE TIME IN PHONATION
/a/, /i/ & /u/ IN FEMALES



FALL TIME OF PHONATION

The results of measurement of fall time in phonation of all the three vowels are presented in table in terras of mean S.D and range . Graph also depicts the mean values of different age groups of males and females.

The inspection of tables 28 a, b & c and graphs 19 & 20 shows that, like in rise time, there is a gradual increase in fall time with age.

For /a/ the increase in from 10.25centisec at 35-45yrs to 28.09centisec at 45-55 years, for /i/ the increase is 9.2 at 35-45yrs to 22centisec at 45-55yrs and for /u/ the increase is 1.05centisec at 35-45yrs 26.047centisec at 45-55yrs.

Correspondingly SD values also show an increase with age is from 2.36 to 21.55 for /a/ from 3.186 to 11.81 for /i/ and from 3.514 to 22.87 at /u/.

Mann-Whitney test of significance was applied. It reveals that, there is a significant decrease at 45-55 years after which there is a gradual decrease with age. The immediate groups do not show significant differences for all 3 vowels.

Hence the null hypothesis stating that there is no significant change in the fall time in phonation of the vowels with increase in age in males is partly accepted and

partly rejected.

In females, there is increase in FT values with age, as in males. Age group 35-45 years show the lowest values, for all the 3 vowels (/a/ - 10.66csec, /i/ - 11.2csec and /u/ - 12.2csec) age. 75-85 years showing the highest values (/a/ - 36csec, /i/ -25.95csec and /u/ - 33.81csec).

Mann-Whitney eas applied to know the significance of difference for /a/ groups IV and V show significant difference with the rest. /i/ and /u/ shows even more gradual increase as only group V is significantly difference from others. It can be concluded that there is a gradual increasein FT with age with significant difference found only after II and III groups.

Hence the null hypothesis stating that there is no significant change in the fall time in phonation of the vowels with increase in age in females is partly accepted, partly rejected.

The difference between males and females are not significant at all age groups. But females show a higher value than males.

Hence the null hypothesis stating that there is no significant change in the fall time in phonation of the vowels with increase in age in females is accepted.

The results of the present study indicates that there is

no changes in FT upto 55-65 years, which is supported by Vanaja (1986).

Further the present study, also shows the elder group shows significant differences from younger groups, which agrees with RT findings.

The results can be summarised as,

1. In both males and females the fall time in phonation increases with age.

2. In males vowel /u/ shows highest range and S.D in all the age groups. Vowel /i/ shows lowest range and S.D in thge age range 35 to 55yrs whereas vowel /a/ shows lowest values in the age range 65 to 85yrs.

3. In females vowel /u/ shows highest S.D and range of mean values followed by /a/ and /i/.

4. Significant differences between males and females in rise time in phonation are not found in any age group.

Table 28: Showing Mean, S.D. and Range of fall time of phonation for males and females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65	65-75	75-85
28.a	Mean	10.25	12.566	12.46	19.06	28.09	10.66	14.46	16.16	26.13	36.00
	S.D.	2.36	1.523	2.597	10.56	21.55	2.71	8.052	7.458	11.898	18.66
(a)	Min.	7.00	10.33	8.00	10.33	7.33	7.00	9.66	9.00	11.66	15.33
	Mix.	14.66	14.66	15.33	40.00	73.66	14.33	37.00	27.33	41.33	73.66
28.b	Mean	9.20	13.26	14.00	18.90	22.00	11.20	14.36	15.66	78.96	25.95
	S.D.	3.186	1.430	5.39	6.42	11.81	2.93	2.98	7.568	7.45	11.62
(i)	Min.	5.00	11.66	9.00	11.33	10.66	8.00	11.00	7.33	11.00	16.66
	Mix.	15.33	15.66	25.00	34.66	46.66	16.33	20.00	28.00	32.00	46.66
28.c	Mean	10:50	13.56	15. 23	16.06	26.047	12.20	13.10	11.80	16.03	33.81
	S.D.	3.514	2.149	6.427	10.58	22.87	4.327	3.421	5.01	7.48	21. 78
(u)	Min.	6.00	11.00	8.66	9.00	11.00	6.00	8.33	7.33	7.00	14.00
	Mix.	16.66	16.66	30.66	42.66	76.66	18.33	21.00	21.33	31.00	76.66

