EFFECT OF AGE ON SUSCEPTANCE

Reg.No.M9312

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT FOR THE FIRST YEAR M.Sc, (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.

ALL INDIA INSTITUTE OF SPEECH AND HEARING : MYSORE - 570 006.

MAY 1994

TO MY DARLING

SUNDAR ANNA, CHANDAR ANNA

SHEELA ANNI AND

MY CUTIEPIE SUDHIR

CERTIFICATE

This is to certify that the Independent Project entitled: EFFECT OF AGE ON SUSCEPTANCE is a bonafide work, done in part fulfilment for the First Year Degree of Master of Science (Speech and Hearing), of the student with Reg.No.M9312.

Mysore
May 1994

Dr.(Miss) S. Nikam,
Director
All India Institute of
Speech and Hearing
Mysore-6.

<u>CERTIFICATE</u>

This is to certify that the Independent Project entitled: EFFECT OF AGE CXI SUSCEPTANCE has been prepared under my supervision and guidance.

Mysore
May 1994

Dr.(Miss)S.Nikam
GUIDE

DECLARATION

I hereby declare that this Independent Project entitled: EFFECT OF AGE ON SUSCEPTANCE is the result of my own study under the guidance of Dr. (Miss) S.Nikam, Professor and Head of the Department of Audiology, and the Director, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore
May 1994

Reg,No.M9312

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INTRODUCTION

The process of aging individual cells has been subject to extensive research, but is still incompletely understood. Effect of aging on the sound conductive mechanisms of the middle ear has been studied by Nixon et al. (1962). They found a slight impairment of transmission of sound in the frequencies above 2 KHz with the maximum effect of 12 dB at 4 KHz. They suggested that this inefficiency of sound transmission was due to alterations in the elasticity of the tympanic membrane and changes in the ossicular joints and tendons.

The histological study of the aging peripheral auditory system is hampered by lack of specificity. However, these studies has demonstrated that arthritic changes including fibrous and bony ankylosis of ossicular articulations do occur, eventhough these changes have no significant effect on hearing, the energy transmission characteristics of middle ear system is disturbed, thereby affecting impedance and admittance of the system. One the ways to consider the energy transfer characteristics of the middle ear system is to measure the energy flow ie. the admittance. From instrumentation and computation point of view, it is often easier to measure the acoustic admittance (Y_n) or energy flow. Acoustic Admittance (Y_A) is the reciprocal of (2A) impedance is $Y_A = \frac{1}{2A}$.

We measure the acoustic mhos. The real or in phase component of acoustic admittance is called as acoustic conductance (G_A) is plotted in the same axis and direction as the real component of acoustic impedance. Acoustic conductance is the energy flowing though an acoustic resistance. The acoustic admittance corrollary of acoustic reactance is acoustic susceptance (B_A). This is the flow of energy both in a stiffness and mass dominated system.

NEED FOR THE STUDY:

Recent reports have indicated that the aging process alters selected aural acoustic immittance characteristics of the middle ear transmission system (Handler and Margolis, 1977: Jerger, 1972; Thompson et al.1979, 1980; Porter, 1972) reported that there is significant difference in susceptance between adults and children. The present study is aimed at finding the age effect on susceptance in Indian population.

This study is to be carried out using 226 Hz probe tone for the comparison of the following parameters across normal hearing adults and children.

- Physical volume
- Peak pressure
- Static acoustic susceptance.

Wiley, Ovlatt and Block (1984) found that the static measures for both acoustic admittance components, acoustic susceptance and conductance under both measurement conditions (peak pressure and ambient pressure) were slightly higher for subjects with notched 660 Has tympanograms compared to static values of subjects with single peaked 660 Hz tympanograms. So using the parameter susceptance at tympanic membrane present study is aimed at validating these results at higher and lower probe tone frequency.

Jerger (1972) reported that males show higher acoustic compliance than females at all ages.

Osterhammel and Osterhammel (1979) reported that there was no dependency of compliance values on sex. This study is to validate the above obtained results in the children and adult group and find out the significant difference in values, if any in males and females.

Present study is aimed at establishing normative data for susceptance and admittance in children and adults in Indian population.

AIM:

I. To establish normative data for susceptance tympanograms and admittance tympanograms in adults and children using Grason-Stadler Incorporation-33 version 2 middle ear analyser.

II. T6 study the effect of 3 probe tone frequencies (226 Hz. 678 Hz, 1000 Hz).

- On susceptance at tympanic membrane in adult males, adult females, male and female children.

III. To find the effect of age and sex on -

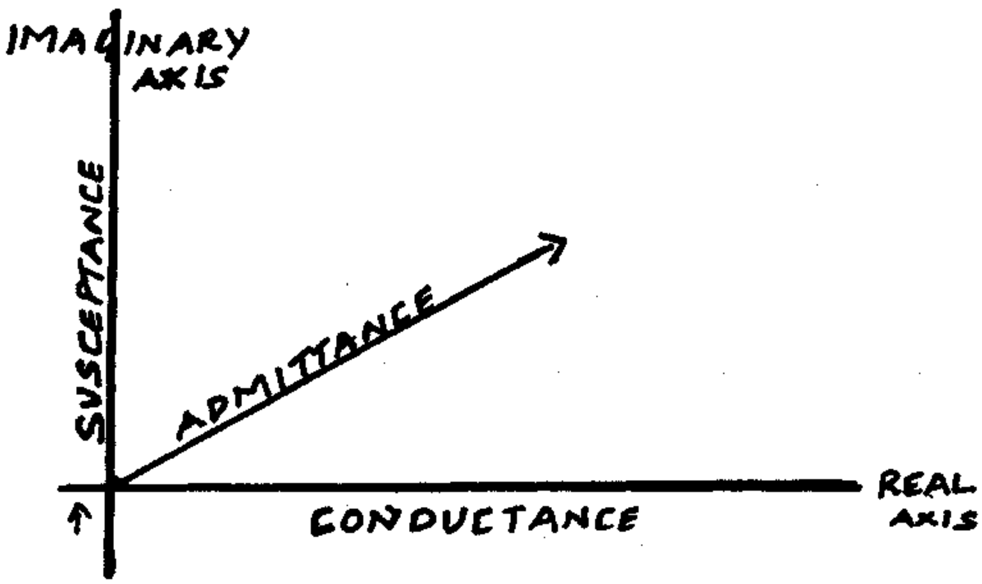
- Physical volume at 226 Hz.
- Peak pressure at 226 Hz.
- Susceptance at tympanic membrane.

REVIEW OF LITERATURE

Admittance is the sura of a real part, conductance G and an imaginary part 1 multiplied by susceptance (B)

$$Y = G + iB$$

$$Y = G^2 + B^2$$



Complex mechanical systems such as the middle ear mechanism can be represented by many interconnected mechanical parts that are either resistance elements, masses or springs. The admittance of whole device can be derived from the combined admittance of each part of the entire system Which are as follows:

Resistance : $Y = 1/r$

Mass : $Y = \dfrac{-i}{2\ fm}$

Compliance : $Y = (2\ fC)i$

Whore f = frequency, m = mass

C = compliance, r = friction

The admittance of a resistance element does not depend on frequency and has a magnitude of 1/r.

