Normal Hearing by Air Conduction As a Function of Age and Sex in Indians

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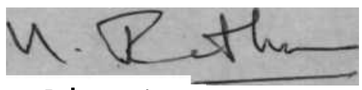
TO ANNA & AMMA

CERTIFICATS

This is to certify that the Dissertation entitled "NORMAL HEARING BY AIR CONDUCTION AS A FUNCTION OF AGE AND SEX IN INDIANS" is the bona-fide work in part fulfilment for M.Sc in Speech and Hearing, of the student with Register No.



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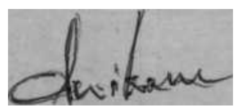

GUIDE

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Dr. (Miss) Shailaja Nikam, Professor and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

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CHAPTER I

INTRODUCTION

Man is born into a society and has to make a living among fellow beings. This calls for an effective psycho - social interaction, which is dependent on the communication skill of the individual.

Communication is the "sending and receiving of messages both verbal and non-verbal, within, between and/or among people."(Oyer and Oyer 1976). It is a "social glue" that bind,people together,that co-ordinates their activities and makes organized social life possible (Woelfel 1976). Any defect in the communication system jeopardizes the survival of the individual as well as the society.

Society is comprised of members of all ages. The contribution of each group is important for the society's well being. In converse, each age group has a specific role to play in the society. To effectively execute these roles, the intra and interpersonal communication among the members of the society is of prime importance.

The geriatric population, which is one of the major sections of the society has been found to be contributing significantly to the betterment of society. They are a 'window'to the past, which aids in the maintenance of culture in the society. They also serve as a frame of reference to the youth, for meeting various problems in the different walks of life. The well being of the geriatric population is important for the maintenance of integrity in the society.

The well being of the older people will be at stake, due to several changes in social, psychological and biological processes that occurs concomitantly with age. One of the types of social trauma experienced as age advances is the retirement from job. This affects the mental well being of the individual. Added to this, the biological changes occur in several body systems. These biological changes are due mainly to the cellular alterations in the body systems. These cellular changes result in structural changes which in turn affects the functioning of the respective body system. These changes which are seen in almost all the body systems, contribute to the myriad of problems encountered in the geriatric population.

One of the most common problem is,a breakdown in the communication system in the older people. The impairment in communication is brought about mainly by the changes in the sensori perceptual and speech mechanism.

Changes in the several stages of speech mechanism have been observed. The supralaryngeal structures have been found to become endentulous, Degeneration of tempromandibular joints, thining of epithelium of tongue and weakening of velopharyngeal muscles, have been reported. The laryngeal structures have also found to undergo changes with age. Atrophy or degeneration of laryngeal cartilages, an increased amount of connective tissue between the muscle fibres, an increase in the fragility of vocalfolds, and accumulation of lipofusion, stiffening of cartilage and atrophy of vocal folds have also been reported. These several structural changes bring about functional changes. Some of the functional concomitants of structural changes in speech mechanism have been found to be,an increase in the fundamental frequency in both males and females, an increase in the intensity, a decrease in the fundamental frequency range, voice tremor, a decrease in speaking rate, changes in the prosody of speech, reduced accuracy of articulation etc. (Ryan & Burk, 1974). Thus all these changes cumulatively affect the communication of the individual. The other factor, which exerts the most debilitating effect on communication process, is the impairment in the sensoriperceptual process.

The sensory process are the links which connect all behaving organisms with the external and internal environment and provide information about the environment (Corso, 1968), The senses may be classified into two categories; 'close' and 'distance' senses. The olfaction, gustation and taction are close senses, whereas hearing and vision are distance senses. The contact with the environment is maintained by the distance senses.

The vision is considered to be a 'spatial sense', whereas the hearing is considered to be a 'temporal sense. Of the two, the temporal sense, that is hearing is more important for communication. A listener must be able to group properly the speech sounds of his language in order to perceive the meaning. An auditory disorder impedes this 'grouping' and the individual mars a sequence of speech sounds, rather than groups of sounds which constitutes words.

Thus, the sense of hearing exercise significant influence on the behaviour of an organism.

With increase in age, the hearing sensitivity deteriorates, resulting characteristically in a high frequency loss. This condition was termed as 'Presbycusis' by Zawaardemaker (1899). But 'Presbycusis' as understood now does not limit to only pure tone loss. The geriatric population showing presbycusis, most often complain of an inability to understand the speech of others, which is incompatible with their average for pure tone. This phenomenon is referred to as "Phonemic Regression". (Gaeth 1848).

The geriatric population as such manifest poor speech discrimination on conventional speech tasks. By increasing the difficulty of the speech task, the performance of the subject becomes very poor. The poorer performance of the geriatric population compared to the younger population on distorted speech tasks have been reported by many studies. These studies have used the following types of distorted speech:

Time altered speech (Bocca and Calearo, 1963, Lutermann, Welsh and Melrose 1966; Sticht and Gray 1961; Konkle Beasley and Bess 1977); Frequency distorted speech (Kirikae 1969), Competing message task (Carhart and Tillman 1971; Carhart and Nichollos 1971; Mukundan 1977). On all these tasks, the older age group's performance and that of the younger subject performance was not comparable.

The findings from puretone audiometric tests and findings on conventional speech and distorted speech tasks reveals the involvement of both the peripheral and central auditory system in presbycusis.

Presbycusis manifests racial and cultural differences, as some disease processes like Otosclerosis, sickle cell anemia, retinitis pigmentosa which have been found to be more common in Indians and Sgyptians (Kamashevaran 1981).

Geriatric studies in the different races, like negroes and whites, have shown a better retention of hearing in the Negreos compared to the whites. (Bunch and Reidford, 1926; John Hopkins Lab, 1931). The cultural and environmental influences on presbycusis has bean brought forth in studies conducted in some of the primitive tribes , Mabaans, Creteans, KalahariBushman etc (Rosen et al 1970). So all these point out, the need to have population specific presbycusis data.

The present study was designed to provide such a data, for Indians, by studying variations in hearing by air conduction as a function of age and sex, in an large age stratified sample.

Need for the Study

A study of the present nature is important for several reasons:

First, due to the advances in the medical sicence, the life span of people all over the world is increasing and the death rate is decreasing drastically. The Indian census in 1971, revealed a decrease in the death rate by nearly 15% during the past 70 years. Therefore the advancement of gerontology has gained momentum, during the past few years. The problems encountered by the aged has become the central interest in social and medical fields.

Second, 6% of the total population are over 60 years of age (1971 census). Among the people above 50 years, 57.8% have been found to have hearing loss (Gill and Sharma, 1957). Thus more than half the aged population are hearing impaired. But the medical and surgical services are of limited value to presbycusis. Therefore more effective audiological rehabilitation services are warranted.

The rehabilitation program centres around an accurate assessment of the handicap. In order to adequately assess the severity of hearing impairment, the factor of prime importance is reference standards against which a person's hearing is evaluated. Therefore, while evaluating the sensitivity loss in an individual, the norms for the respective age group should be available. This is especially so while assessing the hearing loss in aged.

The correction factor for age effects on hearing is very necessary, while evaluating noise induced hearing loss, for compensation purposes. In such cases, the norms for the two sexes should be considered separately. Thus, the establishment of norms for each age group and for the two sexes is basic to diagnosis and rehabilitation.

Presently available norms, are based on the studies conducted in other countries. These norms are not directly applicable to the Indian population.

Limited number of studies conducted in India have not been well controlled, and therefore the findings of these studies have limited application to be considered as norms.

Therefore, the present study was aimed at overcoming the limitations of other studies and provide normative data for normal hearing by air conduction for various age groups and for the two sexes.

The present study was aimed at answering the following questions:

Is there any progressive deterioration in hearing acuity with age?

Is there any difference in the hearing acuity for men and women?

Is there any frequency effect on hearing acuity?

Is there any difference in the hearing acuity for the right and left ears?

Is the hearing acuity in Indians comparable to that obtained in other population?

C H A R T E R 11

REVIEW OF LITERATURE

The effects of aging on man's auditory system has been reported in the literature, as early as 1800. (Zawaardemaker 1894). He observed progressive deterioration of hearing for the high frequency sounds with advancing age. He coined this kind of hearing impairment seen in the aged, as "Presbycusis". This kind of concept, though basically right is too simple, and does not really represent a number of clinical and theoretical aspects characterizing this phenomenon.

For a long period of time, the structural alterations in the presbycusis ears was believed to be limited to the peripheral portion of the auditory system (Davis, 1970). But of recent, many histopathological studies on presbycusis ears have disclosed that no portion of the auditory system is immune to sensecent changes. The physiological alterations in presbycusis ears thus involves all the major divisions of peripheral and central auditory mechanism.

The physiological alterations in the auditory system of presbycusis ears can be studies under the major divisions of hearing mechanism.

I. External Bar

Alterations in pinna and external auditory meatus have been reported in literature.

Pinna: The increase in the size of pinna has been reported by many investigators(Guild, 1942; Tsai et al, 1958; Chon and Chang, 1958; Williford, 1971). The average increase in the length of pinna has been observed to manifest sex differences. In males the increase reported to be 5.13 mm in length and 2.28 mm in width, whereas in females the increase has been reported to be 3.69 mm in length and 2.28 mm in width, as age advanced from 20 to 50 years (Tsai et al, 1958). An increase in stiffness and excessive freckling of pinna has been reported (Senturia, 1957).

External Auditory meatus

\ A number of changes, like : widening of the canal (Fowler, 1940: Show et al 1978). Thinning of skin lining the canal and a diminished elasticity (Senturia 1957;

Rosenwasser 1964) and a pronounced dryness of epidermis of the canal (Senturia, 1957) has been reported.

The external ear structures also have certain important functions. The pinna, for example, contributes to the process of auditory perception.

Menser (1879) reported that pinna aids in the collection of sound waves.

Mach (l875) claimed pinna to be a resonator for high frequency sounds thereby affecting the timbre of the stimulus. The role of pinna in auditory perception has been demonstrated by two hypothesis:

1) Pinna shadow hypothesis (Mills, 1972) which assumes that pinnae function to shadow the high frequency energy for sounds coming from the rear to provide monoaural loudness information.

2) Pinna reflection hypothesis (Battean 1968) which assumes that pinna performs a monoaural time delays of the incoming wavefronts and that the pattern of these delays uniquely specifies the direction. He conducted many experiments and based on the results obtained, he claimed that pinna evidently transforms the sound entering the ear canal in a way that indicates the

sources direction, and distance.

Researches on the effects of hearing protector on localization have confirmed the importance of pinna in localization (Hochberg, 1962; Noble and Russell, 1972)

As in the geriatric population, the pinna and other external eat structures undergo changes, their localization ability might get affected.

2. Middle ear

Substantial changes in the various middle ear structures have been quoted in the literature.

Tympanic membrane

An increase in the flaccidity and thinning of tympanic membrane has been evidenced (Conell, 1952; Rosenwasser, 1964;

Ossicles:

Changes such as, increase in the rigidity of the ossicular chain, ossification of the malleoincudal joint, calcification of the articular cartilage and atrophy of the ossicular chain especially in the crura of the stapes has been reported (Rosenwasser 1963). Klotz and Crabbe (1963) have attributed the rigidity to the sclerosis of the joints. Farrior's(1963) study supported Klotz and Crabbe (1963). He found the older people also, are succeptible to otosclerosis, as in 1/3rd of 125 aged subjects studied had otosclerosis

Muscles and Ligaments

Degeneration and atrophy of the stapedius and Tensor tympani and atrophy of the ligaments attached to pssicles has been observed (Conell, 1952; Rosenwasser 1964; Davis, 1970). These alterations reduces the operating efficiency of Middle ear system, thereby affecting the hearing acuity

Eustachian tube

Nerbonne, Schow, Goset and Bliss (1976) have reported of abnormal negative pressure in the middle ear of aged persons. This has been attributed to atrophy of Lenator and Tensor palatini resulting in reduced palency of eustachian tube.

Evidence for the presence of middle ear involvement was given by Glorig and Davis (1961.). They observed an

A-B gap which increased with age and frequency in older subjects of the sample consisting of the age range 25 to 80 years. This type of pattern in the elderly was termed as Conductive presbycusis by them. But the above findings were questioned by the study of Sataloff, Vassalo and Menduke (1965), as they failed to observe any A-3 gap in subjects aged 62 to 86 years. Thus, though the invlovement of the middle ear is confirmed, their effect on the hearing acuity has not yet been established. The presently prevailing belief is that presbycusis is an sensorineural type of hearing loss. Therefore more importance has been given to the alterations in the inner ear and central auditory system.

3. Inner ear changes

A gross degeneration and atrophy of organ of corti in the aged has been documented by many investigators (Saxen and Von Fienelt 1937; Jorgensen 1961; Schuknecht 1957; etc).

The most important alterations in the inner ear with aging, has been hair cell degeneration (Crowe, Guild, Polvogot 1934; Schuknecht 1955; Pestalozza and Shore 1955; Gacek 1975). The degeneration has been attributed to the decrease in the enzymatic activity of the lysomes in the hair cells.

The other changes which have been observed in the inner ear with aging, are: increase in the stiffness of basilar membrane (Mayer 1920; Crowe et al 1934; Schuknecht 1967, etc) atrophy, rupture, with thinning of membranes at the site of rupture (Schuknecht 1967).

One other important structural alteration observed is, the atrophy of the stria vascularis (Crowe et al 1934; Von Fiendt 1937; Schuknecht 1964,etc). Atrophy of stria vascularis has been considered one of the major factor in the hearing impairment of elderly

4. Auditory nerve

One of the major factor to which the hearing impairment in the aged has been attributed to is the loss of ganglion cells in the spiral ganglion (Schune-keht and Woellner 1955; Raswassen 1940; Fleischer 1956). The loss has been reported to be confined to the basal portion of cochlea initially, later extending to other regions, thereby resulting in a significant hearing loss.

Rasswassen(1940) counted the number of nerve fibres in cross sections of cochlear division of auditory nerve and found 2,200 fewer fibres in the subjects aged 44 to 60 years compared to their younger counterparts. In addition to the loss of ganglion cells, narrowing of internal auditory meatus due to the progressive degeneration of connective tissue, at the base of internal auditory meatus has been reported (Krmpotic - Nemanic 1969).

These alterations in the auditory nerve result in speech discrimination impairment to a greater degree than tonal impairment. Hinchcliffe (1962) has summarized the alterations in the inner ear and auditory nerve as follows:

1. Cochlea:

(a) Atrophy and degeneration of both hair cells and supporting cells of the cochlea.

(b) Angiosclerotic degeneration of the epithelial tissues and vessels of the inner ear, including the organ of corti, basilar membrane and stria vascularis.

(c) Thinning and adhesions of tectorial membrane.

(d) Calcification and loss of elasticity of basilar membrane.

(e) Reduced nutritional content of endolymph.

2. Cochlear nerve

(a) Degeneration and loss of spiral ganglion cells and their associate nerve fibres.

(b) Hypertrophy at the base of the internal auditory meatus which leads to increased pressure and subsequent atrophy of nerve fibres.

Thus varying degree of alterations occur in the inner ear structure with age, which contributes to the auditory problem complex in the aged.

5. Central Auditory involvements

Schuknecht (1955, 1964) stated that the deficit in the number of functional neural units exist not only in the first order neuron but also in the third,fourth order neurons. The above statement implies that the alterations with aging are not limited to the peripheral auditory system but encompasses the central auditory system also. This has been confirmed now, by the histopathological as well as audiological findings in the auditory system of the aged.

Kirikae, Sato, Shitara (1964) have reported of atrophy of neural structures in the ventral cochlear nuclei, the superior olivary complex, the lateral leminiscus, inferior corticular - medial gericulate nuclei and auditory cortex. Similar structural changes have been reported by many other investigators also (Brody 1955, Cragge 1975, Valenstein 1980, etc). Thus, these studies confirm the involvement of the Central auditory system in presbycusis on histological basis

Literature regarding the audiological manifestations of presbycusis also point to the involvement of central auditory system.