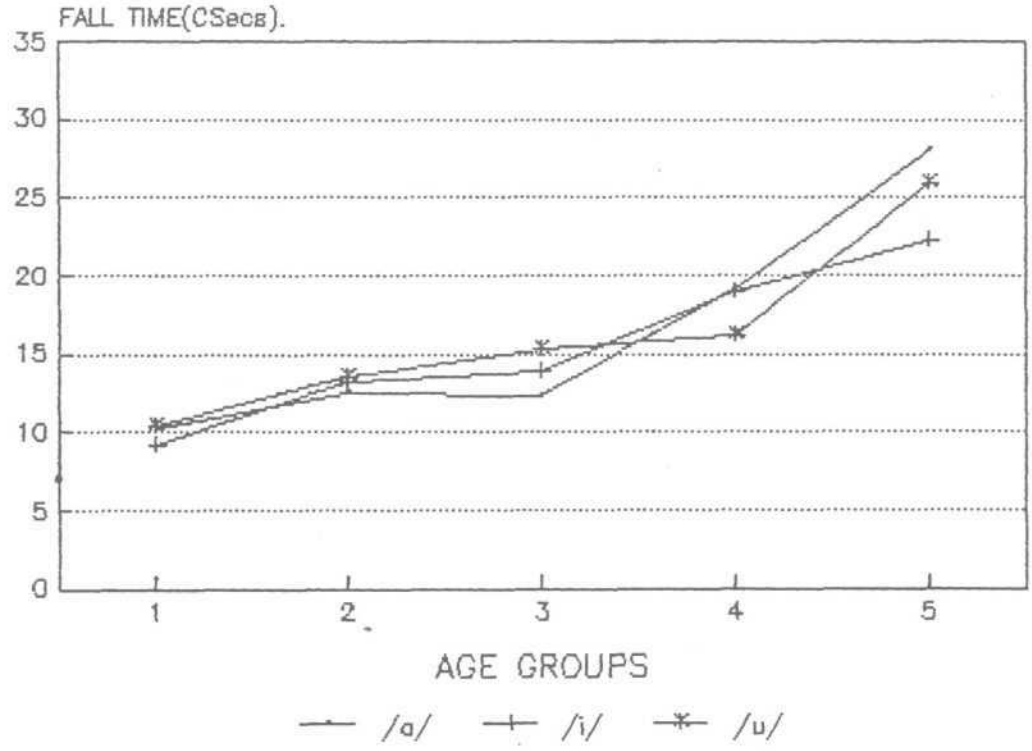
Table-29: Significance of difference age groups of males on fall time in phonation

	45 55	**55-65**	**65-75**	**75-85**
35-45	P	P	P	P
45-55	-	A	A	P
55-65	-	-	A	P
65-75	-	-	-	A

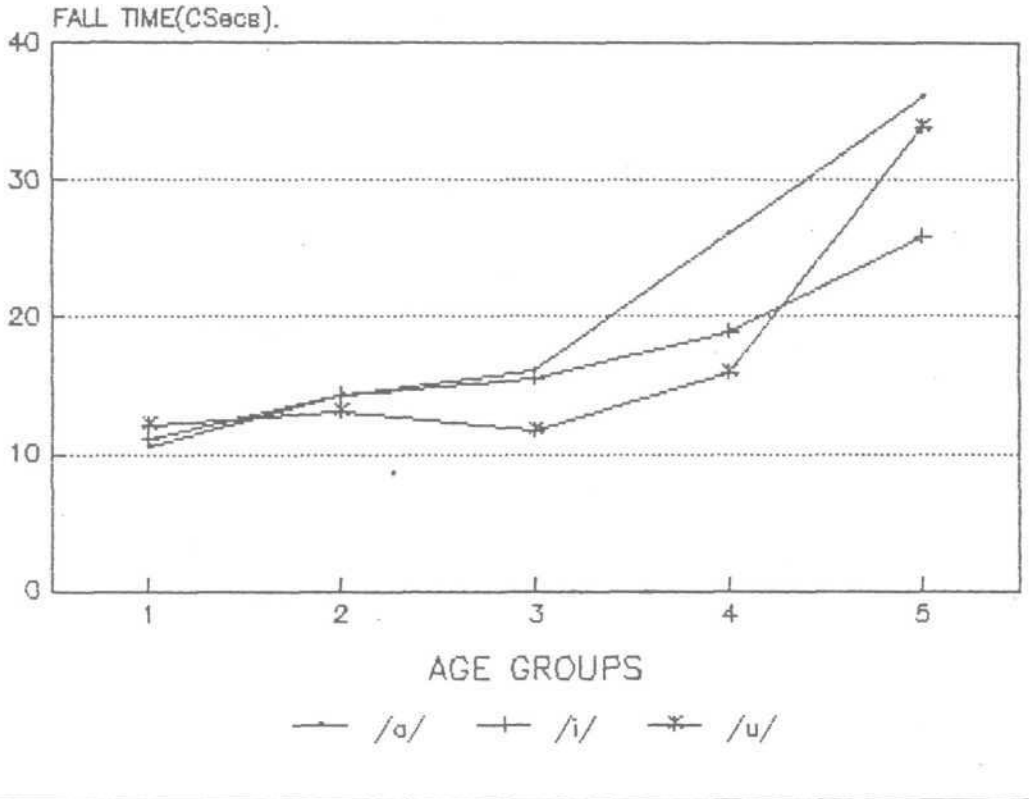
Table-30: Significance of difference age groups of females on fall time in phonation