The admittance of a mass element is purely imaginary with a magnitude of 1/2 fm. Since the admittance of a mass only has a negative imaginary part, it's vector will lie along the imaginary axis and point in a negative direction. The magnitude of the admittance of a mass element, which is a measure of how much it will vibrate for a fixed applied sound pressure, decreases as frequency increases. The admittance of a compliance element is also purely imaginary with a magnitude of 2 fC. This magnitude decreases as frequency decreases.

The acoustic susceptance of the middle ear should be directly calculated by subtracting the acoustic susceptance of the outer ear from that of the total ear. Similarly the acoustic conductance can be derived. Then the acoustic admittance of the middle ear can be (Y_{ME}) obtained from the formula - $Y_{ME}^2 = B_{ME}^2 + G_{ME}^2$.

Where Y_{ME} = Static acoustic admittance of the middle ear.

G_{ME} = Static acoustic conductance of the middle ear

B_{ME} = Static acoustic susceptance of the middle ear.

<u>Normative values</u>

There have been few studies carried out to establish normative data in children and adults using otoadmittance meters for admittance, conductance and susceptance tympanograms.

Porter (1972) took 3 groups of subjects consisting of 18 adults (18-40 years, mean = 25 years) and 18 children (7-14 years, mean = 9 years) who had normal hearing and 18 children with severe - profound hearing loss. The instrument used was Model 1720 Otoadmittance meter.

The values obtained using 220 Hz and 660 Hz probe frequencies are as follows:

		220 Hz		660 Hz	
		B	Y	B	Y
Adults	Mean	.71	.79	1.01	2.93
	SD	.22		.48	
Hearing children	Mean	.60	.65	1.01	2.91
	SD	.19		.40	

The results showed that for susceptance at 220 Hz and 660 Hz, there was no significant difference between adults and children.

. Feldman (1972) studied 100 normal persons, using 220 Ha and 660 Hz probe frequencies and gave the mean and ranges of admittance.

At 220 Hz, the mean was about 0.52 mmhos with a range extending from about 0.30 - 0.80 mmhos. At 660 Hz the mean was 2.6 mmhos with a range of 1.20 - 4.20 mmhos,

Beattie and Leamy (1975) studied 2 groups of subjects. Group-I consisted of 7 males and 13 females in the age of 17-29 years, with a mean age of 20 years. Group-II consisted of 20 males in the age range of 60-78 years with the mean ege of 65 years.

They established normative data for susceptance and conductance at 220 Hz and 660 Hz. The values are as follows:

	Group-I	
	Mean	SD
B. 220 Hz	0.75	0.33
660 Hz	1.46	1.3

According to the Table, B values at 220 Hz are smaller than the respective values at 660 Hz probe frequencies.

The mean values obtained in this study are in close agreement with the above mentioned Porter's study.

The normative data on admittance for children established by Brooks (1971) and Jerger and Jerger et al. (1972) for older children and adults are as follows:

Table-I: Y_A (mmhos)

	10%	90%
Jerger et al (1972)	0.39	1.30
Brooks (1971)	0.35	1.05

For adults is as follows:

Pump speed was 200 dapa/s at 220 Hz.

Table-II Adults

	200 dapa/s
Lower 3Limit	0.57
Median	1.08
Upper limit	2.00

The normative data on the static acoustic middle ear admittance, for the 220 Hz probe tone, when the ear canal static acoustic admittance was calculated at +200 dapa as in Table-I shows that it is reasonable to consider the normal acoustic middle ear admittance range for 80% of the school age population (between 10th and 90th percentiles).

Prom Table-II, it was inferred that the normal static acoustic middle ear admittance ranges for *90%* of the adult population to be between 0.57 and 2.00 acoustic mmhos respectively for the 226 Hz probe tone when the ear canal static acoustic immittance is calculated at -400 dapa with high pump speed (Jerger et al. 1972).

Wiley, Oviatt and Block (1967) studied admittance, conductance and susceptance of 77 women and 50 men with normal hearing. Their age ranged from 20-30 years. These values were computed et 220 H_2 and 660 Hz probe tone frequencies, at peak pressure as drum free condition and -250 dapa as drum tight condition.

Peak Pressure

		Mean	SD
220 Hz	^{B}A	0.69	0.26
220 Hz	^{Y}A	0.74	0.29
660 Hz	^{B}A	2.09	1.05
660 Hz	^{Y}A	3.06	1.72

At higher probe tone frequencies notched tympanograms were observed for susceptance and higher static values were obtained at such notched suapeptance tympanograms.

Static Immittance:

This is the immittance of the tympanic membrane alone, Static immittance can be affected by factors such as

1. Age
2. Sex
3. Probe-tone frequency.

Effect of age and sex:

Brooks (1971) studied 1053 children with the age range of 4-11 years Who had normal hearing. Compliance of each ear and middle ear pressure were computed. The results showed that there was no detectable difference between boys and girls but there was some indication of an increase of compliance with increase in age. Average value for compliance was 0.70 cm^3 with a range of 0.35 cm - 1*40 cm and these have been taken as the limits of compliance with increasing age.

Jerger (1972) studied 700 subjects both normal hearing and sensori-neural hearing loss cases, Age range taken was 6-90 years. Subjects were divided by sex and by age decades. For each sex at each age decade, both the mean and standard deviation of the compliance were computed. The results showed:

- Women consistently showed a lower average compliance and less variance than men at all ages.
- There is a pronounced age efffect in both sexes, but especially men show a well defined maximum in both mean and variance in the age decade 30-39 years. Above this age decade the average compliance declines relatively systematically with increasing age for both sexes.

The maximum average compliance and SD for men aged 30-39 years might be possibly due to greater noise exposure of men in this range. This in turn might fatigue the intra-aural muscles thereby increasing compliance.

Zwislockl, Feldman and Bicknell and Morgan noted that women seemed to show lower compliance than men.

Bicknell and Morgan also noted that women seemed to show a narrower compliance range. Neither study provided quantitative data on sex difference.

Osterhammel and Osterharamel (1979) studied sex variation for the tympanometric compliance values on 286 persons in the age range 10-80 years who had normal hearing. They reported that there was no dependency of campliaice values on sex.

<u>Static susceptanece and age:</u>

Few studies have been conducted to find out the relationship between age and static susceptance.

Thompson, Sills, Recke and Bui (1979) measured the static admittance, static susceptance and static conductance in 60 subjects, 20 through 79 years of age with normal hearing. It was reported that the static values are minimal upto 60 years.

Wilson (1981) computed the aural acoustic immittance (admittance and impedance) during the quiescent and reflexive states in the 18 subjects with normal hearing in each of the age groups (less than 30 years and greater than 50 years).

The results indicated that there was no significant difference between the 2 age groups. The relation between the magnitude changes in sueceptance from quiescent to the reflexive state was the same for the 2 groups.

A study by Blood and Greenberg (1976) contradicts this. They reported that mean of acoustic admittance decreases as the age progresses.

In all these studies children were not included. So the exact effect of age on static susceptance is not clear.

Influence of probe tone frequencies on static susceptance:

From different studies conducted, it was found that the incidence of W-pattern or W-notching increased while going from low probe tone frequencies to high probe tone frequencies. Though acoustic conductance at 220 Hz and 660 Ha was found to be symmetrical, susceptance becomes assymmetrical at higher frequencies.