Carhart (1958) reported a phenomenon termed as 'Benero effect' in the aged, wherein the bone conduction thresholds were lower than air conduction thresholds at 500 Hz. He has attributed this to the impedance changes in the bony tissue of skull

Hinchcliffe (1962) evaluated the performance of older subjects on tasks like frequency discrimination auditory temporaldlscrimination, directional hearing, auditory perceptual judgement, distorted speech tests and the ability to recall long sentences. In all these tasks, the performance of the older subjects was poorer compared to the younger subjects. The tasks chosen for the study, all involved higher level processing and therefore a poor performance on these tasks can be taken as an indication of the involvement of higher auditory system.

Kirikae (1969) administered complex speech tests, like, filtered speech test, synthetic speech, time distorted speech and directional hearing tests to subjects age ranging from 50 years to 75 years, with normal pure tone average. On all these tests, the performance of the older subjects was poor compared to young adults. From this he concluded that senile changes are distributed along the auditory pathway, right from level of spiral ganglion to auditory cortex.

Bergman (1971) observed a deterioration in the scores on distorted speech test, beyond the age of 40 years, and also a decreased efficiency in time sampling, which is mediated by the central auditory system.

Konkle et al (1977) noted a decrease in the intelligibility scores as a function of age, time compression and reduced sensation level regardless of control for peripheral sensitivity. A 20% reduction in scores occured between the ages of 20 years to 57 years and a second reduction of 20% between the ages of 57 years to 70 years. They concluded that, the rate of progression of central auditory disorders tended to increase with age and that "changes in speech intelligibility associated with aging appeared to be closely aligned to the temporal processing power of the Central Auditory processing system."

Hayes and Jerger (1979) investigated the performance on PBmax and SSI tasks, in subjects, ranging in age from 10 years to 89 years. The results revealed a good correlation between the scores on the two tasks uptill the age of 55 years. Beyond the age of 55 years, the scores on the SSI was significantly poorer than on PB max especially in subjects of 80 to 89 years of age. Based on these results, they categorized the presbycusie subjects into two groups. Central and peripheral presbycusis,subjects in the central presbycusis, consistently manifested low frequency hearing loss. Thus from this, they concluded that a low frequency loss in the presbycusic patients would generally imply central auditory system involvement.

Thus, all the above evidences, strongly emphasize that the physiological alterations underlying presbycusis is not the domain of any one part of the auditory system but encompasses the whole of the auditory system, right from Pinna upto the auditory cortex.

On the basis of the histopathological findings Schuknecht has classified presbycusis into 4 types (Schuknecht 1964). These are:

a) Sensory presbycusis: where, the locus of degenerative changes is in the organ of corti of the basal end, with some secondary degenerations of the supporting elements. Audiological manifestation is a bilateral symmetrical abrupt high frequency hearing loss. This type usually begins at childhood. The etiological factor appears to be accumulation of wear and tear pigment.

b) **Neural presbycusis:** The locus of degeneration is the neuronal fibres, particularly in the first order (Cochlear nerve). Here the changes seem to be controlled by genetic factors. A progressive loss of speech discrimination in the presence of normal pure tone thresholds, that is "phonemic regression" is the main characteristic of this type of presbycusis (Gaeth 1948).

Associated degenerative changes in the organ or corti may be present. The symptoms of this type is manifested late in life.

c) Mechanical presbycusis: is due to the disturbance in the motion mechanics of cochlear partition, such as stiffening of basilar membrane or atrophy of spiral ligament. The audiological manifestation is a bilateral symmetrical descending/sloping audiometric curve.

d) Strial/Metabolic Presbycusis: This type is found to affect several members of the family. The onset of hearing loss is insidious and mainly in the 3rd to 6th decade of life and progresses slowly. The audiometric pattern is a flat hearing loss with good speech discrimination. The degeneration changes are atrophy of the stria vascularis which in turn results in deficiency of Endolymphatic potentials.

Johnson and Hawkins (1972) described one more type of presbycusis:- Vascular presbycusis- The alterations seen in this type is similar to that of metabolic presbycusis (Gacek and Schuknecht 1969).

The above described structural changes, alters the functions of the auditory system.

The functional concomitants of the structural changes in the auditory system has been investigated by employing various audiological test. Of these pure tone audiometry has been the most commonly employed measure.

Pure tone audiometric test results are dependent on a number of factors like: the test environment, the tester, the procedure employed for testing, the instructions given to the subject, the calibration of the audiometer, the standards to which the audiometer is calibrated and some of subject varaibles, like, his motivation, his physical and mental state at the time of testing, the background history etc. These factors should be kept under control to obtain reliable thresholds.

In the geriatric population, one of the factors which exercise a contaminating effect on pure tone thresholds is the condition of the cardiovascular system.

Attempts have been made to explore the influence of cardiovascular risk factors on the hearing acuity of an individual.

Hansen(1968) investigated the relation between arterial hypertension and hearing acuity in subjects aged 45 years and above. The results failed to reveal any relation between the two experimental variables, except when the arterial hypertension was associated with angiopathy.

Bochenek and Jackowska (1969) compared the hearing sensitivity in engine drivers, aged 51 to 60 years who had history of atherosclerosis with those who did not have atherosclerosis. A higher incidence of accelerated presbycusis was observed in the group with atherosclerosis. On the basis of these results, they concluded that atherosclerosis accelerated presbycusis.

Rosen and Rosen (1971) in their study, comparing the hearing sensitivity in Mabaans, Finns and Yugoslavians, revealed best hearing in the Finns. On comparing the blood cholesterol levels in the three groups, the Finns had the lowest blood cholesterol level. Correlating the two results, they came to the conclusion that blood cholesterol level and hearing sensitivity are positively correlated.

Drettner Klockhoff and Suedberg (1975) conducted studies on similar lines to explore the relation between various cardiovascular risk conditions and hearing sensitivity Their results failed to reveal any significant correlation between the two.

The literature, regarding the correlation between cardiovascular risk conditions and hearing sensitivity has been equivocal. But this cardiovascular risk factors should be taken into consideration while conducting population studies in the aged.

A number of population studies, either covering the whole age range, from early years of life to old age, or only older age groups,, have been conducted, to establish valid reference levels for the assessment of hearing loss due to purely the aging effect. But most often, the studies in this field, are contaminated by the influence of other factors like noise exposure, either to community or occupational noise, and the several disease process which affect the geriatric population. The influence of the above factor on the aging auditory system has been brought forth by studies conducted, in different population of varying health and environmental conditions.

The population studies will be reviewed under certain heads.

1. **Racial studies**: Bunch and Raidford (1931) have investigated the hearing acuity in two different races, Negroes and White males. The analysis of their data, revealed poorer hearing in the whites compared to the Negroe people of comparable age groups.

The data from World War II nas also shown better Rearing in tne Negroes especially at high frequencies.

The data collected at New York and San Fransisco World Fair (1939) also revealed differences in tne hearing acuity among tne two population; Negroes and Whites. The negroes manifested a greater incidence of low frequency hearing loss in contract to high frequency loss among the Whites.

These studies reveal the non uniformity in the prevalence of presbycusis across races, wnich points to the need for conducting such studies in different races.

The studies in whites nave been tne most abundant, compared to the other races.

One of the large population study was that conducted by Glorig et al (1957) at the Wisconsin state Fair. This was a field study. The sample comprised of both males and females of age ranging upto 79 years. The frequencies were the octave frequencies between 500 Hz to 6000 Hz. The analysis of the results revealed the following:

a) The onset of hearing impairment was more gradual among women compared to men except in the later years.

b) The degree of loss showed an increase with an increase in age.

c) For every additional decade, the median hearing loss increased at 6000 Hz by about 10 dB as compared to 3dB increase at 500 Hz.

d) The two ears showed a difference in the hearing acuity. The left ear was poorer in all the age groups, in both males and females. The difference between the two ears for men ranged from 0.2 dB at 1000 Hz at the age of 30 years to 39 years; to about 9.1 dB at 3000 Hz beyond the age of 50 years to 59 years. These ear differences were found to bear no relationship to handedness.

e) The rate of progression of loss beyond 70 years of age was similar to the rate in the younger age groups.

The results of the Glorig et al study (1957) agreed with the findings of the U.S. National Health

Survey (1958) and Hinchcliffe's study (1959). The health survey, also reported of an increase in the incidence of hearing loss with increase in age, especially beyond 65 years

Hinchcliffe (1959) studied the hearing acuity of a rural population of age 18 to 54 years. The findings revealed, differences in hearing acuity at certain frequencies, in the younger age groups of males and females. The correlation between the hearing acuity of the males and females was high except at mid and high frequencies, where the threshold of hearing was significantly poorer in males. In all the younger age groups, the hearing thresholds for women was significantly better than men at frequencies 3000 Hz, 4000 Hz and 6000 Hz, while in the older age groups, significant differences were observed at 2000 Hz and 8000 Hz also. The differences in the two sexes was attributed to noise exposure, like small arms firing noise, etc., in males. The latter contention has been supported by Glorig et al (1957) wherein they proposed the term 'Sociocusis' for hearing loss, resulting due to the interaction of aging and community noise exposure.

Goetzinger et al (1960) investigated the effects of age and sex on hearing acuity in 45 men and 45 women between the ages of 60 years to 90 years. Fifteen subjects of each sex were tested in each decade. Only subjects with no complaint of hearing loss, no history of ear infection, ototoxicity, noise exposure and family history of loss, were included in the study. Pure tone testing at frequencies 250 Hz to 8000 Hz at octave intervals, with the exception of 6000 Hz was done. The analysis of the results showed the following:

a) The hearing acuity of the right ear was significantly better than that of left ear.

b) The frequency effects were significant, but were not parallel in the two ears.

c) The effect of age was significant for all the age groups.

d) The main effect of sex and the sex by age interaction was insignificant. But observation revealed a slightly better hearing in the lower frequencies in males and better hearing at high frequencies in females. This was confirmed by significant frequency by sex interaction effect.

e) A comparison of this study with that of Glorig et al (1957) for the 60 years to 69 years age group, revealed identical audiometric patterns, for men, except at 4000 Hz. At this frequency the males of Goetzinger's study had poorer hearing about 10 dB compared to the Glorig et al study (1957).

The pattern of hearing loss for female subjects was similar in the two groups with slightly better hearing than the women of Glorig et al study (1957). Melrose, Welsh and Lutermann (1963) following on lines similar to Goetzinger et al (1960) observed very little additional loss beyond the age of 65 years, contradicting the findings of Goetzinger's study. Reasons for such a discrepancy has not been discussed, due to the non availability of the original source

Schaie, Battes and Strother (1965) tested healthy educated volunteers and noted acuity differences between males and females, at high frequencies. The mean difference in the hearing loss between males and females was about 30 dB at 3 octave points above 1024 Hz.

Feldman and Reger (1967) compared the performance of subjects of age 20years to 29 years with the subjects of 50y to 59 years of age, on pure tone audiometry, reaction time measures and speech discrimination. Puretones of frequencies ranging from 250 Hz to 8000 Hz with the exception of 6000 Hz, at octave intervals was employed for testing. The results revealed, an increase in high frequency loss with age, especially beyond 50 years. Beyond the age of 70 years, a slight involvement of the low frequencies were found to be involved. In all the subjects, uptill the 7th decade, normal hearing for frequencies less than 2000 Hz was noted. The 50 years to 59 years old subjects manifested more loss at 4000 Hz compared to 8000 Hz. A similar trend was seen in the young adults also. The latter finding was, therefore attributed to community noise exposure. Of all the frequencies, the 500 Hz was reported to be least susceptible to aging process. The rate of progression of hearing loss was about 10 dB between the third to fifth decade, Beyond fifth decade, it was about 10 dB/decade, The rate of progression, increased with an increase in age. In addition to changes in pure tone, the subjects revealed an increase in speech reception threshold of about 9 dB and a reduction in the discrimination by about 5%/decade beyond the age of 50 years.

Nelson (1965) has reported of pure tone audiometric data for 2 women, of Pennsylvania of age greater than 100 years. In both the subjects, the pure tone configuration was found to be pyramidal with more loss at higher and lower frequencies, in the frequency range of 1125 Hz to 6000 Hz. At this age, the maximum hearing loss was around 95 dB at high frequencies, with mid frequencies, well preserved.

Dayal and Nussbaum (1971), in a retrospective study investigate the consistency of the patterns of pure tone loss in presbycusis over a mean period of 9 years 5 months. Here the records of subjects with hearing loss, due to aging, with a minimum of two audiograms were selected and followed up. During the follow up period, a minimum of three audiograms were obtained. An analysis of the audiogram revealed a sloping or descending audiogram in 88% and flat audiograms in 12% of the subjects tested. Follow up analysis for the subjects revealed an unchanged pattern in 82% of the sloping audiograms and a shift from descending to a flat type in 6%. Of the flat audiograms, the audiogram remained stable in 10% and changed to descending in 2% of the 12% of flat audiograms. On the whole, only in 8% of the subjects, was a change in the pattern observed. This implies that the site of pathology in presbycusis remains relatively same over a number of years/over a long period. In those subjects where changes were observed, the explanation offered was that, either there was a change in the site of pathology or another site of pathology cumulated with the original pathology. The study has confirmed the traditional view of 'presbycusis', as being a high frequency sensorineural hearing loss.

Orchik.(l980) has also reported of some characteristic features of presbycusis. A bilateral high frequency sensorineural hearing loss was found to be one of 'the' characteristic feature of presbycusis. The onset of loss was around 3rd decade. In the initial stages only the involvement of high frequencies were noted, but with increasing age, the loss progressed to involve the low frequencies also. Of the total geriatric population, only 20-25% manifested hearing loss. Among these, the hearing loss was noted only in 20%-25% of subjects above 50 years, whereas it was noted in 40%-50% beyond 70 years of age. The incidence of loss showed an increase with age.

One unique finding reported by Orchik (1980) was an increase in the A-B gap with increase in the hearing loss. Such a phenomenon was attributed to cochlear partition changes and to mechanical changes in the middle ear. This finding supports the findings of Carhart (1958). Further research is warranted in this area.

One study which used the longitudinal approach for investigation the aging effects on hearing was that conducted by Milne and Lander (1975). The subjects in this study ranged from 62 years to 90 years. Bath males and females were included in the study. The results revealed an increase in hearing level with age in each frequency. The hearing level in the 8th decade, was significantly greater compared to 6th decade in both males and females at all frequencies except at 500Hz. The increase was more obvious in men at high frequencies that is 2000 Hz and above. The increase in hearing loss was marked at all frequencies in females. Sex differences were noticed especially in the older age groups. In general, females had more loss at low frequencies, whereas males had more loss at high frequencies. The first significant drop in hearing was at 2000 Hz and 4000 Hz.

As in the study, exposure to noise was not ruled out, the sex differences in the hearing threshold, was attributed to noise exposure in males (Richards 1971, Glorig 1960).

Presbycusis and Noise Induced Hearing Loss

Attempts have been made, to assess the contaminating influence of noise exposure on presbycusis values by studying the hearing patterns in noise free population. For the above purpose the hearing acuity in primitive tribes, like Mabaans, Jamaicans, Creteans, Finns, Bahamas etc. have been studied.

By comparing the results of these studies with other studies, an attempt has been made to provide co-rrection factor for presbycusis.

The hearing sensitivity of Mabaans has been extensively studied by Rosen et al (1962, 1964). Mabaans, are a primitive tribe who live near the Ethiopian Border. These people are not exposed to noise, as their cultural development can be equated to stone age and their diet constitutes of millets, fish and corn. They have excellent physique and manifest a very low incidence of elevated blood pressure, Coronary thrombosis, ulcer, asthama,etc. Thus they represent an ideal population for assessment of pure effects of age on hearing sensitivity. The studies revealed better hearing among the Mabaans compared to the whites, especially at high frequencies throughout their life, from the age of 10 years to 70 years.