	45 55	55-65	65-75	75-85
35-45	A	A	P	P
45-55	-	A	A	P
55-65	-	-	A	P
65-75	-	-	-	A

GRAPH-:19 SHOWING FALL TIME IN PHONATION
/a/, /i/ & /u/ IN MALES



GRAPH-:20 SHOWING FALL TIME IN PHONATION
/a/, /i/ & /u/ IN FEMALES



FUNDAMENTAL FREQUENCY IN SPEECH

It is one of the parameter used clinically all over. This measure is an indicative of a habitual pitch of an individual.

The values of the present study is tabulated in the table-31

Inspection of table, for male groups, reveal that, there is an increase in SFF with age from, 137.8 at 35-45 years to 181.14 at 75-85 years.

However it is not a continuous change with decrease at 45-55 years (128.2) and 65-75 years (147.8). The S.D. also increases from 8.43 at 35-45 years to a 30.129 at 75-85 years.

The Mann-Whitney 'U' test was applied to find out the significance of difference between different age groups. All age group show significant differences with their higher age groups. But only age group 45-55yrs and 65-75yrs showed significant differences with immediate higher age group. This stepwise increase in SFF if evident in graph-21.

Females show a decreasing pattern as shown in the table31 and graph-22. Mean Fo in speech decreases from 223..5H at 35-45yrs to a 179.14H at 75-85 years. This decrease is gradual. The change is not significant if each age group is compared with the immediate next higher group. But lower age group show significant differences with higher age groups 65-75 yrs and above (table-33).

males and females show significant differences in all age groups studied, except the last group 75-85yrs. Throughout the age range studied males show lower SFF than females.

The results can be summarized as.

1) Males, show a higher SFF in older age group than the younger age groups.

2) Males show a decresing trend from 35-45 years to 45-55 years, but it is not statistically significant. Statistically significant increases in present onyl at 55-65yrs and 75-85 years. S.D. values also show increasing trend with age.

3) Females show decreasing trend with age, upto 65-75 years after which it stabilises. But statistically significant decrease is found between 55-65yrs & 65-75 years.

Holien and Shipp, (1972), also reported a decrease in Fo upto 40-45 years and then an increase upto 80-85 years which is similar to the present study (Table).

Gopal (1986) and Nataraja (1988) also reported similar results. They also reported an increase in variability with age which is true in the present study also.

The research in female subjects are varied Stoicreff (1981), Knok (1988) report of decrease in SFF with age in females upto 70 years with a significant drop at age group

50-59 years. Present study also showed decrease in SFF with age but significant drop was found at 65-75 years. Krook reports of increase in SFF after 70 years (which is not statistically significant) such a result was not found in the present study.

Mc Glow and Holien (1963) reported no significant difference in SFF with age, which could be due to the age group studied by them i.e., 73 years to 86 years. This study also did not show statistically significant differences between last two groups studied i.e.,65-75 yrs and 75-85 yrs.

Hence it can be seen that SFF in females does not show a uniform trend as in males.

Trend seen in males is in sharp contrast with that seen in children (Usha,1980 ; Rashmi,1985; Kushalraj,1983). Hence it can be concluded that altogether different factors affect changes in SFF in childhood and in old age.

The changes seen in SFF are similar to the changes seen in mean fundamental frequency in phonation, which has been discussed earlier. Hence it can be concluded that aging affects SFF in males and females differently which may be the result of both hormonal and climacteric changes with age.

Thus the hypotheses stating that " There is no significant change in the speaking fundamental frequency in males and females of different age groups studied " and " There is no significant difference in the speaking fundamental frequency between males and females of the same age group" get rejected.

INTENSITY RANGE IN SPEECH

The intensity range in speech was measured as the difference between minimum and maximum levels in intensity in the three sentences 'idu pa:pu', 'idu ko:ti' and 'idu kempu banna'. The results of analysis are given in table 34 and graph 23 and 24.

The inspection of this table 34 and graph 23 and 24 shows that, higher age groups show a lower mean value than others. The highest mean value is 24.1 dB at 35-45 yrs age group and the lowest mean value is 20.5 dB at 65-75 yrs age groups.