Porter and Winston (1973) studied 16 normal hearing subjects,11 females and 5 males were tested on 5 separate occasions. Recordings of susceptance (B) were obtained with pressure decreasing from 4-200 mm H2o at standard probe frequencies of 220 Hz and 660 Hz. Mean and SD of the males for susceptance in acoustic mmhos at 220 Hz and 660 Hz are as follows:

B 220 Hz	Mean	0.78
	SD	0.31
B 660 Hz	Mean	1.62
	SD	0.51

These values were calculated at maximum susceptance as the drum free values. It was found that test-retest correlation coefficient was found to be very high.

Porter and Winston (1973) did one more study using 220 Hz and 660 Hz probe tone frequencies on 32 normal hearing adults. Recordings were done during increasing and decreasing pressure. Drum free condition was considered to be at maximum susceptance and drum tight as at +200 dapa. The mean and SD values are as follows:

Increasing pressure -

	Mean	SD
B 220 Hz	0.9	0.52
B 660 Hz	1.3	0.77

From the above mentioned 2 studies, it can be seen that as the probe tone frequency increases, the static susceptance increases.

Shanks and Lilly (1981) studied static values on 4 women and 4 men age ranging from 20-31 years (mean - 26 years) with normal hearing. The values were obtained at 220 Hz and 660 Hz. Ear canal pressure was varied from -400 dapa to + 400 dapa and also at ear canal pressure that produced maximum susceptance (MAX).

Static immittance (mean, SD) for 220 Hz and 660 Hz probe tones calculated at maximum (MAX) using recommended (660 Hz at -400 dapa) procedures are as follows:

Static values (acoustic mhos)	220 Hz (MAX)	660 Hz (MAX)
B_a	0.93 (0.37)	1.67 (0.38)
Y_a	0.99 (0.4)	3.09 (1.51)

SD are given in parentheses.

Wilson, Shanks and Kaplan (1984) studied 24 young adults, probe tones used were 226 Hz and 678 Hz. Static values, mean and median for 8 subjects with single peaked tympanogram and 8 subjects with notched tympanogram for ascending pressure direction are as follows!

Susceptance	226 Hz		678 Hz	
	Single	Notched	Single	Notched
Mean	0.59	1.26	1.36	0.32
SD	0.16	0.56	0.39	1.34

From the above valueS, it can seen that there is discrepancy in the static susceptance values between notched and single peaked tympanograms at 226 Hz and 678 Hz. Also it is seen that as the probe tone frequency increases static value . increases.

Peak Pressure and Age:

The measurement of middle ear pressure represents an important diagnostic tool for identifying middle ear disorders. The tympanic membrane best transmits sound energy when the air pressure on both sides of the tympanic membrane is equal.

Though most researchers agree regarding the range of tympanic membrane peak pressures, consistent with normal middle ear pressure, in adults they disagree about the range of tympanic membrane peak pressures, consistent with normal middle ear pressure in children.

Brooks (1971) studied 1053 children 4-11 years of age, middle ear pressure was computed. The results showed the lower limit of the range of tympanic membrane peak pressures consistent with normal middle ears in children is as high as -30 dapa.

Burke and Herer (1972) studied 7 females and 3 males aged 20-24 years (mean = 22 years) and 7 males and 3 females aged 6-11 years (mean = 8 years) having normal hearing.

Measurement of middle ear pressure with otoadm9ttance meter was done. Two response curves for each probe frequencies, a conductance curve (G) and a susceptance curve (B) were obtained. Of the 4 curves per ear, thus obtained, each seemed to peak at different pressure points. The difference ranged from +4 to +22.5 mm H_2o with adults and from -4.5 to + 13,5 mm H2O with children.

Comparing the pressure estimates at 220 Hz and 660 Hz there was si0gnificant mean difference at 0.01 level of confidence with the adult group and at the 0.05 level with children group. The values of peak pressure in both children and adults are as follows:

	220 H_z (B)	660 *Hz* (B)
Adults	11.2	25.5
Children	6.0	13.5

Jerger (1970) proposed -100 dapa as the lower limit of normal range of tympanometric peak pressures.

Renvall et al (1975) found that 90% of their samples of school children who were presumed to have normal middle ears had tympanometric peak pressures exceeding -150 dapa. Therefore, they considered -150 dapa to be the lower limit of normal middle ears.

The presence of lower tympanometric peak pressure in children than in adults is attributed to the ability of some children to maintain relatively lower middle ear pressures than adults (Brooks, 1980).

But it was found that if -150 dapa or -170 dapa is used as the lower limit of normal range as proposed by Renvall et al (1975) 18% of children's ears with middle ear effusion were missed. If -100 dapa is used as the lower limit of normal range as proposed by Jerger, false positive rate was increased to 17.8%, though false negative rate is reduced. So it was clear that screening for the presence of middle ear effusion based on tympanometric peak pressures is insufficient in children resulting in either a high positive or false negative rate depending upon the cut-off tympanometric peak pressures employed.

Brooks (1980) found that the tympanometric peak pressure was between -50 and +50 dapa in adults with normal middle ear.

Physical volume:

Physical volume is a measurement of the volume of the external auditory canal as a sealed cavity under positive pressure of 200 dapa.

Some investigators regard the ear canal volume as pure susceptance. Moller (1960) and Van Peperstraete et al (1972), whereas other investigators suggest the ear canal volume contributes some finite conductance.

Moller (1960) supporting the former, reported that the ear canal has no effect on the real component of admittance (ie) conductance.

Cretan (1978) did not assume that the ear canal could be molded as pure susceptance. He reasoned that the hairs and cerumen in the ear canal produce some sound absorption and thus a finite value of ear canal conductance. Both susceptance and conductance at a given ear canal pressure are attributed to the ear canal volume. It was further reported that at the probe frequency of 220 Hz the ear canal susceptance can be assumed, to be proportional to its volume. But this proportionality was reported to break down at high frequency of 660 Hz (Van Peperstraete et al. 1978).

In normal ears, the recorded tail value of susceptance for negative pressure is always smaller than the one for positive pressure. The volume measurements indicate that the assymetry in suscpetance cannot be attributed completely to the volume change in the ear canal. Some part should be attributed to the middle ear also.

Feldman (1967) studied 33 subjects with normal hearing, Determination of ear canal volume was done for 24 subjects. The mean value of ear canal volume was 0.56 cc and the normal range was 0.4 to 0.8 cc. This mean value does not agree with the mean of 0.8 cc reported by Nixon and Glorig.

4 repeated measurements on 13 subjects. Also with the means ranging from 0.72 cc to 0.87 cc reported by Tillman et al.

Northern and Grimmers (1978) reported that for children the normal ear canal volume, peripheral to an intact drum is approximately 0.6cc - 0.8cc and for adults approximately 1 cc to 1.5 cc.

Shanks and Lilly (1981) studied 4 women and 4 men age ranging from 23-31 years (with a mean age of 26 years) with normal hearing. They had no evidence of middle ear pathology. Susceptance and conductance at 220 Hz and 660 Hz were recorded for pressures ranging from -400 dapa to +400 dapa and at peak pressure. Results showed that the largest mean error in estimating ear canal volume from tympanometry occured for probe frequency and pressure, most commonly used to estimate ear canal volume (ie) for 220 Hz tone and +200 dapa pressure.