The hearing acuity of the Mabaans was compared with the ISO reference levels. For the 10 years to 19 years age group, the hearing of Mabaans was found to be poorer. For the young adults, 20 years - 29 years age group, the hearing acuity of Mabaans and ISO reference levels was almost the same. But a comparison of the reference levels for the middle aged population with Mabaans, revealed better hearing in Mabaans. This was attributed to the noise exposure in the U.S. Population at the Middle age. But the Mabaans manifest reduced cardiovascular anomalies, the better hearing cannot be attributed solely to the lack of noise exposure.

To cross-check the influence of cardiovascular anomalies on the presbycusis values Rosen (1969) compared the hearing levels of populations of varying health and environmental conditions. For comparison, some noise free populations like Creteans, Finns and Bahamas were chosen. The analysis revealed best hearing among the Creteans and next best in Bahamas and Mabaans and the worst was in Finns. Even though all the 4 groups were not exposed to noise, they manifested differences in hearing sensitivity. These differences were explained based on dietary differences among the different groups. The group with minimum saturated fat diet (Creteans) manifested the best hearing sensitivity and vice versa. Thus they concluded that a low fat diet facilitates better nutrition to the cochlea, which results in better preservation of hearing. This study reveals, that the hearing sensitivity differences are due to certain cultural differences.

Raynaud, Camara and Basteris (1969) also investigated the influence of diet on hearing acuity by studying the hearing levels in an nomadic African population of age ranging from 40 to 70 years. The threshold was determined for frequencies 500 Hz to 8000 Hz at octave intervals. Results failed to show any significant correlation between ratio of lipids, lipoproteins and blood pressure and neither was there any exceptional degree of conservation of hearing in the high frequencies as reported by similar studies. The possible reason for such a discrepancy, is the inclusion of pathological ears also in the study.

Mollica (1969) studied 200 subjects of age 25 to 60 years, with occupational noise exposure, of about 110 to 130 dB SPL from 20 years to 40 years. The results revested a greater loss in people who had more exposure to noise and belonged to older age groups. But when correction was applied for presbycusis, keeping all other factors constant, the amount of hearing loss was found to be of equal magnitude in older as well as the younger population. Therefore, an evaluation of noise induced hearing loss should include the assessment of the contribution of effects of aging on the loss. But presbycusis was not responsible for the onset of the evolution of noise induced hearing loss. It only added upto the damage caused by noise exposure.

Rosen et al (l970)studied a sample of the population of Moscow and Georgia to determine the effects of noise, diet and age on hearing acuity. In both the samples, the subjects were categorized into two groups, on the basis of noise exposure. The two groups under study were the clerical and factory workers, of age ranging from 40 years to 59 years. A control group of children of age 10 years to 19 years from the two populations were included in the study. The noise exposure level the factory workers of Georgia was equivalent to the community noise exposure level the clerical workers of Moscow. The diet of Georgia contained minimal fat content in contrast to Mascow's population. The analysis of data revealed (1) better hearing in the clerical workers of Mascow compared to the factory workers of Moscow. This difference was attributed to the greater noise exposure for the factory workers. 2)Better hearing in both the samples of Georgia compared to sample of Moscow. The differences between the clericals of Moscow and the factory workers of Georgia was attributed to differences in the diet of the two populations. A comparison of the children of both the groups did not reveal any difference, thereby ruling out the probability of inherited differences. This study supports the findings of other studies conducted on similar lines.

Noise exposure and cultural differences seem to have an effect on the age related changes of hearing acuity.

One other study which has contributed extensively to this area is that of Corso (1963). The subjects for this study were selected from 6 age categories,(18 years to 65 years) each age group covering a 7 year period. Only those with history of ear pathology and minimal exposure to noise were included in the study. All subjects were subjected to an otological examination prior to audiometric testing. Threshold determinations were made at nine frequencies from 250 Hz to 8000 Hz at octave intervals in both the ears of all the subjects.

The data obtained was analyzed in terms of three types of distribution: (a) Original distribution, included data, for all the subjects in the study,

(b) Screened distribution, which included data, for only subjects who had passed a rigid screening criteria related to the extent of noise exposure and otological disorders.

(c) Truncated distribution which included data for subjects who fell within ± 15 dB from the mode of the screened distribution. The data obtained from screened distribution was considered for recommending standards of normal hearing.

The analysis of data from screened distribution revealed the following:

1. There was a decrease in hearing sensitivity for both males and females with increasing age and a spread in the hearing loss from higher to lower frequencies.

2. The onset of hearing loss with increasing age was more gradual in women compared to men. The rate of progression was however, faster for women compared to men, so that by the age of 51 years to 57 years, the hearing loss for women exceeded that of men, markedly at low frequencies.

3. The rate of progression of loss was uniform as a function of age in women. But in men it varied in an non-uniform manner. From the age of 26 years to 40 years, very little change in hearing level was observed, then a marked drop in the hearing level was

noted. This was followed by a period of relatively little change from 43 years to 57 years which was then followed by another major drop from 59 years to 65 years. Thus the progression of hearing loss in men appeared to occur in steps of about 15 years.

4. On average, the hearing sensitivity of women was better than that of men.

5. The variability was lower in women compared to men, except in the two older age groups (51 years to 57 years and 59 years to 65 years). In these age groups, women manifested poorer hearing and greater variability at the lower frequencies, that is below 1000 Hz. On the other hand, men had significantly poorer hearing and greater variability at frequencies above 3000 Hz. The differences between the two sexes was most marked at high frequencies, with the cross-over point falling at 1000 Hz.

6. The onset of hearing loss was earlier in men by atleast 5 years compared to women, that is, the onset of loss occurred at the age of 32 years in men and at the age of 37 years in women.

7. Minor differences, of about 5 dB was obtained between the data for the two ears.

The findings of the present study was claimed to be a valid estimate of the 'pure' effects of age on hearing and was recommended as reference levels for normal hearing by air conduction for the various age groups.

Attempts have been made to study the variations in pure tone thresholds with age and sex in the Indian population.

Indian studies

Kapur and Patt (1967) surveyed the hearing sensitivity in Todas, a tribal population living in the hilly regions of Nilgiris. This tribe had minimal exposure to noise, they neither used weapons like guns for hunting, nor did they use any musical instruments for entertainment,

Hearing measurements were conducted in a mobile ambulance, with ambient noise level of 40 dB (C) Scale. Total number of subjects included, 50 males and 43 females, of age ranging from 6 years to 70 years. The analysis of the results revealed, normal hearing in 74% and hearing loss in 26% of the test population. Of the latter, 25% had conductive loss and only 1% manifested sensorineural hearing loss.

To study the characteristic features of presbycusis, Kapur and Patt (1967) collected one more sample comprising of 31 males and 29 females. The values given by Glorig et al (1957) for the 10 to 19 years age group, was used as reference zero, and the data was analyzed.

The analysis of data, revealed a slight elevation thresholds with age, in males but not observed in females. The changes in threshold, in males was maximally at 250 Hz, 500 Hz, 6000 Hz and 8000 Hz. The general trend revealed, better mean hearing levels in females compared to males at all frequencies except at 2000 Hz. Analysis of median thresholds, revealed better hearing in females at all frequencies except 2000 Hz and 8000 Hz.

Comparison of median thresholds of male and female Tbdas with Mabaans, revealed better hearing in Todas, at all frequencies except at 6000 Hz. The retention of hearing with age, was found to be better in Todas(males and females) compared to the data reported by Glorig et al (1957). But in general, the difference in threshold between Tbdas and Mabaans were very signi-

The effect of age on blood pressure was also studied in 37 males and 28 females. The female Todas had lower diastolic and Systolic pressure compared to Male Todas. The changes in mean blood pressure with age was negligible. In male Todas, a slight elevation in blood pressure with age commencing from 4th decade onwards was observed.

The findings of the above study cannot be accepted without reservations as the criterion used for the selection of subjects for presbycusic study has not been specified. The statistical measures employed are not specified and it seems, all the conclusion are based on the analysis of the mean and median values. This being a field study, the findings are not comparable to strictly controlled laboratory studies.

Seth and Kacker (1971) assessed the level of hearing in a sample of 100 subjects, ranging in age from 5 years to 77 years. The subjects for the study comprised of student population and patients visiting the outpatient section of the All India Institute of Medical Sciences, New Delhi and the relatives of the patients. The criterion used for selection was a negative history of ear pathology , complaint of hearing loss or dizziness.

Hearing measurements were conducted at 8 frequencies, 125 Hz, to 8000 Hz in both ears of each subject. The subjects were categorized into 8 age groups, with a class interval of 5 years. The results of the study, revealed a gradual increase in the loss of hearing with increasing age, especially after the fourth decade of life. The hearing loss was more marked at high frequencies, while the speech frequencies were well preserved.

This study has a number of drawbacks which limits its utility for establishing norms. The criteria of selection of subjects is very lax. Exposure to noise, which exerts the most contaminating influence on presbycusis values, has not been ruled out in the study sample. As majority of subjects were from the patient population, the influence of other ailments on hearing is probable.

Thus the values obtained do not reflect purely the effects due to aging. The number of subjects has not been maintained constant in the various age groups.

The testing procedure employed for the study has not been specified, that is whether the standard procedure of testing was employed for the youngest age group. Only data for the two age groups: (11 years to 20 years) and (61 years to 70 years) were analyzed in detail, and for all others only median, and range was computed. The statistical measures employed has not been specified, and all the conclusions are based on median threshold values for each age group. The data regarding right and left ear differences and sex difference has not been reported.

Punnan (1976) has also made an attempt to study the nature and degree of hearing loss in the aged population. He selected a sample of 100 subjects of age ranging from 35 years to 74 years from the attendants of patients, reporting at the All India Institute of Speech and Hearing, Mysore. The subjects were categorized into 4 age groups, comprising of 25 subjects in each. All the subjects were Otologically screened prior to testing.

Hearing measurements were conducted in a sound treated room, at frequencies ranging from 250 Hz to 10,000 Hz at octave intervals; for both the ears. The analysis of data revealed a gradual increase in hearing loss with age and frequency. The onset of hearing loss was reported to be earlier by about 5 years, compared to the Western reports: But specific studies to which the data was compared has not been specified. This study has a number of drawbacks, which limits its applicability. First, apart from otological screening, the criteria used for the selection of subjects and the sex representation of the sample has not been specified. These two factors are most important, as they have a significant effect on the age-related changes of hearing acuity. Though the graphs have been given separately for the two ears, whether the statistical analysis was also done separately for the two ears has not been given.

The only statistical measures reported in the study are the mean, median and standard deviation scores. Details of the statistical analysis has not been given. The utility of the study is limited due to inadequate statistical analysis.

The studies concerning the age and sex related changes in hearing acuity in the Indian population is meagre. The few attempts that have been made also have limited applicability because of the inadequacies of these studies.

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CHAPTER III

METHODOLOGY

The aim of the present study was to provide air conduction pure tone threshold data in a large age stratified sample of Indian population.

Subjects:

A total of 180 subjects, were randomly selected from the general population. The sample included literate as well as illiterate people. The age range of the subjects was from 10 years 6 months to 87 years. The subjects in this study were all volunteers.

The subjects were categorized into six age groups: lOyears 6 months-20 years 6 months; 20 years 6 months -30 years 6 months, 30 years 6 months - 40 years 6 months; 40 years 6 months - 50 years 6 months; 50 years 6 months-60 years 6 months; 60 years 6 months and above, based on their chronological age. The age was determined from the date of birth. But when this data was not available, the age of the subject was derived from the time of occurrence of certain important events in their life, like their age at the time of marriage, the age of the first child, the number of children they have, and the age differences between each child, the time of retirement, etc.

Each age group covered a span of 10 years period, except for the oldest age group. The subjects above 60 years were put into one group. The interval between the two extreme group was 80 years. Each age group consisted of 30 subjects, with equal sex representation.

A screening criteria, based on the background information like medical history, history of noise exposure, history of ototoxicity and results of impedance audiometry, was set up, for the selection of subjects to the study. The history form used to obtain the above information for each subject has been given in Appendix (A).

The following criteria was employed for selection of subjects:

1. A negative history of any kind of ear abnormalities, structural and functional, prior to, as well as at the time of testing.

2. A negative history of head injury.

3. A negative history of systemic diseases like, diabetes, cardiovascular and central nervous system affectoons.

4. A negative history of the consumption of high doses of streptomycine, Kanamycine and Neomycine.

5. A negative history of upper respiration tract infection at the time of evaluation.

6. A negative family history of hearing loss.

7. A negative history of noise exposure, meeting the DRC criterion given by OSHA was used as the guidelines.

Equipment:

An impedance bridge (Madsen ZO 73) equipped with earphones (TDH - 39) set in supra aural cushions Mx 41/AR) was used for impedance screening.

For obtaining pure tone thresholds, a single channel screening audiometer (MAICO, MA 27) with earphones (TDH - 39) set in supra aural cushions (Mx 41/AR) was used for all the subjects.

The instruments were calibrated as per ANSI (1969) standards. Details of the calibration procedure given in Appendix 'C'. Once in every two days, the output SPL of the earphones was checked, throughout the period of the study.

Systolic and Diastolic blood pressure was measured using a BP apparatus.

Test environment:

Impedance screening, and pure tone testing was done in sound treated rooms. The ambient noise measured, using a sound level meter (Bruel & Kjaer, type 2209) coupled with an 1/2" condensor microphone (Bruel & Kjaer, type 4165). The noise levels were found to be sufficiently low, as not to interfere with threshold testing. Noise levels at different weighting networks and at octave frequencies, given in Appendix 'D'.

Test Procedure:

Impedance Screening:

For each subject, Tympanometric and Reflexometric measurements, were done to rule out middle ear pathology.

Tympanogram was obtained with a 220 Hz probe tone for both the ears of a subject. Then, the contralateral reflex thresholds were measured, for frequencies, ranging from 250 Hz to 4000 Hz at octave intervals.

Subjects, who had a normal pressure peak ($\pm$50 mm H_2O), and, reflexes atleast at any three frequencies in both ears, were included for the study.

Pure tpne testing

The conventional procedure was used for pure tone testing, and the thresholds were obtained using the modified Hughson-Westlake procedure (Carhart and Jerger, 1959). The pure tone thresholds were obtained for seven frequencies, ranging from 250 Hz to 8000 Hz, at octave intervals, using only right earphone, but with the left earphone covering the non test ear. Both the ears of the subject were tested one" at a time.

Prior to the commencement of testing, the instructions given to the subject were as follows:

"I am going to test your hearing by presenting different kinds of tones to your ear, through the ear-phones. First, the tone will be presented at a level you can well hear. As soon as you hear the tone, raise your finger and hold it up as long as you are hearing the tone. As soon as you don't hear the tone, put the finger down immediately. The level of the tone will be varied, but each time, the tone is heard, even for the faintest, you should indicate. Only one ear will be tested at a time. Are you ready?

The Kannada version of the above instructions are as follows:

ಈಗ ನಿಮ್ಮ ಕಿವಿಗೆ ಶಬ್ದಗಳನ್ನು ಕೊಡುತ್ತೇನೆ. ಮೊದಲು
ನಿಮಗೆ ಶಬ್ದ ಜೋರಾಗಿ ಕೇಳಿಸುತ್ತೆ. ? ಶಬ್ದ ಕೇಳಿಸಿದ ತಕ್ಷಣ ಬೆರಳು ತೋರಿಸಿ.
ಶಬ್ದ ಕೇಳಿಸುವವರೆಗೂ ಬೆರಳು ತೋರಿಸುತ್ತಿರಿ. ಶಬ್ದ ನಿಂತ ತಕ್ಷಣ ಬೆರಳು ಕೆಳಗೆ
ಬಿಡಿ. ಶಬ್ದ ಕೆಲವು ಸಲ ಜೋರಾಗಿ ಕೆಲವು ಕೆಲವು ಸಲ ಸಣ್ಣಗೆ ಕೇಳಿಸುತ್ತೆ. ಶಬ್ದ ತುಂಬಾ
ಸಣ್ಣಗೆ ಕೇಳಿದರೂ ಬೆರಳೂ ತೋರಿಸಿ ಒಂದು ಸಲಕ್ಕೆ ಒಂದು ಕಿವಿಲಿ ಶಬ್ದ ಬರುತ್ತೆ.
ಸಿದ್ಧವಾಗಿದ್ದೀರಾ ?