However the range and S.D value show that variability increases with age.

Mann-Whitney 'U' test was applied to knowe the significance of difference. The age group 55-65 yrs show significant difference with the lower age group but not with the higher age groups. Similarly age group 65-75 yrs show significant differnces with the age group 45-55yrs.

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

Inspection of mean values for females show that, age group 35-45 and 4 5-55 yrs show lower values thant the higher age groups. Lowest mean and S.D values are 19 and 3.829 at the age group 55-65 years and the highest mean and S.D values are 26.3 and 7.875 at the age group 35-45 years.

Examination of table for significant of diffrerences shows that, significant diffrerences are present only between 35-45 yrs and 65-75 yrs age group.

Hence the null hypothesis stating that there is no significant difference across age group in females in intensity range in speech is accepted.

Comparisons between males and females in terras of intensity range in speech show that significant differences are present only in the age group 55-65 yrs.

In general females do not show any change with age in intensity range in speech whereas males show significant difference lower age groups and 55 to 75 yrs.

Significant difference between males and females in intensity range in speech are not found in majority of group.

Hence the null hypothesis stating that there is no significant difference between males and femals in intensity range in speech is accespted.

Gopal (1986) reports males showed decreasing trend with age and females showed inconsistent resutls.

These changes in males with age may reflect the inability to raise the loudness level during speech.

FREQUENCY RANGE IN SPEECH

The frequency range in speech was analyzed using three sentences "idu papu " "idu koti" and "idu kempu banna" . The results of this are given in the table 37 and graph 25 and 26.

The highiest mean value is 86.714Hz at 75-85 yrs and the lowest is 50.6Hz at 35-45yrs age group. Generally the age group above 55yrs highier mean values. S.D values also show similar results.

The results of Mann-Whitney 'U' test applied to know the significance of difference shows that, age group 35-45yrs is significantly lower than all other age groups. Similarly age group 45-55 yrs shows significantly lower values than all other higher age groups. Age group 75-85 yrs shows significant differences with all other age groups (table-29).

Hence the null hypothesis stating that there is no significant differences in frequeny range in speech in males with increase in age is rejected.

Mean values of frequency range in speech in females show a gradual increase with age (graph-20). The lowest mean value is 28.2 at 35-45yrs and the highiest is 82.857 at 75-85 yrs. The S.d values also shows lowest value in the age group 35-45yrs (7.743) and the highiest is 82.857 at the age group 75-85yrs (27.236).

Hence the null hypothesis stating that there is no significant difference across age groups, in terras of frequency range in speech, in females is accepted.

The examination of the results of the Mann-Whitney 'U' test shows that, the increase in frequency range in speech with age is significant only between 35-45yrs and 55-65 yrs. No other age group shows significant differences (table-30).

Comparison of frequency range in speech in males and females show that significant differences in mean values of frequency range in speech are present in the age range 35 to 55 yrs but not in older age range.

Hence the null hypothesis stating that there is no significant difference between males and females of the same age group in terms of frequency range in speech, in females is partly accepted and partly rejected.

The results can be summarised as,

1. In males gradual increase in frequency range in speech with age is seen whereas females do not show much changes in frequency range in speech with age.
2. Significant difference between males and females in frequency range in speech is present in lower age groups.

Nataraja (1988) reported that significant differences were found between males and females in the age range 16 to

45 yrs. The present study also show significant differences between males and females in the age groups 35-45, 45-55 yrs. but not in the age groups 55-65 yrs and above.

Gopal (1986) reported that males showed increasing trend upto 45yrs followed by decrease in mean values upto 65 yrs. Females showed increasing trend with age in the age range 16 to 65 yrs.

These differences in males between geriatric age groups and adult age groups may reflect progressive loss of control over phonatory mechanism in older males. However it is intersting to note that frequencu range in speech in females do not change significantly with age. this needs further investigation.

TABLE :31. SHOWING f_0 IN SPEECH, i.e., SFF (Mean, S.D and Range) for males and females.

TABLE :34. SHOWING FREQUENCY RANGE IN SPEECH (Mean, S.D and Range) for males and females.