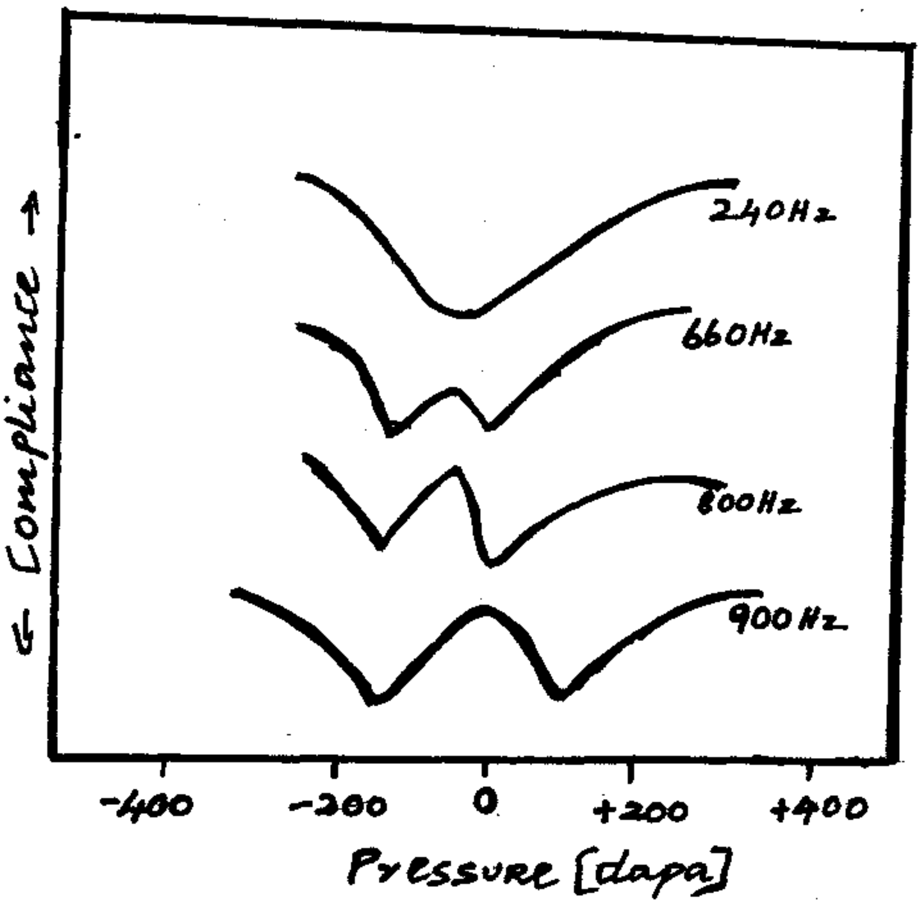
Shanks (1984) reported that the amplitude of tympanograms is inversely related to the volume of the ear canal (ie) the tympanometric amplitude is greater for a smaller ear canal volume. The tympanometric amplitude reduces non-linearly with increases in ear canal volume. The changes in sound pressure level will be greater and therefore tympanometric amplitude will be greater in smaller ear canals. The larger the ear canal volume becomes, the broader and shallower the tympanogram becomes.

The discrepancy in the mean values of ear canal volume in adults and children across different studies can be attributed to the difference of techniques related to the depth of insertion of the speculum. When ear canal volume exceeds the 0.55 to 0.6 cc range, the implication is that the examiner is not inserting the speculum deep enough into the ear canal.

Tympanometric configuration - Effect of probe frequencies:

Alberti and Jerger (1974) described, tympanometric peak amplitudes and shapes observed using various probe tones in normal middle ears.

Figure illustrates the relationship between peak amplitudes, shape and probe tones. It shows that as the probe tone frequency increases, the amplitude also increases, when probe



240Hz
660Hz
800Hz
900Hz
← Compliance →
-400
-200
0
+200
+400
Pressure [dapa]

tone frequency approaches 660 H_z, notching of the tympanogram begins to occur. This notching becomes more prevailment as the probe tone frequency increases beyond 660 Hz upto 900 Hz, Alberti and Jerger (1974) referred to the notching shape as 'W' shaped. Majority of normal middle ears have 'W' shaped tympanograms for probe frequency above 900 Hz.

Liden, Harford and Hallen (1974) stated that since high frequency probe tones around 800 Hz were near the resonance frequency of the middle ear and since ear canal pressure changes cause changes in the resonance characteristics of the middle ear, the 'W' shaped tympanograms reflect increased interaction among the probe tone frequencies, resonance characteristics of the middle ear and external ear canal pressure.

Colletti (1976) studied 72 ears - 20 normal and rest pathological ears. All selected ears underwent the multi-frequency tympanometry. The investigation started from 200 Hz and moved towards higher frequencies in 200 Hz step. In the group with normal middle ear, following types of tympanograms were observed.

- From 200 ^{H}z to between 650 Hz and 1200 Hz 'V' shaped characteristics (Ist range).
- 'W' shaped was present in an interval of around 300 Hz over the frequency previously described (2nd range).

- Finally, the tympanograms aasumed the 'V' inverted shaped Which began at between 1000 Hz and 1400 Hz and became more evident at higher frequencies (3rd range).

This study supported Liden et al. who proposed the usage of 800 Hz probe tone, as tympanometric shape shows clear dependency on the probe tone frequency.

Margolis and Popelka (1977) investigated tympanometric assymmetry in 17 normal adult subjects. The data are discussed in terms of 5 categories of subjects based on otologic history and shape of the 660 Hz tympanogram. All subjects had single peaked tympanogram at 220 Hz.

Case I - Included five audiometrically and otoscopically normal subjects with normal, single peaked tympanograms at 660 Hz.

Case II - Included 3 normal subjects with double peaked 660Hz acoustic susceptance tympanogram.

Case III - Included 2 normal subjects with double peaked acoustic susceptance (B_A) and conductance (G_A) tympanogram at 660 Hz.

As the probe tone frequency increased, the tympanogram became more assymmetrical with higher B_A values on the positive pressure side of the tympanogram. The mean G_A tympanogram for normal subjects increased in magnitude as probe frequency increased, but remain nearly symmetrical around the maximum, that occurs near ambient ear canal pressure.

In the Case II and III, the absolute values of acoustic reactance and resistance are nearly equal at 660 Hz and these subjects demonstrated substantially lower acoustic reactance than acoustic resistance in the region of ambient ear canal pressure.

Van Peperstraete, Creten and Van Camp (1979) investigated the tail assymmetry of susceptance tympanogram. A flow measuring device enabled an accurate determination of ear canal volume changes during tympanometry. For these measure-merits one finds that not only is the assymmetry due to the ear canal volume change, but that finite drum susceptance exist at high transtympanic pressure. They found B_t and G_t at 220 Hz and 660 Hz using Grason Stadler otoadmittance meter model 1720.

Susceptance at the drum from measurements of 19 ears:

- A residual B_d existed, both for high positive and high negative transtympanic pressures. For both pure tone frequencies 220 Hz and 660 Hz the values B_d^+ and B_d^- were unequal.

- The ratio of the susceptances B_d 660 Hz / B_d 220 Hz at the tails of the tympanogram is mostly smaller than 3.
- The B_d^- for a negative pressure is greater than B_d^+ for a positive pressure across the drum.

For a hard-walled cavity of small dimensions, the recorded susceptance is proportional to the probe tone frequency which means that B 660 Hz/B 220 HZ = 3.