For the majority of subjects, the instruction was given in English or Kannada. Only in subjects who had no knowledge of either of the languages, was the instructions given in their mother tongue. The same version, as given in English, was translated into the respective native languages.

Blood pressure Measurements

The diastolic and systolic blood pressure was measured for each subject, by a Trained nurse at the ENT department of the Institute.

The data obtained from Tympanometric, Reflexometric, pure tone audiometery testing and Blood pressure were recorded on a single sheet. (Appendix 'B')

Analysis:

Statistical measures like mean, median, standard deviation was computed for each age group separately for the two ears, for males and females and for the different frequencies.

Analysis of variance was applied to determine the effect of age, sex and frequency on pure tone thresholds. Paired 't' test was applied to study the differential performance of the two ears. Produce moment correlation was computed to determine the relation between blood pressure and pure tone thresholds.

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<u>RESULTS</u>

The data was collected for air conduction pure tone thresholds for 180 subjects, in right and left ears, at 7 test frequencies; 250 Hz to 8000 Hz, at octave intervals. This data was subjected to statistical analysis. Measures of central tendency, Mean and Standard deviation was computed for each agr group, for each ear, at all test frequencies for both males and females. Median values were computed for plotting the audiometric curve.

A Two-Way ANOVA was applied to study the main effects of age, sex and their interaction effects on hearing acuity, for the right and left ears separately. A One - Way ANOVA was employed to study the effect of frequency on the hearing acuity. Paired 't' test was applied at each frequency for all the age groups to determine right - left ear difference.

The audiometric profiles for males and females, for all age groups was prepared by plotting the median threshold values for the respective age group as a function of frequency. The profiles for the right and left ears are given separately.

The analysis of the data has been presented under the following heads:

Effect of Age:

The mean hearing thresholds presented in Tables 1 to 4, reveal an increase in hearing threshold with age in the whole sample.

The variability, computed from standard deviation (Tables 1 to 4) revealed greater variability among the older groups compared with the younger age groups.

The audiometric profiles, also shows, the age effect, which is manifested by a horizontal and vertical shift in the audiometric centres for the whole sample (Figures 1-4).

The 'F' ratio computed, using a Two-Way ANOVA, at each frequency for right and left ears, for both males and females revealed a significant (0.01) effect of age on hearing acuity (Tables 5-13). That is, a significant increase in threshold was observed with

The standard deviation scores, also showed an increase in variability with age in both males and females. The average increase in variability was found to be slightly more in females compared to males.

The audiometric profile (Figs. 1-4) for males and females, does not show, a consistent sex difference, across frequencies and age groups.

The 'F' ratio computed, also failed to reveal a significant sex difference in most of the age groups, and frequencies. Only at the 50y 6m to 60$ 6m age group manifested a significant sex difference (0.01) at 500 Hz in the left ear (Table 5-13).

Effect of Frequency

The mean hearing thresholds, at the test frequencies, showed a more marked increase in hearing level, with age at high frequencies, compared to low frequencies. A average difference in the hearing level between the youngest and the oldest age group was about 15 dB at 250 Hz and 45 dB at 8000 Hz (Tables 14 - 24).

age, across all frequencies, in right and left ears and for both males and females.

Effect of Sex:

In general, the mean hearing threshold for males was about 5 dB higher than females. The increase in the threshold from the youngest and oldest age group, in males and females was about 29 dB and 25 dB respectively. The maximum shift in threshold was observed between 4th and 5th decade in females, whereas it was between 5th and 6th decade in males.

The maximum hearing loss was at 8000 Hz in both males and females. The increase in hearing level in males and females was equivalent at low frequencies, but at high frequencies, the increase was more in males compared to females (Table 1 to 4) .

Beyond the 3rd decade, the high frequency loss (above 1000 Hz) was more in males compared to females, except in the 50y to 60y age group. The females of 50y to 60 years consistently showed higher thresholds across all frequencies, compared to males. The oldest males revealed higher thresholds in the lower age groups and frequencies was not consistent (Table 1-4).

The standard deviation scores, also showed an increase in variability with age in both males and females. The average increase in variability was found to be slightly more in females compared to males.

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The performance of males and females also showed a slight difference with respect to the test frequency, discussed under the 'Sex Effect' above.

The variability was also found to increase, substantially with increase in frequency (Table 1-4).

The frequency curves for the various age groups, also shows a prominent, high frequency slope, for both males and females, in right and left ears (Figs. 5-8) with age.

The 'F' ratios computed for frequency effect in each group, revealed a significant frequency effect (0.01) beyond the 4th decade. The findings in the two ears were similar for all age groups except in the 30y 6m to 40y 6m age group. Males and females, of this age group, showed a significant (0.05) frequency effect in their left ear.

The hearing acuity was observed to vary more as a function of frequency in the older age groups compared to the younger age groups.

Ear Difference:

The mean values computed for the two ears, in all age groups and test frequencies, failed to reveal a consistent right-left ear difference (Table 25-26).

The graphical representation of the scores for the two ears, are also not very different for the two ears.

The correlation Co-efficient computed for the determination of ear differences also did not show a significant ear difference. Out of the 84 possible correlations, only in 7 instances, was the difference between the two ears significant. The instances where a significant difference was obtained were : for males at 8000 Hz in the l0y 6m to 20y 6m age groups, at 250 Hz in the 20y 6m to 30y 6m age group, at 4000 Hz in the 30y 6m to 40y 6m age group, at 500 Hz in the 50y 6m to 60y 6m age group and at 250 Hz in the 60y 6m and above age group. For females, significant differences were observed only at 4000 Hz in the 20 years 6 months to 30 years 6 months age group add at 8000 Hz in the 30 years 6months to 40 years 6 months age group.. It can be seen from the Table 26,27that the distribution of these differences are random. Therefore, for all practical purposes the right and left ears can be considered to be equally sensitive to tonal stimuli.

Product moment correlation was applied to study the relation between blood pressure and hearing acuity.

Since the analysis showed insignificant correlation , the factor , blood pressure was not considered for discussion.

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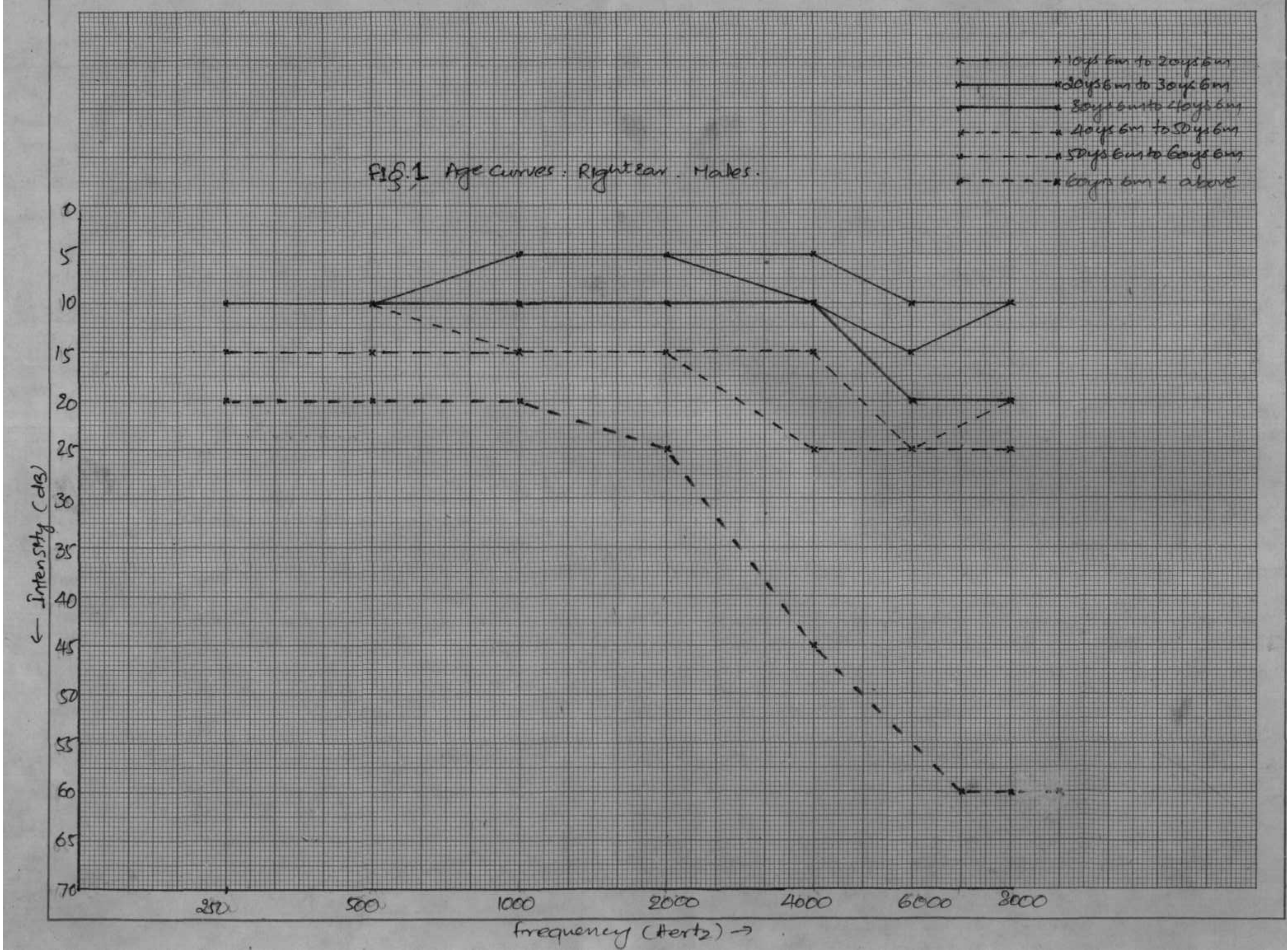


Fig. 1 Age Curves : Right Ear . Males.
10yrs 6m to 20yrs 6m
20yrs 6m to 30yrs 6m
30yrs 6m to 40yrs 6m
40yrs 6m to 50yrs 6m
50yrs 6m to 60yrs 6m
60yrs 6m & above
← Intensity (dB)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
250
500
1000
2000
4000
6000
8000
Frequency (Hertz) →

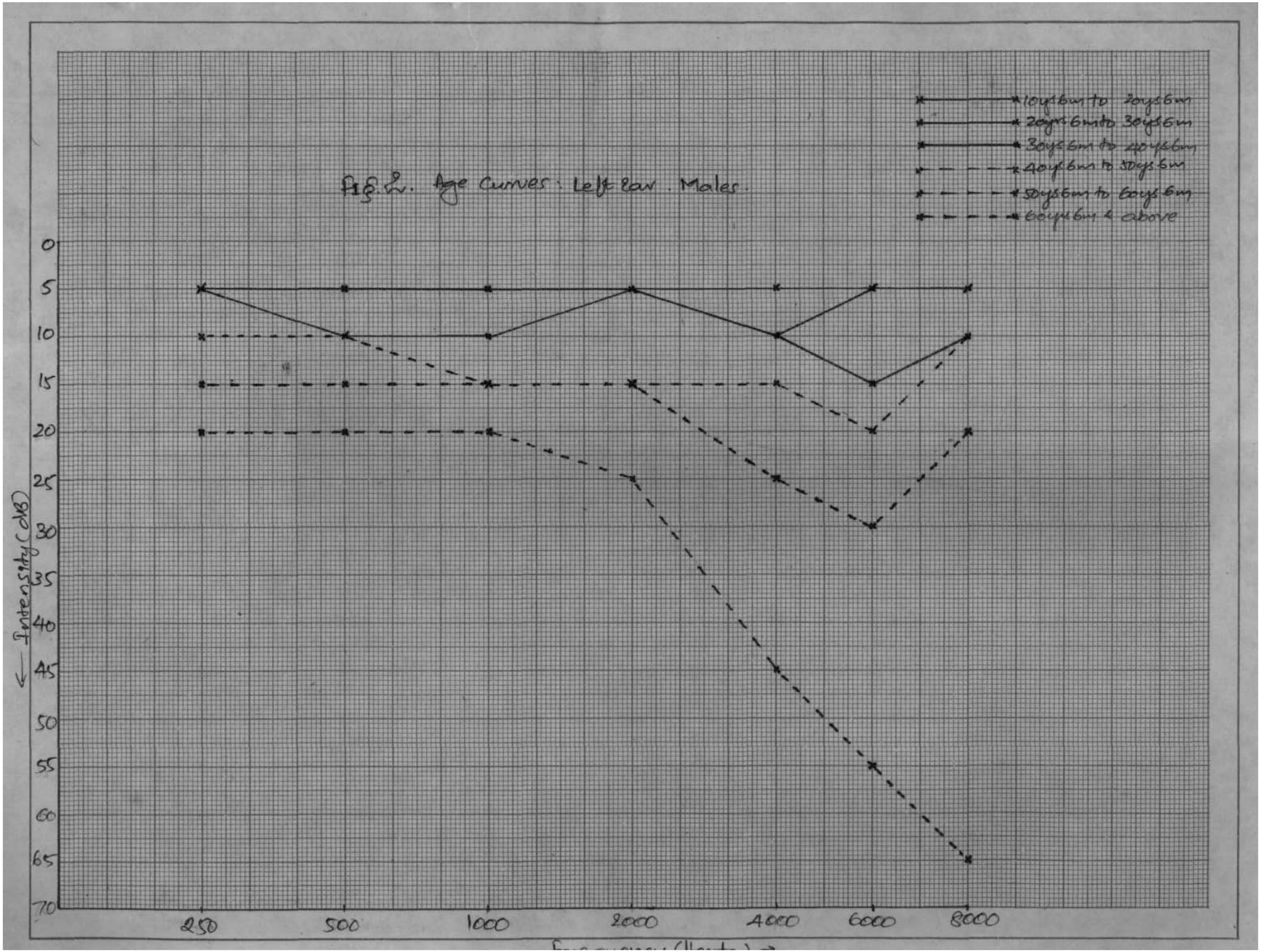
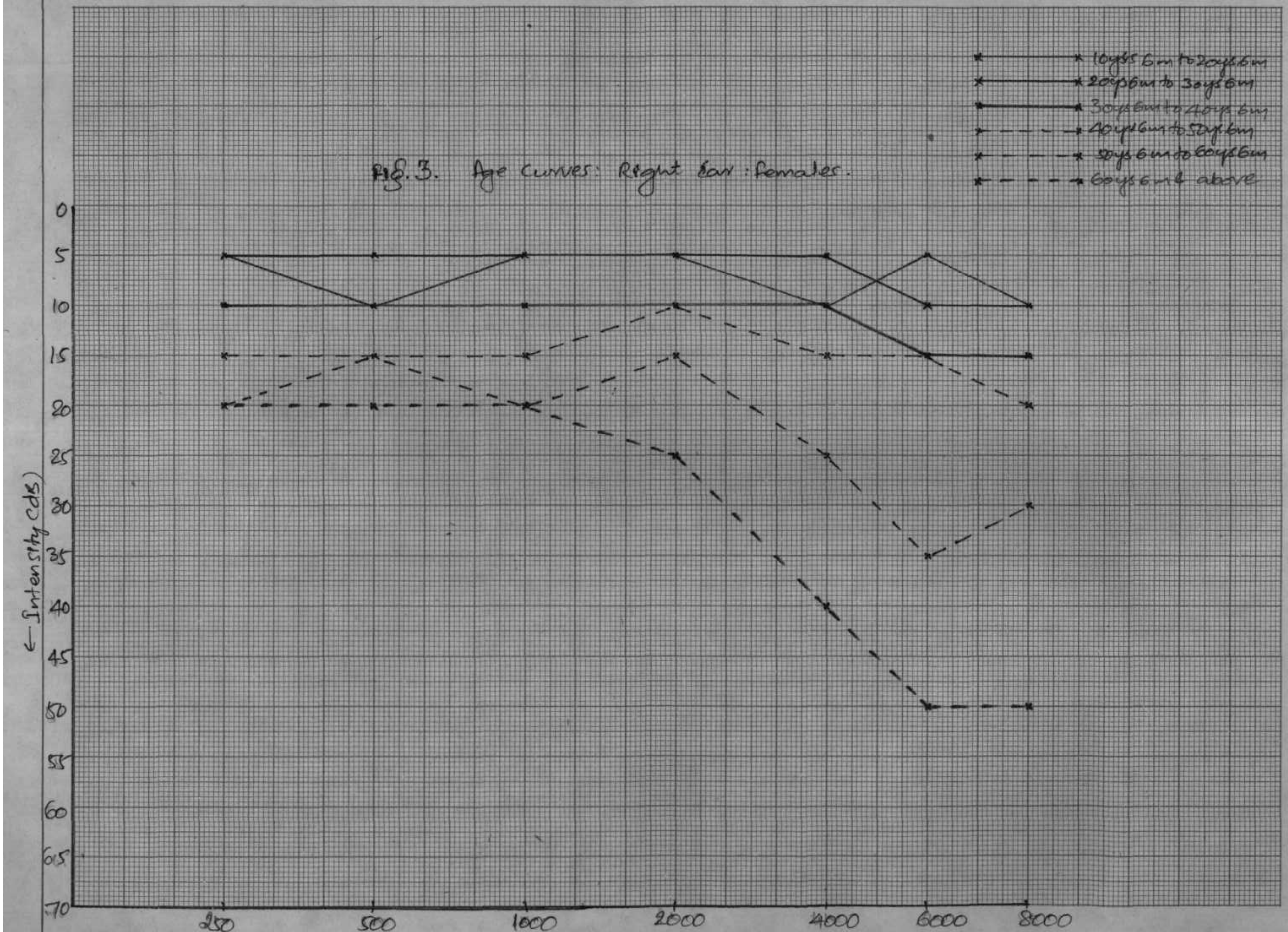