Table: *37*- Showing INTENSITY RANGE in Speech (Mean, S.D. and Range) for males and females

	Age group	35-45	45-55	55-65	65-75	75-85	35-45	45-55	55-65 .	65-75	75-85
31	Mean	2235	204.40	211.10	179.60	179.14	137.80	128.20	152.10	147.80	181.14
	S.D.	9.11	35.89	34.15	34.46	51.77	8.43	15.99	13.43	14.31	30.12
	Min.	210.00	160.00	155.00	153.00	130.00	120.00	110.00	128.00	120.16	137.00
	Mix.	240.00	253.00	258.00	253.00	260.00	152.00	152.00	170.00	161.00	217.00
34	Mean	50.60	65.10	78.90	65.50	86.71	28.20	32.40	43.70	56.80	82.85
	S.D.	18.57	17.14	22.66	18.76	55.55	7.74	8.072	13.54	23.99	27.23
	Min.	28.00	43.00	34.00	45.00	29.00	15.00	20.000	25.00	38.00	56.00
	Mix.	83.00	90.00	108.00	96.00	188.00	38.00	45.00	62.00	108.00	123.00
37	Mean	24.10	22.10	23.50	20.50	21.57	26.30	25.30	19.00	20.80	21.00
	S.D.	3.92	5.14	6.34	4.85	6.21	7.87	4.11	3.82	3.29	5.19
	Min.	18.00	15.00	13.00	15.00	12.00	15.00	18.00	12.00	16.0	15.00
	Mix.	31.00	29.00	33.00	33.00	28.00	40.00	34.00	25.00	26.00	30.00

Table-32: Significance of difference age groups of males on Fundamental Frequency in Speech (SFF)

	45 55	55-65	65-75	75-85
35-45	**A**	P	**P**	P
45-55	-	**P**	**P**	P
55-65	-	-	A	P
65-75	-	-	-	P

Table-33: Significance of difference age groups of females on Fundamental Frequency in Speech (SFF)

	45 55	55-65	65-75	75-85
35-45	A	A	P	**P**
45-55	-	**A**	A	A
55-65	-	-	P	A
65-75	-	-	-	A

Table-35: Significance of difference age groups of males on Range of intensity Speech (SIR)

	45 55	55-65	65-75	75-85
35-45	A	P	**A**	A
45-55	-	P	**P**	A
55-65	-	-	A	A
65-75	-	-	-	A

Table-36: Significance of difference age groups of females on Range of Intensity in Speech (SIR)

	45 55	55-65	65-75	75-85
35-45	A	A	**P**	A
45-55	-	**A**	A	A
55-65	-	-	A	A
65-75	-	-	-	A

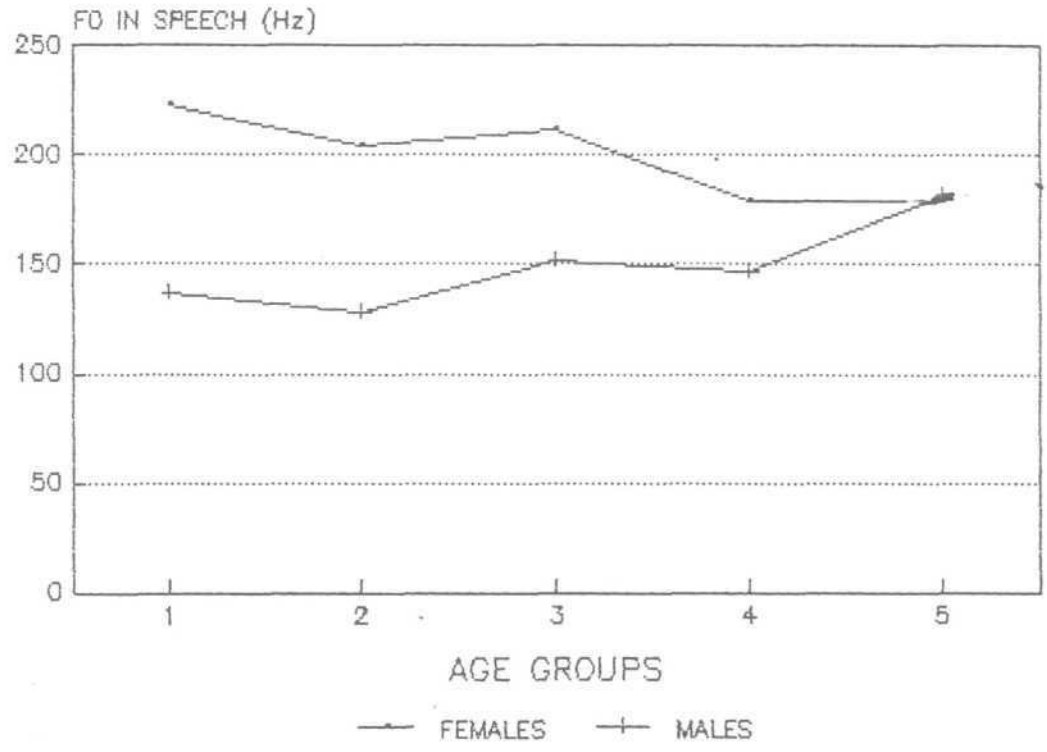
Table-38: Significance of difference age groups of males on Range of frequency in Speech (SFR)