Vanhuyse et al. and Van Camp et al (1984) developed a classification system for simultaneously recorded susceptance (B) and conductance (6) tympanograms using a high frequency probe tone such as 678 Hz. The susceptance and conductance tympanograms were described according to the number of extrema or direction changes measured. The admittance tympanograms are explained with reference to the relationship between resistance and reactance which exhibit less complex patterns. The 4 basic normal tympanograms are as follows:

1) The single peaked or 1B1G tympanogram has one extremum for each admittance component. This tympanogram is recorded when reactance is negative (ie. ear is stiffness controlled) and resistance is smaller.
2) The 3B16 patterns shows notching of the B tympanogram, although susceptance remains positive for all ear canal pressures. Here the minimum notched B is slightly more

negative than maximum G value. In addition, the more positive B maximum is larger in amplitude than the negative minimum. Vanhuyse et al. attributed this difference to the monotonically reduced resistance tympanogram as a function of ear canal pressure.

3) Notching occurs in both the B and G tympanogram in the 3B3G pattern. When, this pattern is recorded, the minimum notched B value generally is negative. The 3B3G tympanogram is recorded when reactance is recorded, when reactance is positive, near 0 dapa and is negative for extreme pressures and when resistance is greater than reactance.

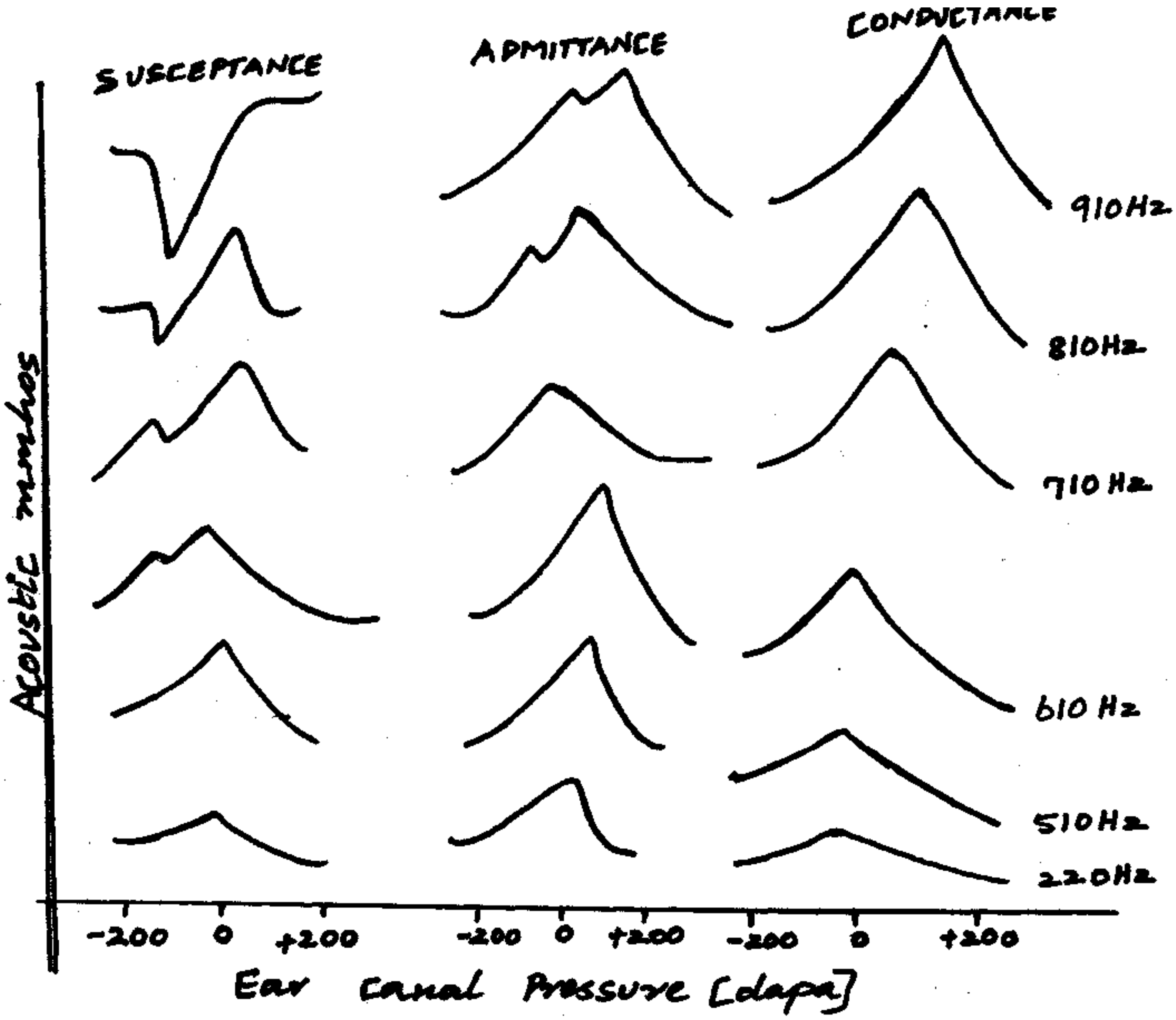
4) The most complex pattern, 5B3G also is found when the middle ear system is mass controlled. In contrast to the 3B3G pattern, the reactance in 5B3G pattern is greater than resistance near ambient air pressure.

According to Vanhuyse et al. the normally notched tympanogram must meet the following criteria:

- The number of extrema must not exceed 5 for B and 3 for G tympanograms•
- The distance between the outer most B maxima must be smaller than the distance between the B maxima.

- The distance between the outer most maxima must not exceed 75 dapa for tympanograms with 3 extrema (3B3G) and must not exceed 100 dapa for tympanograms with 5 extreme (5B3G).

Margolis, Van Camp, Wilson and Cretan (1985) described the amplitude and shape of susceptance, conductance and admittance tympanograms obtained from young adults with normal middle ears using probe tone frequencies varying between 220 Hz and 910 H_z and an absolute acoustic immittance device.



Susceptance, conductance and admittance tympanograms from one normal subject at 6 probe frequencies and positive and negative direction are shown in the figure.

In the figure, the peak amplitude on the susceptance tympanogram is greater than that on the conductance tympanogram and the peak amplitude on the admittance tympanogram is only slightly greater than that on the B tympanograms for 220 Hz probe tone. This relation between the 3 components occurs at 220 Hz as the resistance of middle ear is very small here. As the probe tone frequency increases, normal middle ears start to demonstrate notching in the B, G, and Y tympanograms.

Maryolis et al. (1985) attributed the changes in the susceptance and conductance tympanometric patterns with probe-frequency changes, to the shift in acoustic reactance from large negative value to small positive values.

METHODOLOGY

The methodology of the present study is described under the following headings:-

1. Subjects:

Criteria for selection of subjects:

Adults - Totally 30 normal hearing adults whose PTA of both ears within 20 dB HL in octave frequencies from 250 Hz to 8 KHz (ANSI 1969) were selected. The subjects were 15 males and 15 females age ranging from 18-26 years.

Children - 30 normal hearing children whose PTA of both ears lie within 20 dB HL in octave frequencies from 250 Hz to 8 KHz (ANSI 1969) were selected. This group consisted of 3 age groups ie 8 years, 10 years and 12 years respectively. Each age group had 10 subjects ie. 5 females and 5 males.

In order to meet the criteria for selection the subjects should have an 'A' type tympanogram with the reflexes present on an immittance instruments which would indicate the absence of any middle ear pathology.

Justification:

1. The occurrence of middle ear pathology after the age of 8 years is less.

2. Significant difference in terms of physical volume peak pressure and static admittance values are not expected between the adjacent age groups. Hence children in the age group of 8, 10 and 12 years were selected.