Fig. 2. Age Curves : Left Ear . Males .
10yrs6m to 20yrs6m
20yrs6m to 30yrs6m
30yrs6m to 40yrs6m
40yrs6m to 50yrs6m
50yrs6m to 60yrs6m
60yrs6m & above
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Intensity (dB)
250
500
1000
2000
4000
6000
8000

Rt Ear Female



Lt Ear Females

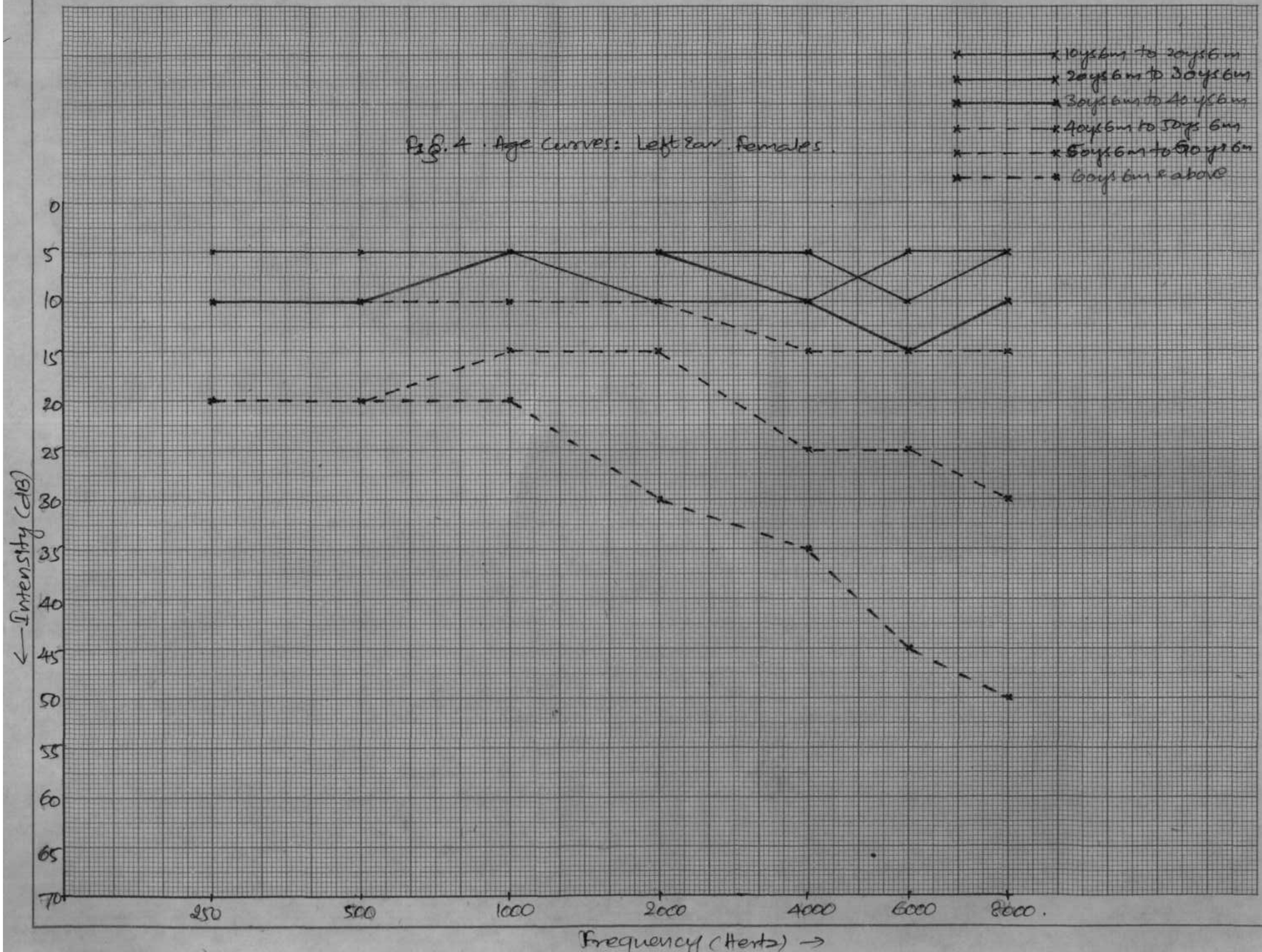


Fig. 4 . Age Curves: Left Ear. Females.

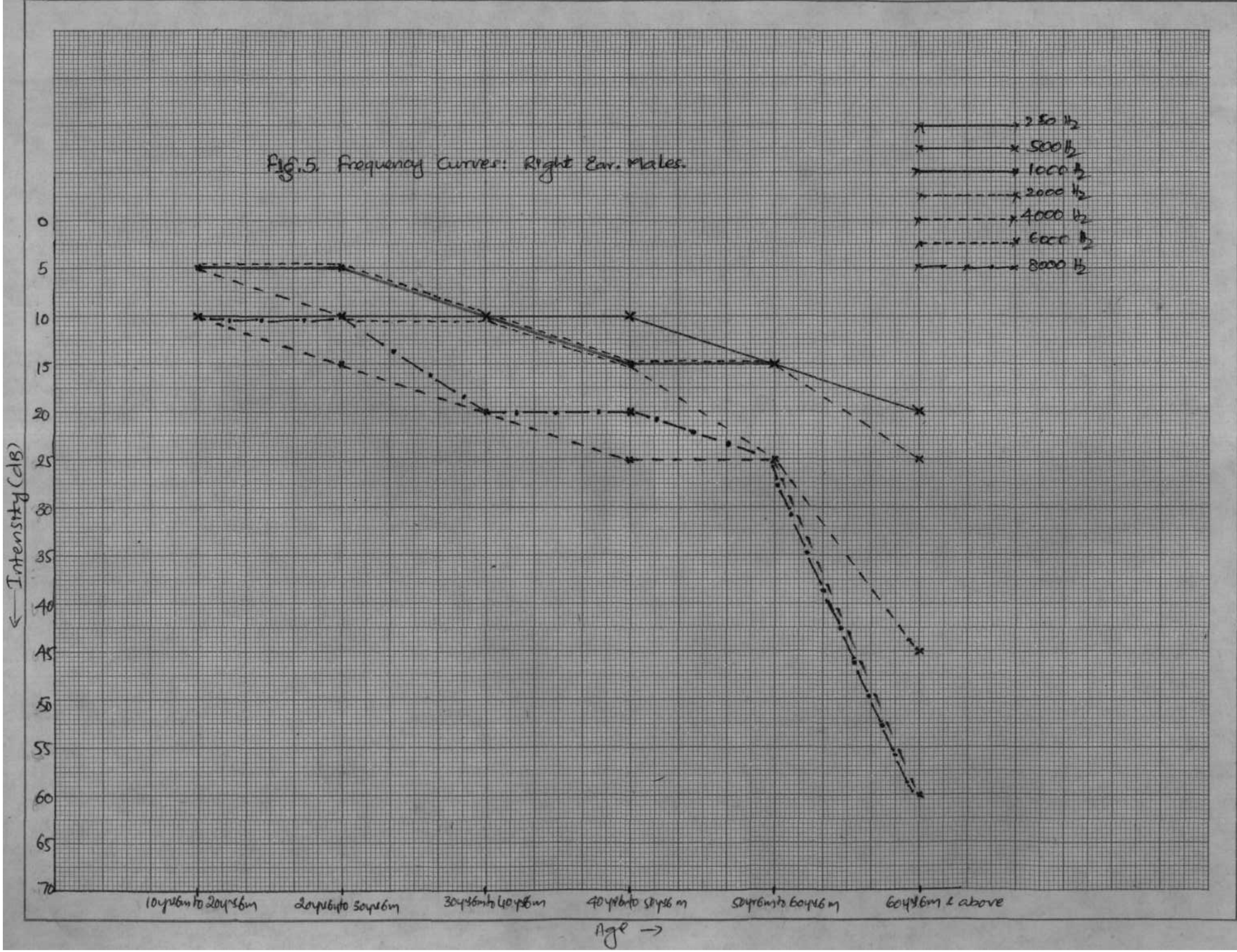
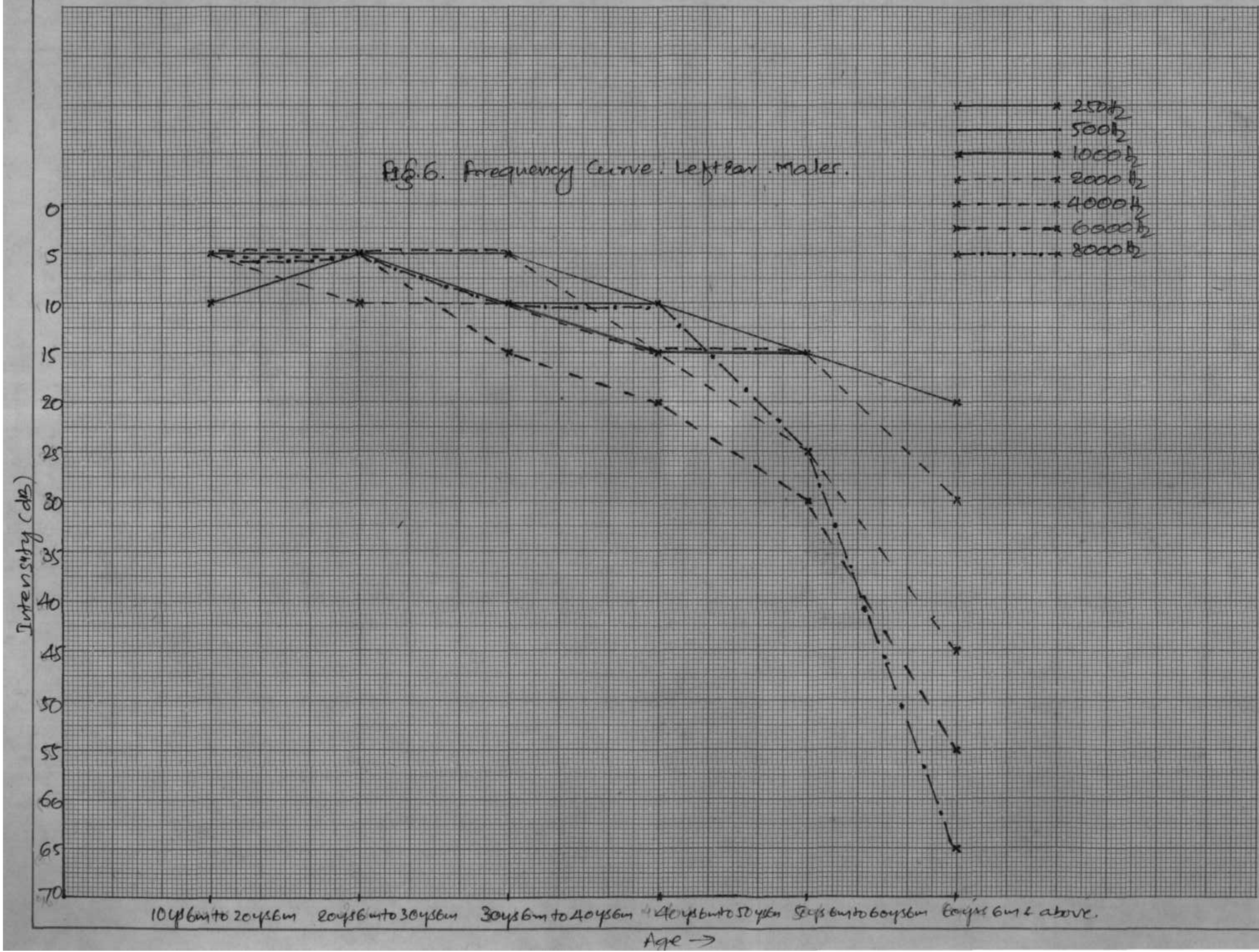


fig.5. Frequency Curves: Right Ear. Males.
250 Hz
500 Hz
1000 Hz
2000 Hz
4000 Hz
6000 Hz
8000 Hz
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Intensity (dB)
10yrs 6m to 20yrs 6m
20yrs 6m to 30yrs 6m
30yrs 6m to 40yrs 6m
40yrs 6m to 50yrs 6m
50yrs 6m to 60yrs 6m
60yrs 6m & above
Age →

Fig.6. Frequency Curve: Left Ear. Males.