	45 55	55-65	65-75	75-85
35-45	A	P	P	P
45-55	-	P	P	P
55-65	-	-	A	P
65-75	-	-	-	P

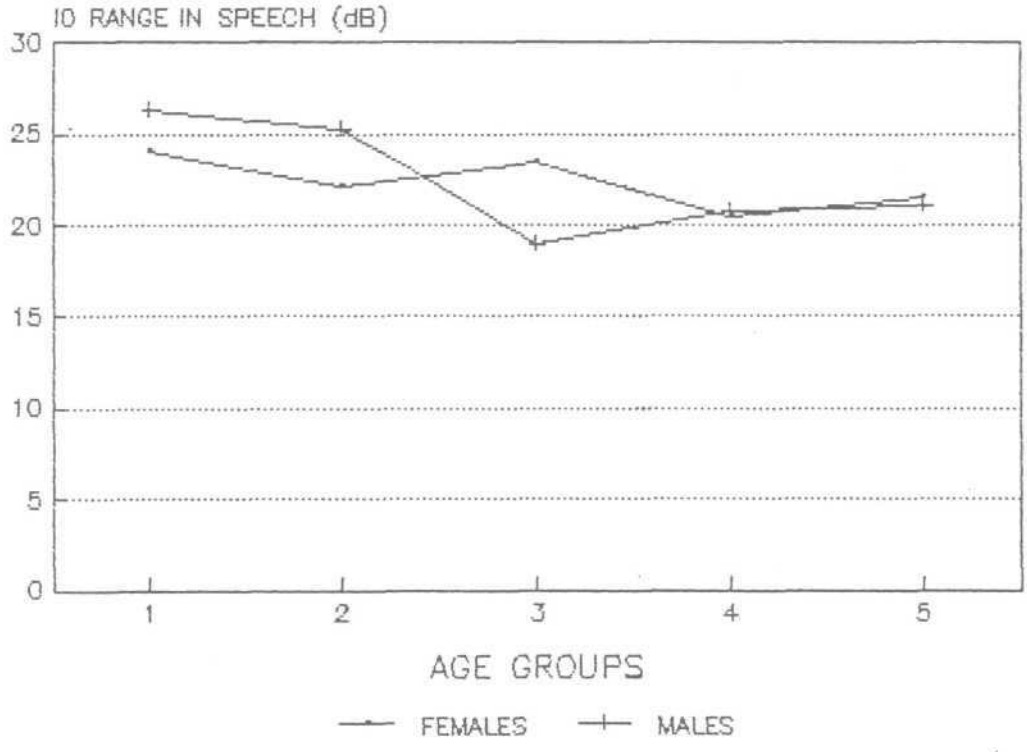
Table-39: Significance of difference age groups of females on Range of Frequency in Speech (SFR)