2. Instrumentation:

The Grason Stadler Middle Ear Analyzer 33 version 2 was used for the present study. It is a microprocessor based admittance audiometer which has facilities for complete automatic or manual diagnostic testing for analysis of middle ear function. Admittance (Y) and its components susceptance (B) and conductance (G) can be measured with probe tone frequencies of 226 Hz, 678 Hz and 1000 Hz.

An audiometer namely Madsen OB 822 calibrated according to ISO Standards was also used to check the behavioural thresholds (air conduction using earphone TDH 39 and bone conduction using bone vibrator *RADIO EAR B*-71) at octave frequencies using the Modified Hughson-Westlake Procedure.

3. Calibration:

The Grason Stadler Middle Ear Analyzer 33 version 2 has been calibrated according to the standards specified in the manual.

The audiometer has been calibrated using a Sound Level Meter - B&K 2230 and a microphone - B&K 4144. The calibration of earphone output has been accomplished with the help of artificial ear - B&K 4152, along with the sound level meter and microphone of one inch and earphone (TDH 39).

4. Test environment:

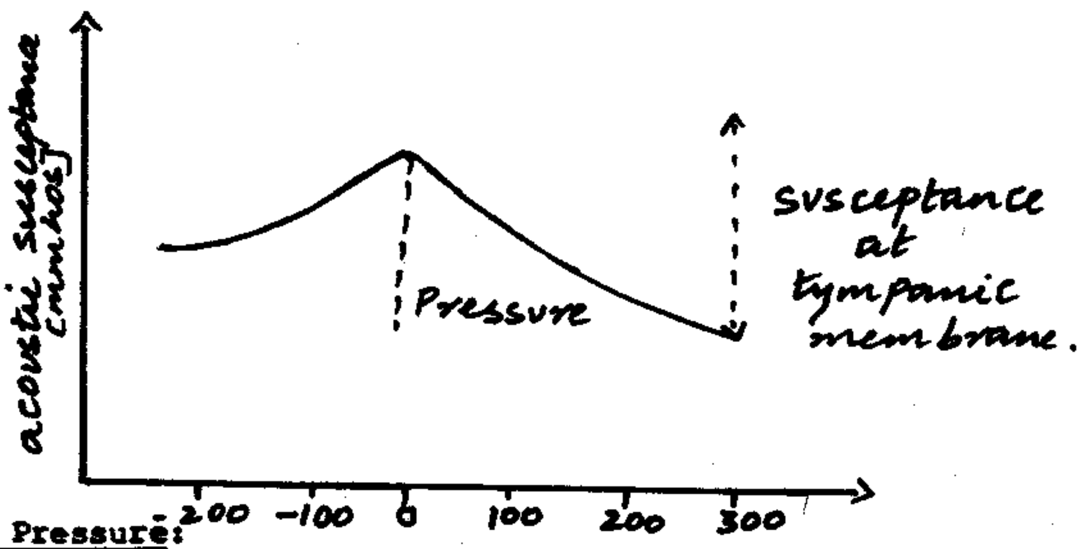
The test was conducted in an air conditioned sound treated room. The noise levels were measured using a Sound Level Meter (B&K 2209) an Octave Filter Set (B&K 1613) and a Condensor Microphone (B&K 4165) and the noise levels were within the permissible limits as given in ANSI Standards (1969).

5. Test procedure:

The patient was seated comfortably. The probe box was attached to the velcrostrip on the shoulder mount or clothes clip and position on the patient. Then the presence of obstructive cerumen in the ear canal was checked. The correct size of the ear tip was selected and positioned on the probe. Then it was securely inserted into the ear canal to obtain an airtight seal. The probe tone of interest 226 Hz was selected and the pump speed was selected as 200 dapa. Then the ' start' button was pressed.

The pressure was varied front -400 dapa to +200 dapa to obtain a tympanogram. Since the instrument was an automatic one, the tympanometric values including the values of the physical volume, admittance at the tympanic membrane, peak pressure and gradient was displayed on the screen after getting the tympanogram. Tytnpanograms at 678 Hz and 1KHz were obtained using a similar procedure.

Susceptance tympanogram was then obtained for 226 Hz, 678 Hz and 1 KHz using a similar procedure• The susceptance tympanogram obtained at 226 Hz is represented as shown belowz



Peak Pressure:

The ear canal pressure corresponding to the tympanometric peak was considered as the estimate of peak pressure.

Physical volume:

The physical volume Which is the volume of the ear canal was calculated at high positive pressure (ie) +200 dapa which was built in the ear canal.

Peak compensated acoustic susceptance at the tympanic membrane

The susceptance of the middle ear without the effects of the ear canal was estimated from the tympanogram. The following steps were used in calculating suaceptance at the tympanic membrane.

1. Acoustic susceptance was calculated with the ear pressurised to + 200 dapa, the value that results in the minimum value $B_{(MIN)}$.
2. Acoustic susceptance calculated at the ear canal pressure corresponding to the tympanometric peak gave the peak value for single peaked tympanogram $B_{(MAX)}$. In a notched tympanogram, the susceptance at the tympanic,membrane was calculated at the minimum value in the notch.

3. The pressure change was done from -400 dapa to +200 dapa.

Equation for calculating susceptance at the tympanic membrane:

$$B_{tm} = B_{max} - B_{min}$$

RESULTS AND DISCUSSION

One of the aims of the present study was to find the effect of probe frequency, on susceptance tympanogram in males and females in both adults and children.

At lower probe tone, frequencies as well as for high probe tone frequencies (678 Hz and 1000 Hz) notched susceptance tympanograms were obtained. At 226 Hz, only single peaked tympanograms were obtained in the present study. Effect of probe tones on admittance tympanograms was also found.

The percentage of occurrence of notched tympanograms in both males and females in both adults and children for susceptance and admittance tympanograms are given in Table-1.

	Admittance		Susceptance	
	678 Hz	1000 Hz	678 Hz	1000 Hz
Adults				
Males	0%	30%	30%	70%
Females	0%	50%	23.3%	93.3%
8 years				
Males	0%	10%	0%	30%
Females	0%	20%	0%	20%
10 years				
Males	0%	30%	0%	20%
Females	0%	0%	0%	0%
12 years				
Males	0%	20%	20%	40%
Females	0%	10%	0%	30%

From the Table-1, it can be seen that, in the admittance tympanogram, notches are seen only at 1000 Hz and not at 678 Hz. The percentage of occurrence of the notches is more in adult females (ie) 50%, when compared to adult males and children.

In the susceptance tympanogram, the percentage of notches is more in adults than in children. In adults females have the higher percentage of notches (ie) 93.3%.

Among children of 12 years age, the group has more percentage of notches than 8 years and 10 years age group.

Relatively more notched tympanogram were observed with 1000 Hz tone compared to 678 Hz probe tone. Almost all age groups showed notched tympanograms at 1000 Hz, even if their tympanograms showed no notches at 678 Hz.

Present study supports the study by Margolis et al. (1985) who reported that as the probe tone frequency increases, the occurrence of notching occurs more in susceptance than admittance tympanogram.

One of the aims of the present study was to establish normative data for admittance and susceptance tympanograms for adults and children of both sexes.

Mean, standard deviation and range for physical volume, peak pressure and measurements at tympanic membrane, are given in Tabular form in the following pages.

Statistical analysis was done using 'paired' and 'unpaired' 't' test to find the significant difference between males and females in both adults and children at 0.05 level of significance for the following parameters.