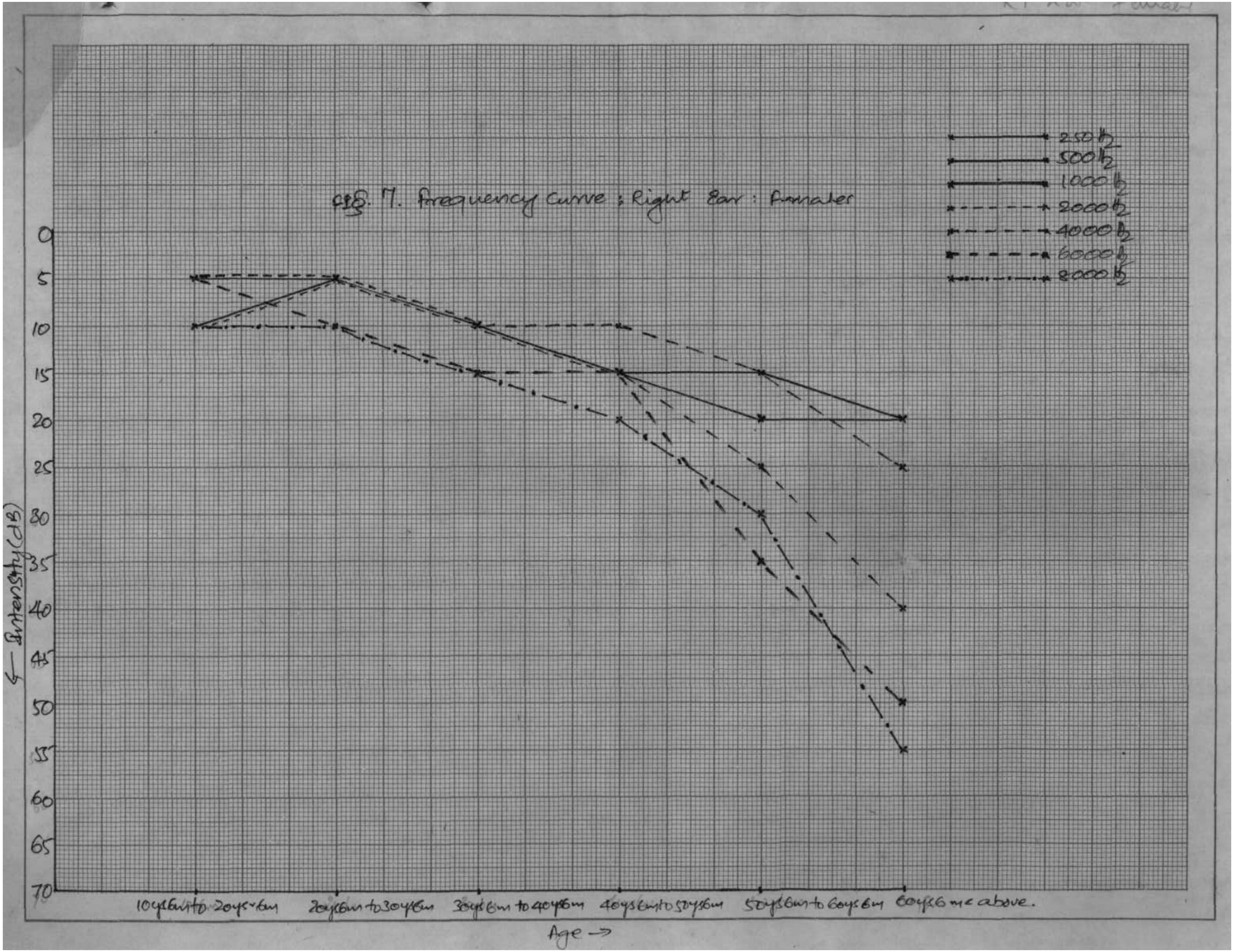
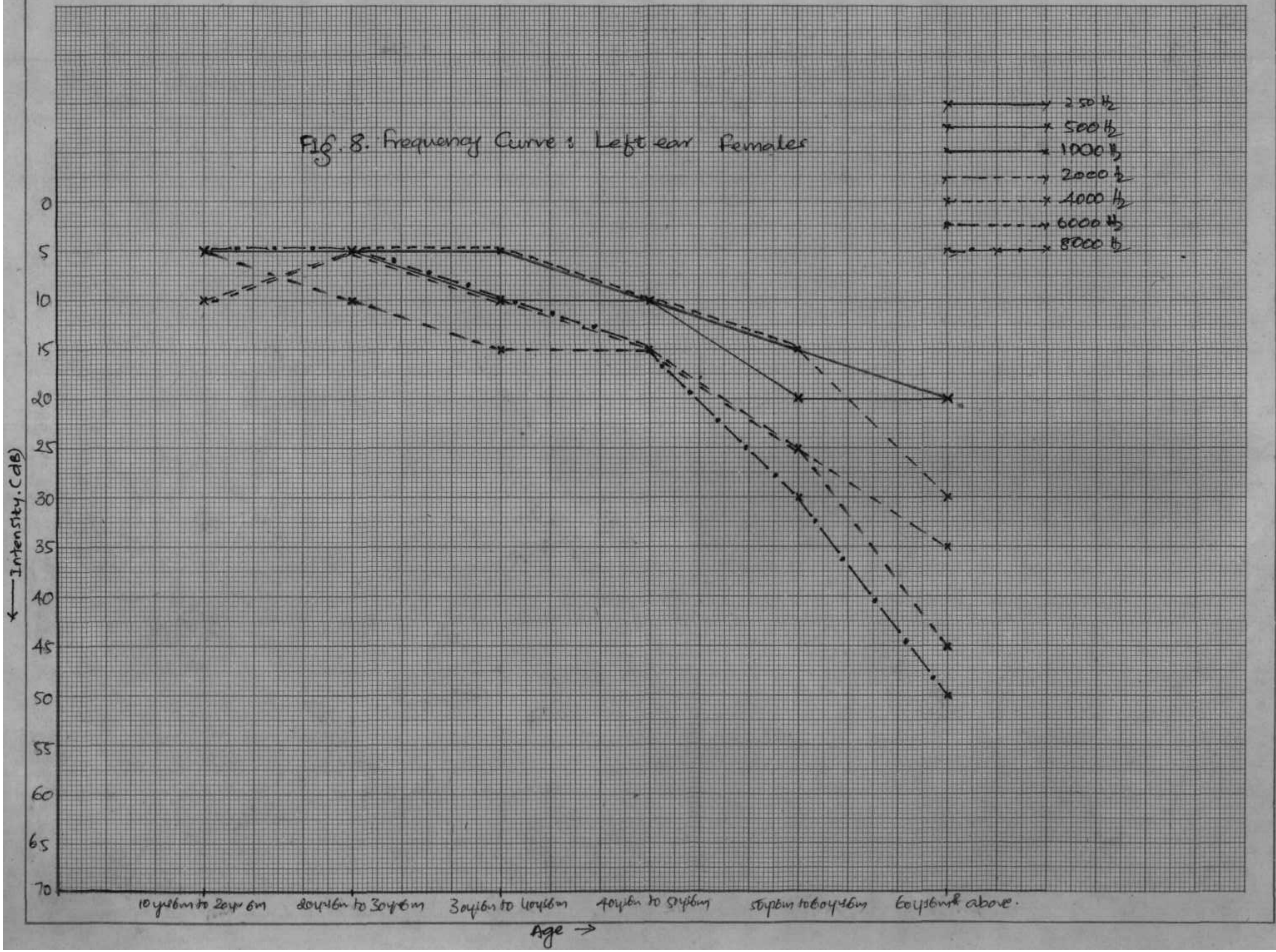


Fig. 7. Frequency Curve : Right Ear : Females
250 Hz
500 Hz
1000 Hz
2000 Hz
4000 Hz
6000 Hz
8000 Hz
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Intensity (dB)
10yrs 6m to 20yrs 6m
20yrs 6m to 30yrs 6m
30yrs 6m to 40yrs 6m
40yrs 6m to 50yrs 6m
50yrs 6m to 60yrs 6m
60yrs 6m & above.
Age

Fig. 8. Frequency Curve : Left ear Females



	10y 6m- 20y 6m.	20y 6m- 30y 6m.	30y 6m- 40y 6m.	40y 6m- 50y 6m.	50y 6m- 60y 6m.	60y 6m- & above
250 Hz						
Mean	8.66	8.33	11.00	13.00	14.33	22.66
Median	10.00	10.00	10.00	10.00	15.00	20.00
SD	4.42	5.23	8.28	8.19	7.76	11.32
500 Hz						
Mean	9.33	8.66	10.66	14.00	14.00	23.66
Median	10.00	10.00	10.00	10.00	15.00	20.00
SD	3.20	6.40	5.93	6.86	6.32	16.02
1000						
Mean	7.33	6.66	11.66	12.33	15.66	24.33
Median	5.00	5.00	10.00	15.00	15.00	20.00
SD	2.58	5.87	6.98	7.53	5.30	13.74
2000						
Mean	6.33	4.33	11.33	14.00	16.66	26.33
Median	5.00	5.00	10.00	15.00	15.00	25.00
SD	4.80	6.51	5.16	7.60	9.57	11.09

Table I (contd.)

4000 Hz						
Mean	7.00	8.66	13.33	16.33	27.66	46.00
Median	5.00	10.00	10.00	15.00	25.00	45.00
SD	5.27	6.93	12.50	6.93	10.50	14.90
6000 Hz						
Mean	10.00	12.33	17.33	23.00	26.66	51.66
Median	10.00	15.00	20.00	25.00	25.00	60.00
SD	6.81	7.76	9.61	9.22	13.84	14.22
8000 Hz						
Mean	10.33	9.33	18.33	17.00	27.00	59.00
Median	10.00	10.00	20.00	20.00	25.00	60.00
SD	6.11	8.00	12.77	8.82	13.86	19.56

TABLE I: Mean, Median and Standard Deviation scores at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 6000 Hz and 8000 Hz for Right Ear of Males of all age groups.

	10y 6m- 20y 6m.	20y 6m- 30y 6m.	30y 6m- 40y 6m.	40y 6m- 50y 6m.	50y 6m- 60y 6m	60y 6m- & above
250 Hz						
Mean	7.00	5.33	9.00	10.00	13.66	19.00
Median	5.00	5.00	5.00	10.00	15.00	20.00
SD	4.14	5.16	8.06	4.63	5.50	11.83
500 Hz						
Mean	8.33	7.33	9.33	10.33	13.00	21.66
Median	10.00	5.00	10.00	10.00	15.00	20.00
SD	3.62	5.30	6.23	5.50	4.14	8.80
1000 Hz						
Mean	8.33	6.00	9.66	12.00	14.00	23.66
Median	10.00	5.00	10.00	15.00	15.00	20.00
SD	3.62	4.30	5.50	6.76	6.60	11.56
2000 Hz						
Mean	6.00	3.33	8.33	14.33	14.33	29.00
Median	5.00	5.00	5.00	15.00	15.00	30.00
SD	7.12	6.45	7.24	7.04	6.23	12.56

Table 2(contd.)

4000 Hz						
Mean	6.33	9.00	15.66	16.66	23.33	47.66
Median	5.00	10.00	10.00	15.00	25.00	45.00
SD	6.67	6.03	11.00	9.76	10.63	14.76
6000 Hz						
Mean	7.33	9.00	17.33	21.33	29.33	54.00
Median	5.00	5.00	15.00	20.00	30.00	55.00
SD	6.23	7.60	11.32	14.20	11.78	14.42
8000 Hz						
Mean	3.66	6.33	16.66	13.00	25.33	56.66
Median	5.00	5.00	10.00	10.00	20.00	65.00
SD	6.11	7.90	14.35	8.41	9.90	20.15

TABLE 2 : Mean, Median and Standard Deviation scores at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 6000 Hz, 8000 Hz for Left ear of Males of all age groups.

	10y 6m- 20y 6m.	20y 6m- 30y 6m.	30y 6m- 40y 6m.	40y 6m- 50y 6m.	50y 6m- 60y 6m.	60y 6m- & above
250 Hz						
Mean	8.00	7.00	12.66	15.33	20.00	20.33
Median	5.00	5.00	10.00	15.00	20.00	20.00
SD	6.49	6.49	4.16	8.33	7.55	9.15
500 Hz						
Mean	8.00	6.00	10.00	14.00	18.66	20.66
Median	10.00	5.00	10.00	15.00	15.00	20.00
SD	4.55	5.07	6.26	6.86	6 .11	8.63
1000 Hz						
Mean	6.66	6.33	10.00	13.33	18.33	21.00
Median	5.00	5.00	10.00	15.00	20.00	20.00
SD	4.87	3.51	5.34	6.98	9.19	10.21
2000 Hz						
Mean	7.33	5.66	8.66	11.66	16.33	28.66
Median	5.00	5.00	10.00	10.00	15.00	25.00
SD	5.30	5.30	4.80	5.23	7.66	10.60

Table 3. (contd.)

4000 Hz						
Mean	9.66	3.66	12.00	12.66	28.00	37.66
Median	10.00	5.00	10.00	15.00	25.00	40.00
SD	6.67	5.50	7.74	4.95	15.90	12.65
6000 Hz						
Mean	7.00	9.00	13.66	14.33	34.66	46.66
Median	5.00	10.00	15.00	15.00	35.00	50.00
SD	10.98	9.48	6.11	9.61	19.22	14.59
8000 Hz						
Mean	8.66	7.66	14.33	19.00	35.33	49.33
Median	10.00	10.00	15.00	20.00	30.00	50.00
SD	7.43	7.28	6.22	10.88	24.96	17.61

TABLE 3: Mean, Median and Standard Deviation scores at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 6000 Hz, 8000 Hz for Right Ear Females of all age groups.

	10y 6m- 20y 6m.	20y 6m- 30y 6m.	30y 6m- 40y 6m.	40y 6m- 50y 6m.	50y 6m- 60y 6m.	60y 6m- & above
250 Hz						
Mean	5.33	5.33	10.00	12.00	21.33	19.33
Median	5.00	5.00	10.00	10.00	20.00	20.00
SD	4.42	4.80	6.55	9.19	11.87	7.28
500 Hz						
Mean	7.00	5.66	9.66	11.66	20.66	20.00
Median	5.00	5.00	10.00	10.00	20.00	20.00
SD	4.14	4.57	5.50	7.71	7.28	8.01
1000 Hz						
Mean	5.66	5.00	7.66	10.66	17.66	23.00
Median	5.00	5.00	5.00	10.00	15.00	20.00
SD	3.72	5.00	4.57	5.63	11.15	11.14
2000 Hz						
Mean	8.00	3.33	6.00	11.33	15.33	29.66
Median	10.00	5.00	5.00	10.00	15.00	30.00
SD	5.92	6.21	4.31	7.43	9.15	11.41

Table 4. (Contd.)

4000 Hz						
Mean	7.33	5.00	11.66	12.00	30.66	41.00
Median	10.00	5.00	10.00	15.00	25.00	35.00
SD	8.21	5.67	6.45	5.28	17.81	15.50
6000 Hz						
Mean	7.00	7.00	13.66	14.66	33.00	46.33
Median	5.00	10.00	15.00	15.00	25.00	45.00
SD	8.41	7.74	6.40	10.26	21.61	18.27
8000 Hz						
Mean	7.00	5.00	11.66	16.00	35.33	47.66
Median	5.00	5.00	10.00	15.00	30.00	50.00
SD	5.28	7.56	5.87	12.42	23.18	18.88

TABLE 4: Mean,Median and Standard Deviation scores at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 6000 Hz,and 8000 Hz for Left ear of Females of all age groups.

TABLE 5: : Results of two way analysis of analysis of variance for the main effects of age, sex, and their interaction effects for Right Ear at 250 Hz & 500 Hz.

250 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio.
Sex	1	35.66	35.66	0.42
Age	5	4241.11	848.22	10.12*
Sex and age	5	324.44	64.88	0.77
Error	169	14164.45	83.81	

500 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	8.88	8.88	0.19
Age	5	4653.33	930.66	20.25*
Sex X age	5	316.12	63.22	1.37
Error	169	7766.67	45.95	

* Significant at 0.01 level.

TABLE 6 : Results of Two Way analysis of variance for the main effects of age, sex and their interaction effects for Right Ear at 1000 Hz to 2000 Hz.

1000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	6.81	6.81	0.12
Age	5	5765.70	1153.14	20.58*
Sex X age	5	162.35	32.47	0.57
Error	169	9469.34	56.03	

2000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	0.55	0.55	0.01
Age	5	10004.44	2000.88	37.58*
Sex X age	5	156.12	31.224	0.58
Error	169	8996.67	53.23	

* Significant at 0.01 level

TABLE 7: Results of Two Way analysis of variance for the main effects of age, sex and their interaction effects for Right Ear at 4000 Hz and 6000 Hz.