	45 55	55-65	65-75	75-85
35-45	A	P	A	A
45-55	-	A	A	A
55-65	-	-	A	A
65-75	-	-	-	A

GRAPH-:21 SHOWING FUNDAMENTAL FREQUENCY
IN SPEECH IN MALES & FEMALES



GRAPH-:22 SHOWING INTENSITY RANGE
IN SPEECH IN MALES & FEMALES



GRAPH—:23 SHOWING FREQUENCY RANGE IN SPEECH IN MALES & FEMALES

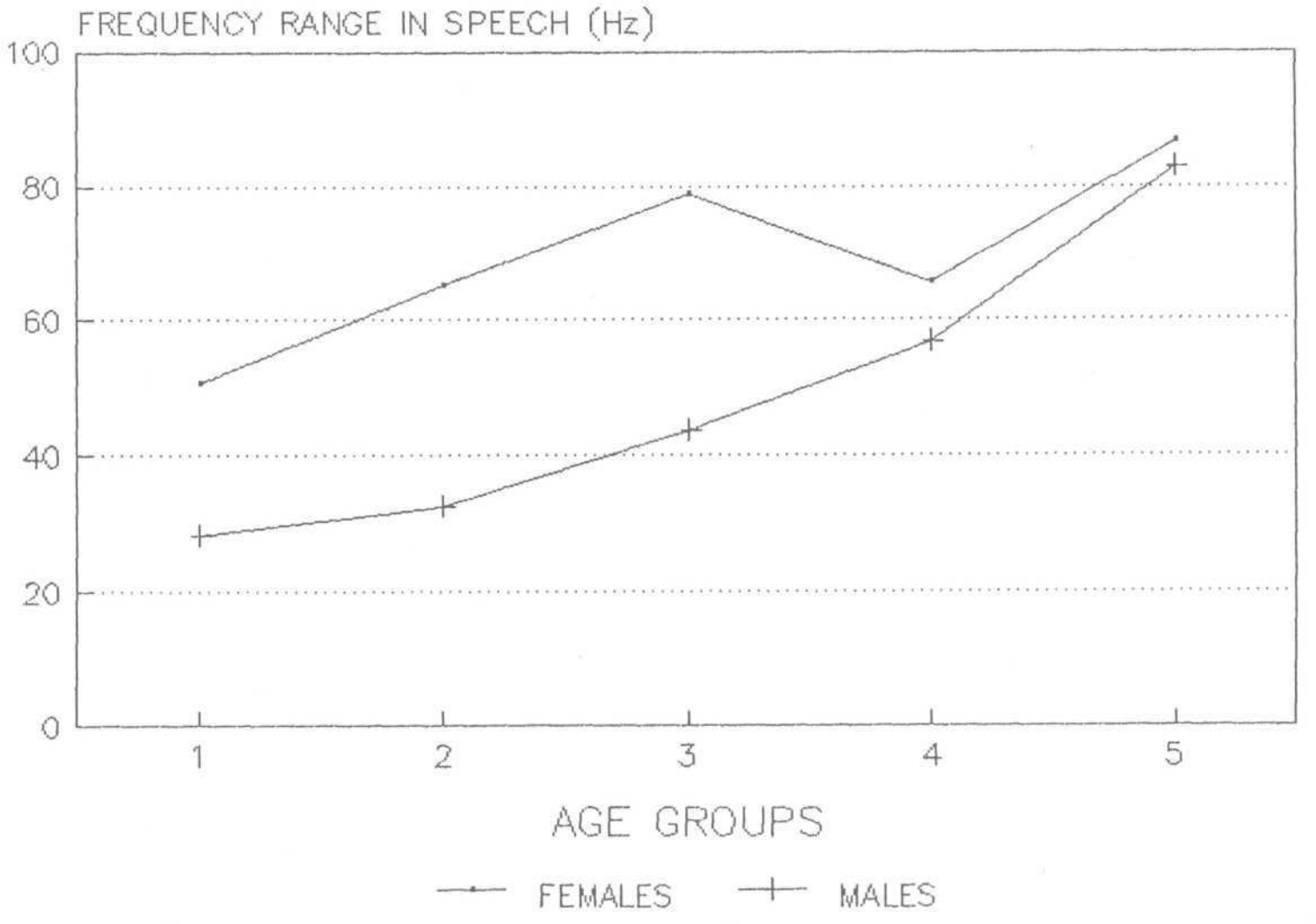


Table-40: shotting significant difference across sex (Hales and females)

	MFO			PFR			PFX			PFS			PJR			PJK			PJS			MPD			PRT			PFT					
	a	i	u	a	i	u	a	i	u	a	i	u	a	i	u	a	i	u	a	i	u	a	i	u	a	i	u	a	i	u	SFF	SFR	SJR
1 Vs 1	P	P	P	A	P	P	A	a	A	P	P	P	P	A	A	A	A	P	A	A	P	A	A	A	A	A	A	A	A	A	P	P	A
2 Vs 2	P	P	P	P	P	P	A	A	A	P	P	P	A	A	A	P	P	A	A	A	P	A	A	A	A	A	A	A	A	A	P	P	A
3 Vs 3	P	P	P	A	A	A	A	A	A	P	P	P	A	A	A	A	A	A	A	A	P	A	A	A	A	A	A	A	A	A	P	P	P
4 Vs 4	P	P	P	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	P	A	A
5 Vs 5	P	A	P	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	A

Grp. AGE-RANGE

1 - 35-45 yrs

2 - 45-55 yrs

3 - 55-65 yrs

4 - 65-75 yrs

5 - 75-85 yrs

SUMMARY AND CONCLUSIONS

The past two decades have been witness to an increasing application of acoustic analysis to the study of speech development in children. "Sometimes the acoustic analysis is appropriate to test certain hypothesis about developmental changes in anatomy, motor control and physiological function" (Kent, 1976).

Objectives of sutdy of variations in acoustic parameters with age are to establish norms across all age groups; to relate to the developmental of motor control of laryngeal phonatory mechanism; to help in differentiation of normal from dysphonics; to know normal pattern of age changes and to differentiate from disorders in old age.