1. Physical volume at 226 Hz in susceptance tympanogram.
2. Peak pressure at 226 Hz in susceptance tympanogram
3. Susceptance at tympanic membrane.

Table-2: Showing the mean, standard deviation and range for physical volume for admittance and susceptance at 226 Hz, 678 Hz and 1000 Hz for males and females in adults.

Parameter	Probe tone frequency (in Hz)	Mean		Standard deviation		Range	
		Males	Females	Hale	Females	Male	Females
Admittance	226	1.14	1.48	0.16	0.26	0.0 1.5	1-2.2
	678	3.46	4.35	0.45	0.76	2.5-4.6	2.8-5.3
	1000	5.75	7.3	0.63	1.41	4.4-7.1	4.2-9.7
Susceptance	226	1.11	1.48	0.16	0.22	0.7 1.4	1-2
	678	3.41	4.33	0.42	0.79	2.5-4.2	2.37-5.4
	1000	5.71	7.44	0.63	1.49	4.4-7.1	4.3-10.4

Table-3: Showing the mean, standard deviation and range of physical volume for admittance and susceptance at 226 Hz, 678 Hz and 1000 Hz for male and female children.

Parameter		Probe tone frequency and age	Mean		S.D		Range	
			Male	Female	Male	Female	Male	Female
Aamittance	8 years	226 Hz	0.87	0.83	0.24	0.49	0.6-1.3	0.7-1
		678 Hz	2#67	2.58	0.89	0.36	1.8-4.7	2.1-3.1
		1000 Hz	4.31	3.99	1.86	0.52	3-8.9	3.4-5
	10 years	226 Hz	0.96	0.72	0.16	0.13	0.8-1.2	0.5-0.9
		678 Hz	3.04	2.22	0.53	0.35	2.4-3.7	1.8-2.6
		1000 Hz	5.21	3.62	0.79	0.45	4.2-6.3	3-4.3
	12 years	226 Hz	0.96	0.98	0.17	0.21	0.7-1.2	0.6-1.2
		678 Hz	3.02	2.96	0.5	0.59	2.3-3.8	1.9-3.6
		1000 Hz	5.11	4.88	1.0	0.96		3.3-5.9
Suscepanee	8 years	226 Hz	0.85	0.82	0.24	0.16	0.6-1.3	0.6-1.1
		678 Hz	2.61	2.34	0.82	0.36	1.8-4.3	1.98-3.1
		1000 Hz	4.28	4.25	1.78	0.59	3-8.5	3.5-5
	10 years	226 Hz	1.03	0.69	0.54	0.14	0.7-2.5	0.5-0.9
		678 Hz	2.74	2.2	0.53	0.29	2.1-3.7	1.8-2.6
		1000 Hz	4.98	3.97	0.79	0.39	4.2-6.3	3.1-4.5
	12 years	226 Hz	0.99	0.99	0.17	0.21	0.7-1.2	0.6-1.2
		678 Hz	3.03	2.99	0.46	0.60	2.4-3.7	1.9-3.6
		1000 Hz	5.04	4.88	0.84	1.01	3.9-6.1	3.2-6

Table-4: Showing the mean, standard deviation, 't' values and probability of physical volume at 226 Hz in susceptance tympanogram between adults and children.

	Mean	SD	't' value	Probability level	Significance
Adults	1.3	0.27	8.2505	0	S
Children	0.9	0.29			

Table-5: Showing the mean, SD, 't' value and probability of physical volume between males and females in both adults and children at 226 Hz in susceptance tympanogram.

	Mean	SD	't' value	Probability level	Significance
Adults					
Males	l.11	0.16	-7.18	0	S
Females	1.48	0.22			
8 years					
Males	0.85	0.24	0.324	0.75	NS
Females	0.82	0.16			
10 years					
Males	1.03	0.54	1.94	0.686	NS
Females	0.69	0.14			
12 years					
Males	0.99	0.17	0	1	MS
Females	0.99	0.21			

From Table-2 it could be inferred that for adults, both in males and females as the probe tone frequency increases, the physical volume also increases in both admittance and susceptance tympanogram.

Prom Table-3, it could be inferred that there is an increase in physical volume as the probe tone increases within each age group in both males and females in admittance and susceptance tyrapanogram.

Between the children's group, there is a slight increase in physical volume in 10 year, old and 12 year old males and females when compared to 8 year old males and females, but there was no significant variation between the 10 year old and 12 year old group in either admittance and susceptance tympanograms.

As shown in Table-4, from paired 't' test, it was found that there was significant difference between adults and children in physical volume for susceptance tympanogram at 226 Hz.

As shown in Table-5 from unpaired 't' test. It was found that there was no significant difference in both males and females in the children group, consisting of 8 years, 10 years, and 12 years. But between adult males and females there was significant difference in physical volume.

Table-6: Showing mean, standard deviation and range for peak pressure at 226 Hz, 678 Hz and 1000 Hz in admittance and susceptance tympanograms in adult females and males.

Parameter	Probe tone frequency (in Ha)	Mean		SD		Range	
		Hale	Female	Male	Female	Male	Female
Admittance	226	2.67	0	12.3	12.18	-45-25	-30-45
	678	3.83	5.5	10.64	13.73	-25-35	-15-50
	1000	-4.83	-3.33	25.51	37.63	-80-20	-125-60
Susceptance	226	5.33	7.67	25.05	25.52	-90-50	-35-95
	678	6.17	6.33	29.03	28.1	-90-55	-45-115
	1000	4.31	1.74	21.58	25.57	-55-50	-45-70

Table-7: Showing the mean, Standard deviation and range for peak pressure at 226 Hz, 678 Hz and 1000 Hz for admittance and susceptance tympanograms in male and female children.

Parameter	Age	Probe tone frequency & age (in Hz)	Mean Males	Mean Females	SD Males	SD Females	Range Males	Range Females
Admittance	8 years	226	-7	•11.5	23.24	23.10	-50-10	-60-10
		678	-4.5	-8	21.79	20.78	-50-10	-55-10
		1000	5.5	-6	30.77	21.83	-65-50	-50-15
	10 years	226	1.5	-12	8.83	22.51	-15-15	-60-5
		678	14	-9	13.08	21.58	-10-30	-55-10
		1000	12	0.5	24.74	22.66	-35-35	-50-20
	12 years	226	5.5	0.5	15.71	8.32	-20-25	-15-10
		678	12.5	4.5	29.74	11.65	-10-95	-5-35
		1000	17.5	15	26.59	22.61	0-90	-5-70
SuscePance	8 years	226	-5.5	0	24.32	8.16	-50-20	-15-10
		678	4	6	30.17	11.25	-55-35	-15-20
		1000	-5	-1	45.77	46.6	-90-35	-95-35
	10 years	226	5	-22.5	13.74	18.6	-25-20	-50-5
		678	16	-3.5	18.97	33.67	-20-35	-55-35
		1000	14	-7.5	32.9	37.44	-45-55	-50-55
	12 years	226	4	2	16.12	8.88	-20-20	-10-20
		678	13.5	15.5	12.03	19.64	-5-30	0-60
		1000	-13	4.5	34.33	25.76	-80-35	-40-45

Table-8: Showing mean, standard deviation, 't' value probaility of peak pressure at 226 Hz for susceptance tympanogram between adults and children.