4000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	293.89	293.89	2.99
Age	6	28111.11	5622.22	57.28*
Sex X age	5	582.78	116.55	1.18
Error	169	16586 .67	98.14	

6000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	306.81	306.81	2.31
Age	6	35309.03	7061.80	53.24*
Sex X age	5	1175.69	235.14	1.77
Error	169	22416.67	132.64	

* Significant at 0.01 level.

TABLE 8 : Results of Two Way analysis of variance for the main effects of age, sex and their interaction effects for Right Ear at 8000 Hz.

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	55.56	55.56	0.31
Age	5	44999.45	8999.89	51.22*
Sex X age	5	1291.10	258.22	1.47
Error	169	29693.34	175.70	

* Significant at 0.01 level

TABLE 9: Results of Two Way analysis of variance for the main effects of age, sex and their interaction effects for left ear at 250 Hz.

250 Hz.

Source of variation	df	Sum of squares	Mean sum of squares	F. Ratio
Sex	1	108.89	108.89	2.03
Age	5	4964.45	992.82	18.52*
Sex X age	5	391.11	78.22	1.46
Error	169	9060.00	53.60	

TABLE 10 : Results of One Way analysis of variance for
'A' the main effects of age on hearing acuity in left ear for males and females at 500 Hz.

MALES

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	5	2083.33	416.66	12.21*
Within	84	2866.67	34.12	

3/4 3/4

FEMALES

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	5	3128.89	625.77	15.31*
Within	84	3433.34	40.87	

'B' Showing the obtained 't' values for the main effect of sex on hearing acuity left ear for all age groups.

Age group	't' value
10 years 6 months - 20 years 6 months	0.93
20 years 6 months - 30 years 6 months	0.92
30 years 6 months - 40 years 6 months	0.15
40 years 6 months - 50 years 6 months	0.54
50 years 6 months - 60 years 6 months	3.54*
60 years & above	0.54

* Significant at 0.01 level

TABLE 11: Results of Two Way analysis of variance for the main effects of age, sex, and their interaction effects for Left ear at 1000 Hz and 2000 Hz.

1000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	13.88	13.88	0.27
Age	5	6738.33	1347.66	26.50*
Sex X age	5	234.45	46.89	0.92
Error	169	8593.34	50.84	

2000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	3.47	3.47	0.05
Age	5	12947.91	2589.58	39.48*
Sex X Age	5	145.70	29.14	0.44
Error	169	10576.67	65.58	

* Significant at 0.01 level

TABLE 12: Results of Two Way analysis of variance for the main effects of age, sex and their interaction effects for Left Ear at 4000 Hz and 6000 Hz.

4000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	151.25	151.25	1.34
Age	5	31614.83	6322.96	56.37*
Sex X Age	5	818.78	163.75	1.46
Error	169	18956.67	112.10	

6000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	347.22	347.22	2.26
Age	5	40530.00	8106.00	52.86*
Sex X age	5	659.44	131.88	0.86
Error	169	25913.34	153.33	

* Significant at 0.01 level

TABL3 13: Results of Thro Way analysis of variance for the main effects of age, sex, and their interaction effects for Left ear at 8000 Hz.

8000 Hz

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Sex	1	1.25	1.25	
Age	5	48765.69	9753.13	57.47*
Sex X age	5	1707.92	341.58	2.01
Error	169	28676.97	169.68	

* Significant at 0.01 level

TABLE 14: Results of One Way analysis of variance for the effects of frequency in Right Ear of Males of 10y 6m to 20y 6m and 20y 6m to 30y 6m.

10y 6m to 20y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	219.05	36.62	1.49
Within	98	2396.67	24.45	

20y 6m to 30y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	540.00	90.00	1.98
Within	98	4443.34	45.34	

Visvesvaraya Technological University.
Belgaum.

A Seminar Report on

"Control Area Network"

Submitted in partial fulfillment of the requirement for the award of degree of ***8 sem B.E*** *in Computer-Science & Engineering*

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TABLE 16: Results of One Way analysis of variance for the effects of frequency in Right Ear of Males of 50y 6m to 60y 6m and 60y 6m and above.

80y 50y 6m to 60y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	3744.76	634.12	6.11
Within	98	9996.67	102.00	

60y 6m and above

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	21502.38	3583.73	18.16*
Within	98	19336.67	197.31	

* Significant at 0.01 level

TABLE 17: Results of One Way analysis of variance for the effects of frequency in Left Ear Males of 10y 6m to 20y 6m and 20y 6m to 30y 6m

10 6 m to 20y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	234.56	39.12	1.27
Within	98	3006.67	30.68	

20y 6m to 30y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	371.42	61.90	1.59
Within	98	3803.34	38.80	

TABLE 18: Results of One Way analysis of variance for the effects of frequency in Left Ear of Males of 30y 6m to 40y 6m and 40y 6m to 50y 6m

30y 6m to 40y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	1471.43	245.23	2.67
Within	98	8980.00	91.63	

40y 6m to 50y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	1431.43	238.57	3.24
Within	98	7203.34	73.50	

TABLE 19: Results of One Way analysis of variance for the effects of frequency in Left Ear of Males of 50y 6m to 60y 6m and 60y 6m and above.

50y 6m to 60y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	4153.33	692.22	10.09*
Within	98	6716.67	68.54	

60y 6m and above

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	23741.42	3956.90	20.66*
Within	98	18763.34	191.46	

* Significant at 0.01 level

TABLE 20: Results of One Way analysis of variance for the effects of frequency in the Right Ear of females of 10y 6m to 20y 6m and 20y 6m to 30y 6m.

10y 6m to 20y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	95.71	15.95	0.33
Within	98	4693.34	47.89	

20y 6m to 30y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	252.86	42.14	1.04
Within	98		40.23	

TABLE 21: Results of One Way analysis of variance for the effects of frequency in the Right Ear of females of 30y 6m to 40y 6m and 40y 6m to 50y 6m

30y 6m to 40y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	401.43	66.90	1.91
Within	98	3423.34	34.93	

40y 6m to 50y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	506.67	84.44	1.38
Within	98	5996.67	61.19	

TABLE 22: Results of One Way analysis of variance for the effects of frequency in the Right Ear of females of 50y 6m to 60y 6m and 60y 6m and above.

50y 6m to 60y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	5879.52	970.47	4.57*
Within	98	20766.67	212.28	

60y 6m and above

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	14164.76	2360.79	15.61*
Within	98	14820.00	151.22	

* Significant at 0.01 level

TABLE 23: Results of One Way analysis of variance for the effects of frequency in the Left Ear of females of 10yrs. 6m to 20yrs. 6m and 20y 6m to 30y 6m

10y 6m to 20y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	79.05	13.17	0.36
Within	98	3520.00	35.91	

20y 6m to 30y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	106.20	17.70	0.47
Within	98	3565.00	37.14	

TABLE 24: Results of One Way analysis of variance for the effects of frequency in the Left Ear of females of 30y 6m to 40y 6m and 40y 6m to 50y 6m

30y 6m to 40y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	608.10	101.35	3.08
Within	98	3216.67	32.83	

40y 6m to 50y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	341.43	56.90	0.79
Within	98	7013.34	71.S6	

TABLE 25: Results of One Way analysis of variance for the effects of frequency in the Left Ear of females of 50y 6m to 60y 6m and 60y 6m and above.

50y 6m to 60y 6m

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	5594.77	932.46	3.31
Within	98	23980.00	244.69	

60y 6m and above

Source of variation	df	Sum of squares	Mean sum of squares	F Ratio
Among	6	13822.37	2303.72	12.38*
Within	98	18233.34	186.05	

*Significant at 0.01 level

TABLE 26 : Showing the obtained 't' values for ear difference for Males across frequencies.

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	6000 Hz	8000 Hz
10y 6m - 20y 6m	1.22	0.90	1.14	0.23	0.35	1.29	4.33
20y 6m - 30y 6m	2.36	1.02	0.60	0.99	0.20	1.92	1.53
30y 6m - 40y 6m	0.92	0.73	1.06	1.87	2.26	0.00	0.34
40y 6m - 50y 6m	2.05	4.26	0.27	0.31	0.17	0.48	1.98
50y 6m - 60y 6m	0.68	1.12	1.07	1.07	1.25	1.13	0.58
60y 6m and above	2.22	0.54	0.25	0.98	0.46	0.67	0.54

TABLE 27: Showing the obtained 't' values for ear difference for Females across frequencies.

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	6000 Hz	8000 Hz
10y 6m - 20y 6m	2.08	0.89	0.74	0.46	1.04	0.00	0.80
20y 6m - 30y 6m	1.83	1.10	1.28	1.04	2.31	1.18	0.18
30y 6m - 40y 6m	1.65	0.29	1.96	1.69	0.12	0.00	3.14
40y 6m - 50y 6m	1.40	1.00	1.18	0.20	0.67	0.19	1.44
50y 6m - 60y 6m	0.51	1.01	0.32	0.75	0.75	0.47	0.00
60y 6m and above	0.62	0.42	1.15	0.43	1.24	0.05	0.58

Expected 't' values at .05 and .01 levels of significanee are
2.14 and 2.98 respectively.

CHAPTER V

DISCUSSION

The present study results are discussed along the following lines:

Effect of Ape

The results obtained in the present study revealed an increase in hearing thresholds with age in both men and women. The onset of hearing loss (greater than 25 dB), as a function of age occurred in the 5th decade of life for both men and women.

The elevation of hearing thresholds was gradual upto 4th decade, in both men and women. But the threshold elevation was marked, about 12 dB, between 4th and 5th decade in women, and between the 5th and 6th decade in men.

A comparison of the present study data with that of Corso (1963) study, shows better hearing acuity at all frequencies in the subjects of the present study. The difference in the mean thresholds for the two groups, was most marked for the lower age groups compared to the older age groups. The mean difference was negligible in the oldest age group in the two studies.

A difference in the onset of loss between the two studies was observed. In contrast to the present study, the onset of loss reported in Corso's (1963) study, was in the 3rd decade.

The above mentioned differences between the two studies may be attributed to the differences in the reference standards, type of earphones, the age grouping and the selection criteria employed in the two studies.

The standards employed in the present study was ANSI (1969), and in Corso's (1963) study was ASA (1951). The mean threshold difference obtained between the two groups, may in part be due to the differences in the reference level.

A superficial analysis of the data, after the conversion of the mean scores into ASA values, revealed poorer hearing thresholds in the subjects of the present study at mid-frequencies and better hearing thresholds at higher frequencies, when Compared with Corso's (1963) study. On the other hand, when the mean scores in the two studies were directly compared, better hearing thresholds were observed at all the frequencies. Thus, the latter findings point out that the differences obtained between the two studies can partially be atti attributed to the differences in the reference zero levels employed in the two studies. Added to this, the earphone used in the present study was TDH - 39 whereas the earphones used by Corso (1963) was PDR - 8. This difference also might have contributed to the discrepancy obtained in the two studies.

In Corso's (1963) study, noise exposure to stimuli such as Pop-music or rock-n-roll music has not been accounted for in the criteria used for the selection of subjects. Exposure to rock-n-roll music has been reported to result in hearing loss (Lipscomb 1969; 1972; Ulrich & Pinheiro 1974). Majority of the youth of the U.S. population are exposed to such music and therefore this factor has most relevance while establishing hearing thresholds values. Thus, the above mentioned factor might be one of the probable reasons for the poorer hearing in the younger subjects of Corso's (1963) study.

The stresses to which the U.S. people are subjected to, are more compared to the Indians. Excessive stress has been reported to result in various cardiovascular affections in turn, have been found to have a detrimental effect on hearing acuity (Rosen and Rosen 1971; Hansen 1968, Drettner et al 1975). Thus, more stress expericenced by U.S. population may also be one reason for the differences in the threshold values obtained in the two studies.

The increase in the hearing level with age was about 15 d3 in Corso's (1963) study, whereas in the present study, it was about 30 dB. This difference may be because of the inclusion of subjects older than 65 years in the present study.

The upper age limit in Corso's (1963) study was 65 years, whereas it was 89 years in the present study. Thus, the mean threshold values in the oldest age group of the present study, thereby increase the range. The study conducted by Goetzinger et al (1961) support the above contention.

In Goetzinger et al (1961) study, the mean hearing threshold for subjects between the ages of 60 years to 89 years was about 21.7 dS. A progression in the hearing acuity was observed in the subjects with increase in age. The U.S. National Health Survey (1958) also has reported, a marked increase in hearing level in subjects above 61 years. These studies, provide one explanation for the differences obtained in the two studies.

Comparison of the present study with Seth and Backer's (1971) study also reveal better thresholds for the subjects in the present study, for the mid age groups. In the young and older age groups, the thresholds obtained in Seth and Backer's (1971) study was better compared to the present study. The possible explanation for the above findings, is the majority of the subjects above 60 years were selected from a home for the aged in Mysore. These subjects were afflicted with some disease or the other. The most common disease was asthma. In addition some subjects complained of a mild problem in following speech, and a mild fluctuating hearing loss. Therefore,these factors might be responsible for the poorer hearing thresholds obtained in the aged subjects. The poorer thresholds obtained for the middle-aged subjects in Seth and Kacker (1971) study may be attributed to possible inclusion of subjects with noise exposure, as the subjects were not screened for noise exposure. In addition the sample was also not screened for ototoxicity. So all these factors might have contaminated the results of Seth and Kacker's study (Seth & Kacker 1971).

Punnan (1976) study also revealed a deterioration in hearing acuity with age. This finding is in agreement with the present study findings.

Sex difference

A deterioration in the hearing acuity with age was manifested by both men and women. A statistically significant sex difference for the main effects of age was not observed. But a slight trend towards, better hearing in women compared to men for mid and high frequencies (1000 Hz and above was observed. At the lowest frequency (250 Hz) the mean thresholds for females was poorer compared to males.

The onset of hearing loss in males and females was in the 5th decade. The progression of loss was similar in both males and females upto the 4th decade.

The females showed a marked increase in threshold between the 4th and 5th decade, whereas the males showed a marked shift in the threshold between the 5th and the 6th decade.

The changes in the hearing acuity from the youngets to the oldest age group was about 21.9dB in males and 24.5 dB in females. Thus, the changes in hearing acuity was slightly more in females.

The hearing thresholds was slightly poorer in males in all the age groups except in the 50 years 6 months to 60 years 6 months group. In this group, the females had poorer thresholds compared to males, by about 5 d3. This trend was observed across all the frequencies.

In males and females of all age groups, the poorest thresholds were observed at 6000 Hz.

In contrast to the present study, Corso (1963), found a significant sex difference in his study of U.S. subjects age ranging from 18 years to 64 years. The hearing acuity in women was found to be more acute compared to that of men, except in the 51 years to to 57 years and 59 yaars to 65 years age gro-ups.

In these groups the women showed poorer hearing compared to men only in the low frequencies. This finding, in part supports the findings of the present study, wherein the women of 50 years 6 months to 60 years 6 months age group manifest poorer hearing compared to men.

In Corso (1963) study, the differences between the two sexes was most marked at high frequencies. The present study results also partly agrees with the above findings, as the maximum mean differences between the hearing thresholds for men and women was observed above 2000 Hz. But this mean difference was not statistically significant in the present study.

The onset of hearing loss was in the 3rd decade for men and women but was about 5 years earlier in men compared to women. Differences in the rate of progression has been reported to be faster and uniformly distributed as a function of age. The deterioration in hearing in Corso's (1963) study, seemed to occur stepwise. These findings contrast the findings of the present study. Probable reasoning is the differences in the age groupings of these studies.

The differential frequency effect was observed in the 3rd decade for both men and women in Corso's(1963) study. The present study also revealed similar findings.

The differences were more marked in the younger and middle age groups compared to the older age groups, between the oldest age groups of the two studies was negligible. (1.01 and 2.33 respectively).