Acoustic analysis is found useful in identifying various types of dysartheias, in adults and old age. Many of the parameters given by Michel and Wendahl (1971), Kim (1982), Yoon (1984), were found useful in identification of voice disorders. Some of these parameters are also studied in children (Kushal Raj (1983), Rashmi (1985)) in adults (Usha, (1980), Gopal, (1986) and Vanaja (1986)).

Hence these parameters listed below were selected in order to study changes in voice as a function of age in the age range 35 to 85 years in both males and females.

These parameters were studied in a sample of 96 adults both males and females, 10 males and 10 females were selected in each decade.

1) Maximum phonation duration.
2) Fundamental frequency in phonation.
3) Fundamental frequency in speech.
4) Frequency range in phonation.
5) Frequency range in speech.
6)Intensity range in phonation.
7) Intensity range in speech.
8) Extent of fluctuation in frequency.
9) Speed of fluctuation in frequency.
10) Extent of fluctuation in intensity.
11) speed of fluctuation in intensity.
12) Rise time of phonation.
13) Fall time of phonation.

Test material included maximum phonation sample of 3 vowels /a/, /i/ and /u/ and repetition of 3 Kannada sentences "idu pa:pu", "idu ko:ti" and "idu kerapu banna".

Maximum phonation duration was measured using a stop watch. Fo and related measures in phonation were analyzed by digitizing through ADC with sampling for of 8000Hz and analyse using a computer.

To measure SFF, SFR, SIR the 3 Kannada sentences were fed into pitch analyzer (PM-100).

The data thus obtained was subjected to statsticial analysis, in order to determine the mean, S.D. and significance of difference between sex and different age groups.

Following conclusion were drawn after statistical analysis:

1) In males and females the maximum phonation duration decreased with age.
2) Variability measure in MPD shown increase with age.
3) Males and females do not show any significant differences in MPD, throughout the age group studied.
4) In males, Fo in phonation increases with age and
5) In females, Fo in phonation shows progressive decrease with age.
6) Variability measure in Fo in phonation shows increase with age in both males and females.
7) Males and females show significant difference in fundamental frequency in majority of age groups studied in all three vowels.
8) In males, fundamental frequency in speech increases with age as in fundamental frequency in phonation.
9) In females, fundamental frequency in speech shows increasing trend upto 55 years after which little changes is seen.
10) In males, frequency range in phonation shows an increasing trend with age.
11) In females, such a trend was not seen.
12) Significant difference between males and females in frequency range in phonation are seen only in the age range 35 to 55 years.

13) In males intensity range in phonation shows lower values in age groups 55-65 and 65-75 years compared to other age groups.
14) In females, no such changes are seen.
15) Generally, no significant difference are found between males and females in terras of intensity range in phonation in all the vowels.
16) In males higher extent of fluctuation in frequency in phonation is seen in the age group 75-85years in all the three vowels.
17) In females the extent of fluctuation in frequency in phonation is higher in the age groups 55-65 years and 75-85 years.
18) Significant difference between males and females in extent of fluctuation in frequency in phonation is seen in the age groups 35-45 years, 45-55 years and 55-65 years.
19) In males age groups 65-75 years and above shows higher value than other age groups with respect of speed of fluctuation in frequency in phonation.
20) Females generally show a lower speed of fluctuation in frequency in phonation in the age groups 35-45years and 45-55 years.
21) Significant difference between males and females are present in the majority of age groups studied.

22) In males, older age groups 65-75years and 75-85 years show higher values in extent of fluctuation in intensity of phonation than the rest.

23) Females also show such a trend.

24) Generally significant difference between males and females in extent of fluctuation in intensity in phonation are not found in majority of age groups studied.

25) In male speed of fluctuation in intensity in phonation do not *very* systematically with age.

26) Also, lowest values are seen in the age groups 55-65 years in males.

27) In females increasing mean values with age are present..)

28) All age groups show higher variability in both males and females.

29) Both males and females show an increasing trend in rise time in phonation with age.

30) Significant differences are not found between males and females in all age groups, for all the three vowels.

31) In both males and females the older age groups show significant differences when compared with younger age groups.

32) Again as in rise time in phonation values, significant differences are not found between males and females in all age groups.

33) In males gradual increase in frequency range in speech with age is seen whereas females do not show much changes in frequency range in speech with age.

34) Significant difference between males and females in frequency range in speech is present in lower age groups.

35) In general females do not show any change with age in intensity range in speech whereas males do not show any significant change with age.

36) Significant difference between males and females in intensity range in speech are not found in majority of groups.

RECOMMENDATIONS

1) Similar study may be carried out with larger population.

2) The clinical application of these parameters may be explored.

3) Relationship between acoustical, anatomical and physiological changes with age may be explored.

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