The differences between the two studies is partly attributable to the difference in the standards employed by the two studies. On converting the mean scores to ASA standards for each age group at each frequency, slight sex differences were evident. The hearing thresholds of the male subjects in this study was poorer than the male subjects of Corso's (1963) study at mid frequencies, but was better at frequencies above 4000 Hz. In contrast; the hearing thresholds in women were poorer to the women subjects of Corso's (1963) study, even at high frequencies. Therefore the differences in the standards may have contributed to the discrepancy between the two studies. In addition to this, the already mentioned factors, like difference in earphones and difference may all have contributed to this discrepancy. The greater noise exposure in U.S. women contribute to the poorer hearing observed in U.S. women.

In contrast to Corso's (1963) study, and in support of the present study, Goetzinger et al (1961) have also reported of an absence of significant sex difference in the hearing acuity of subjects whose age ranged from 60 years to 89 years.

Sex difference in hearing acuity has been reported in Todas, a primitive tribe in residing in the hilly regions of Nilgiris in India. The female Todas were found to have better hearing compared to male Todas (Kapur & Patt 1967).

Apart from this one study, data concerning sex difference, in hearing acuity in Indians is not available. The data reported by Kapur and Patt (1967) cannot be generalized as the study has certain limitations, which are brought out in Chapter II.

Effect of frequency

A significant frequency effect on the hearing acuity was observed in the older age groups. The differential frequency effect occurred in the 3rd decade of life for both males and females, but reached prominence only in the 4th decade. This finding is in agreement with the findings of Corso's (1963) study, wherein the differential frequency effect occurred at the age of 32 years in men and at 37 years in women.

The degree of hearing impairment with age was more at high frequencies compared to the two frequencies in both men and women. This finding is in agreement with findings of several other studies (Corso, 1963; Goetzinger (1961). Seth and Kacker 1971, Punnan 1976).

In Corso's (1963) study, the hearing acuity was within 20 dB at low frequencies (250 Hz, 500 Hz, 1000 Hz and 1500 Hz) even in the oldest age group.

The results in the present study varies slightly from Corso's (1963) findings. Here the thresholds were within 20 dB at all frequencies in 4th decade for males and females, but in the 50 years 6 months to 60 years 6 months age group the thresholds were within 20 dB at frequencies lower than 1000 Hz. In the oldest age group, that is 60 years and 6 months to 89 years at 500 Hz itself the threshold was above 20 dB. This implies, that the onset of hearing loss as a function of age is frequency dependent. Feldman and Reger's (1967) study support the above contention. In their study of subjects of age 20 years to 29 years and 50 years to 89 years, they found a high frequency loss in the 50 years to 89 years age group. In the age group of 70 years and above,moderate loss with slight involvement of low frequencies was observed and beyond 80 years, an involvement of all the frequencies was reported.

Corso (1963) study revealed the loss at 1000 Hz was found to be similar for men and women, but at frequencies above 1000 Hz, the males showed more loss compared to females.

Hinchcliffe (1959) also found the hearing of women of 18 years to 54 years of age, to be better than men, at frequencies 3000 Hz, 4000 Hz and 6000 Hz. In the older women, the difference was significant even at 2000 and 8000 Hz.

In the present study, also, the hearing for high frequencies was found to be slightly poorer in males compared to females. But this difference was not found to be statistically significant.

The increase in hearing level with age was found to be more for high frequencies compared to the low frequencies. In the present study the increase in hearing threshold with age was about dB, at 250 Hz whereas it was dB at 8000Hz. Studies along these lines have reported of similar findings. Glorig et al (1957) found a 3 dB increase in the median threshold at 500 Hz. In Corso's (1963) study the increase in hearing level at 250 Hz was 2 dB and at 8000 Hz was 10 dB. The elevation of thresholds with age at 260 Hz and 8000 Hz was greater in the present study. This again may be due to the inclusion of very aged people in the pldest age group of the study which might have shifted the mean threshold substantially.

Ear difference:

In the present study, the ear difference was not found to be statistically significant. This finding is in agreement with Corso's (1963) study. But studies of Goetzinger et al (1961), Glorig et al (1957) revealed a significant ear difference, the left ear being poorer compared to right ear.

Though an overall ear difference was not found to be significant, some differencies in the two ears was observed in certain instances. At 500 Hz, the results of the two-way ANOVA in the left ear was deviant from the right ear findings. The sex by age interaction was found to be significant at this frequency. On further analysis, only the50 years 6 months to 60 years 6 months age group manifested significant sex difference. The reason for this finding could not be worked out, from the available literature. Probably this is a unique finding, as is the case of 'Bevero effect' observed by Carhart ( ), which needs to be further investigated.

Apart from this one more difference seen in the performance of two ears was, the 50 yeara 6 months to 60 years 6 months aged women in this study, manifested poorer hearing compared to males. A similar finding has been reported by Corso (1963), but only at low frequencies and in both ears.

The reason attributed is the sudden shift in hearing threshold in women at this age but reason for the occurrence only in the left ear, is to be computed from carrying out further research, as it could not be reasoned out either from the available literature or from the background history collected for the subjects.

In general the present study results substantiate the findings of Corso's (1963) study. One major difference between the two studies, is the hearing levels for all the age groups and for both males and females were more acute compared to Corso's subjects. These findings, point out that possibly the hearing acuity of Indians is better compared to the U.S. population.

Clinical implications:

The normative data presented for each age group may be used for the estimation of hearing loss in clinical population and in deciding the compensation for the noise induced hearing loss population.

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CHAPTER VI

SUMMARY AND CONCLUSIONS

The present investigation was undertaken to study the age and sex variation, if any, in hearing by air conduction, among a group of subjects of Indian nationality. A sample of 180 subjects of age ranging from 10 years 6 months to 87 years were selected randomly from the general population. The sample was categorized into six age groups: 10 years 6 months to 20 years 6 months; 20 years 6 months to 30 years 6 months; 30 years 6 months to 40 years 6 months; 40 years 6 months to 50 years 6 months; 50 years 6 months to 60 years 6 months and 60 years 6 months and above.

The number of subjects and the sex representation was maintained constant in each age group.

Background information to rule out the history of middle ear pathology, ototoxicity, noise exposure was obtained for each subject, Air conduction pure tone audiometric testing and impedance audiometric testing was done for each subject in a sound treated room. The data was analyzed graphically and statistically.

The results obtained were as follows: The hearing thresholds, increased as a function of age. The sex differences in the hearing acuity was not significant across most age groups and frequencies. In the age group of 50 years 6 months to 60 years 6 months, a significant sex difference was obtained at 500 Hz, only in the left ear. The dependency of hearing acuity on frequency was most marked in the older age groups compared to the younger age groups. The ear difference was not found to be statistically significant. The variability was found to be more at high frequencies and in older age groups.

Conclusions:

The following conclusions can be drawn from the findings of the present study:

1. Significant changes in hearing acuity occurs with age.

2. The prevalence of high frequency loss is greater in the geriatric population.

3. The age related changes in hearing seems to be common for males and females.

4. The hearing acuity changes related to age do not seem to be different for the right and left ears.

Suggestions for further Research

1. Variations in hearing acuity with age,at 125 Hz may be studied.

2. Similar study may be carried out in noise exposed population and compare the findings with the present study.

3. The rate of progression of hearing loss as a function of age and sex may be studied.

4. For age groups beyond 60 years, the progression of loss per decade may be studied.

5. Similar study may be carried out on a larger population.

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APPENDIX 'A'

Name: Age: Sex

Address: Education:

Occupation:

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1. **EAR complaints**
   1) Hearing loss :
   2) Earache :
   3) Ear discharge :
   4) Ear blockage :
   5) Tinnitus
   6) Bleeding from ear :
   7) Other Ear Infection :

II. Vertigo

III. Nausea or vomitting:

IV. Headache :

V. Head Injury :

VI. Infections

a) Cold :

b) Malaria :

c) Mumps :

d) Whooping cough :

e) High Fever with/ without convulsion :

f) Upper Respiratory tract infections:

Appendix 'A' contd.

VII. General diseases

1) Leprosy :

2) Typhoid :

3) Epilepsy :

4) Encephalites :

5) Meningitis :

6) Poliomyelitis :

7) Renal diseases :

8) Diabetis :

9) Syphilis :

10) Myasthenia Gravis:

11) Cardiac problems:

VIII. Drugs **Dosage**

1) Streptomycin :

2) Neomycin :

3) Kanamycin :

4) Aspirin :

5) Others :

IX. Exposure to Noise

a) Workers in Industry :

b) Workers in Railways :

Appendix 'A' contd.

c) Workers in Airlines :

d) Listeners of Music at high intensity :

e) Typists :

f) Weavers :

g) Tailors :

h) Flour Mill workers :

i) Workers in heavy traffic area :

j) Motor garage workers :

k) Drivers in Automobiles :

l) Workers in press :

m) Military personnel:

X. <u>Family history of hearing loss</u>: :

XI. <u>Surgery</u> :

APPENDIX 'B'

Name | Age: | Sex:

Tympanogram: Right | Left

Reflex Thresholds	250	500	1K	2K	4K
Right (Phone) :					
Left (Phone) :					

Pure tone Thresholds	250	500	1K	2K	4K	6K	8K
Right Ear							
Left Ear							

E.N.T Examination:

Blood pressure:

APPENDIX 'C

The procedure adopted for the calibration of the audiometer was as follows:

For the calibration of intensity, the test earphone (TDH - 39) of the audiometer was coupled with an Artificial ear (Bruel & Kjaer Type-4152 with Condenser Microphone Type 4144). This system with preamplifier was then connected to a Audio Frequency Analyzer (Bruel & Kjaer Type 2107). The attenuator dial of the audiometer was set at 70 dB HTL, then the output of the audiometer was checked at each frequency from 250 Hz to 8000 Hz. A correction of -5 dB was applied at 6 KHz with reference to ANSI (1969) standards.

For checking the linearity of the attenuator, the same set up as for intensity calibration was used. Here at frequencies at 500 Hz, 1000 Hz and 4000 Hz, the attenuator dial reading was increased in 5 dB steps and the concomitant SPL reading were noted.

To ensure, the accuracy of the test frequencies, the output of the earphone was fed to a frequency counter (Radart 203) maintaining the intensity at a constant level, the frequencies were sweeped from 250 Hz: through

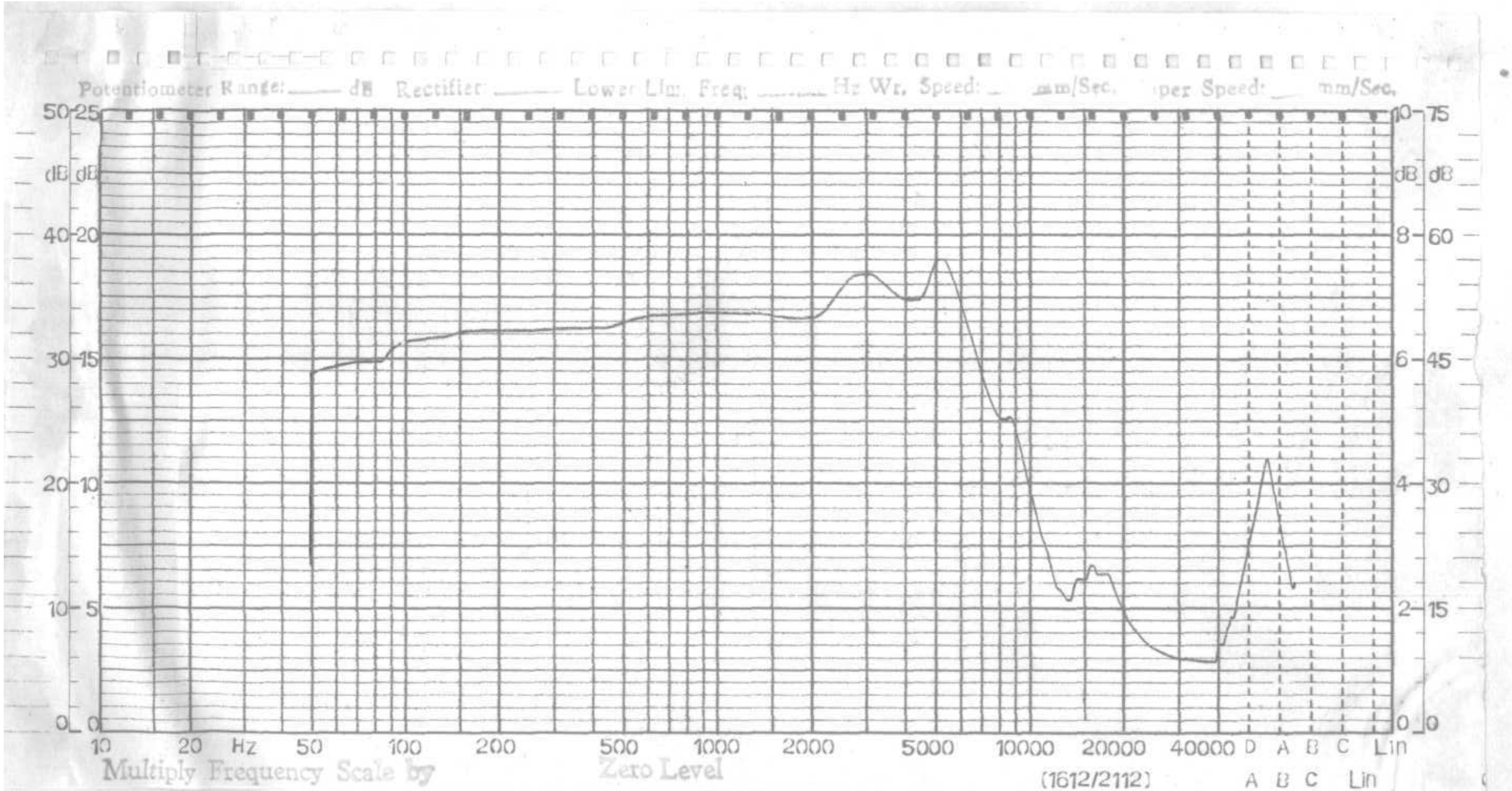
8000 Hz. The corresponding read out for each frequency was noted. The deviations were fount to be within permissible limits.

Distortion measurements were made and was found within permissible limits.

The frequency response of the earphones was also determined. The output from the beat frequency Oscillator (Bruel & Kjaer type) was fiven to the artificial ear (Bruel and Kjaer Type 4152). The output from the test earphone (TDH - 39) was given to an Audiofrequency analyzer (Bruel and Kjaer type 2107). The output from the analyzer was given to a level recorder (Bruel & Kjaer type 2305). As the Beat frequency Oscillator scanned through the frequency range from 20 Hz to 20 KHz, the graphical recording of the frequency response of the earphone was obtained. The response curve for the right and left earphones has been given in figure 'A'.

Accuracy of Frequency in Hz

250	500	1000	2000	4000	6000	80000
252	502	1010	2006	4015	6001	7981



Frequency Response Characteristics of the Earphone used in the Study

APPENDIX 'D'

Ambient Noise Measurement

The ambient noise in the test room was measured using a Sound Level Meter (Bruel & Kjaer Type 2209) with an half an inch condenser microihone (Bruel & Kjaer Type 4165) and Octave Filter Set (Brue & Kjaer Type 1613).

The noise measurements were done at 'A' and 'C' weighting networks, and at frequencies, 250 Hz to 8000 Hz, at octave intervals.

The noise levels in dB (C) scale was 33 dB. The noise at each octave frequency has been given in Table below:

Central frequency of the octave band in Hz.	SPL values in side the test room. Ref. 0.0002 dy/cm^2	ISO (1964) specifications SPL values in audiometric rooms. Re. 0.0002 dy/cm^2
250	21	25
500	10	26
1000	6	30
2000	8	38
4000	10	51
8000	10	56