	Mean	SD	't' value	Probability level	Significance
Adults	6.5	25.098	2.407	0.0154	S
Children	2.83	18.001			

Table-9: Showing mean, standard deviation, 't' value and probability of peak pressure between males and females in both adults and children at 226 Hz in susceptance tympanogram.

	Mean	SD	't' value	Probability level	Significance
Adults					
Males	5.33	25.05	-.36	0.7221	NS
Females	7.67	25.52			
8 Years					
Males	-5.5	24.32	-0.68	0.5064	NS
Females	0	8.16			
10 Years					
Males	5	13.74	3.76	0.0014	S
Females	-22.5	18.6			
12 years					
Male*	4	16.12	0.34	0.7352	NS
Females	2	8.88			

Table-6 it can be inferred that the normal range for males at 226 Hz in admittance tympanogram was -45 to 25 dapa and that for females was -30 to 45 dapa.

Brooks (1980) reported the normal range for tympanometric peak pressures to be between -50 dapa to + 50 dapa in adults. The results of the present study supports this range.

In susceptance tympanogram, at 226 Hz the normal range was between -90 to 50 dapa in males and -35 to 95 dapa in females.

Table-7 shows that with an increase in age in the admittance tympanogram at 226 Hz, the range became narrower in both male and female children. In the susceptance tympanogram in males at 226 Hz there was a narrowing of the range as the age increases unlike in female children.

The normal range for children in admittance tympanogram at 226 Hz was -50 to 10 dapa and that for susceptance was -50 to 20 dapa.

Brooks (1971) proposed that the normal middle ear pressure in children is as high as - 30 dapa. In the present study, the lowest limit exceeds beyond that reported by Brooks (1971). This difference might be due to -

1. Number of subjects selected, which Was 30, compared to 1053 in Brooks study.
2. Age range according to Brooks study was 4-11 years, but in the present study it was 8, 10 and 12 years.

3. Criteria employed for the selection of subjects - in Books study it was normal hearing children. In the present study, PTA within 20 dB, with normal bone conduction thresholds from 250 Hz - 4 KHz and an 'A' type in the impedance audiometry.

As seen in Table-8 paired 't' test showed that there was significant difference between adults and children in peak pressure in susceptance tympanogram at 226 Hz.

As shown in Table-9, from unpaired 't' test it was found that except for 10 years males and females, there was no significant difference between males and females in the adult group, 8 years and 12 years group in peak pressure.

Table-10 Showing mean, standard deviation and range for admittance and susceptance at tympanic membrane at 226 Hz, 678 Hz and 1000 Hz in admittance and susceptance tympanogram for males and females in adults.

Parameter	Probe tone frequency	Mean		SD		Range	
		Males	Females	Males	Females	Males	Females
Admittance	226 Hz	0.73	0.76	0.59	0.27	0.3-3.1	0.4-1.6
	678 Hz	1.96	2.44	1.19	0.99	0.64-5.44	0.85-4.88
	1000 Hz	1.56	1.39	0.90	0.92	-0.41-3.62	0.39-3.64
Susceptance	226 Hz	2.28	1.93	0.46	0.46	1.42-3.25	0.78-2.9
	678 Hz	5.2	4.65	1.25	0.93	2.05-8.61	1.82-6.76
	1000 Hz	7.5	3.44	2.12	1.58	2.6-11.61	0.19-6.1

Table-11 Showing mean, standard deviation and range for admittance and susceptance at tympanic membrane at 226 Hz, 678 Hz and 1000 Hz in admittance and susceptance tympanogram for male and female children.

Parameter		Probe tone frequency	Mean		SD		Range	
			Males	Females	Males	Females	Males	Females
Admittance	8 years	226 Hz	0.54	0.45	0.14	0.11	0.4-0.9	0.3-0.6
		678 Hz	1.65	1.44	0.62	0.46	0.7-2.3	0.56-1.9
		1000 Hz	2.46	1.88	0.77	0.72	0.93-3.07	0.6-2.9
	10 years	226 Hz	0.56	0.39	0.13	0.17	0.4-0.8	0.1- 0.6
		678 Hz	1.78	1.18	0.67	0.32	0.96-3.17	0.8-1.8
		1000 Hz	1.74	1.82	0.59	0.41	0.88-2.8	1.24-2.55
	12 years	226 Hz	1.02	0.53	0.69	0.29	0.4-2.2	0.2-1.2
		678 Hz	2.22	1.5	1.49	1.33	0.66-5,37	0.35-4.8
		1000 Hz	5.08	1.74	9.46	1.21	0.66-3.83	0.56-3.66
SuscePtance	8 Years	226 Hz	1.39	1.24	0.21	0.23	1.11-1.85	0.9-1.57
		678 Hz	3.61	3.39	1.04	0.54	2.46-5.91	2.8-4.33
		1000 Hz	5.13	4.52	1.86	1	3.38-8.51	3.32-6.7
	10 years	226 Hz	1.35	1.06	0.20	0.17	1.12-1.76	0.75-1.26
		678 Hz	4.16	3.06	0.66	0.31	3.23-5.42	2.44-3.32
		1000 Hz	5.7	5	0.72	0.49	4.72-7.25	4.51-0.19
	12 years	226 Hz	1.75	1.52	0.49	0.47	1.23-2.99	0.84-2.38
		678 Hz	4.25	3.99	0.67	1.26	3.27-5.08	2.06-6.36
		1000 Hz	5.83	5.60	1.02	1.51	4.55-7.49	2.64-7.68

Table-12 showing the mean, SD, 't' value and probability of susceptance at tympanic membrane between adults and children at 226 Hz, 678 Hz, and 1000 Hz

	226 Hz					678 Hz					1000 Hz				
	Mean	SD	't'Value	Probability level	Significance	Mean	SD	't' value	Probability level	Significance	Mean	SD	't' value	Probability level	Significance
Adults	2.12	0.49	8.14	0	S	4.93	1.13	6.058	0	S	5.62	2.77	0.9108	0.3664	NS
Children	1.39	0.38				3.74	0.89				5.31	1.23			

Table-13: Showing the mean, SD, 't' value and probability of susceptance at tympanic membrane between males and females in both adults and children at 226 Hz, 678 Hz and 1000 Hz,

	Mean	SD	't' value	Probability level	Signifi-cance
226 Hz. Adults					
Males	2.28	0.46	-2.82	0.0067	S
Females	1.93	0.46			
8 years					
Males	1.39	0.21	1.5	0.15	NS
Females	1.24	0.23			
10 years					
Males	1.35	0.20	3.46	0.0028	S
Females	1.06	0.17			
12 years					
Males	1.75	0.49	1.0489	0.3081	NS
Females	1.52	0.47			
678 Hz Adults					
Males	5.2	1.25	-1.82	0.0748	NS
Females	4.65	0.93			
8 years					
Males	3.61	1.04	0.60	0.5553	NS
Females	3.39	0.54			
10 years					
Males	4.16	0.66	4.76	0.0002	S
Females	3.06	0.31			
12 years					
Males	4.25	0.67	0.57	0.5777	NS
Females	3.99	1.26			
1000 Hz Adults					
Males	7.5	2.12	-8.028	0	S
Females	3.44	1.58			
8 years					
Males	5.13	1.86	0.91	0.3748	NS
Females	4.52	1			
10 years					
Males	5.7	0.72	2.55	0.0199	S
Females	5	0.49			
12 years					
Males	5.83	1.02	0.26	0.7970	NS
Females	5.68	1.51			

Table-14 Showing the 't' value, and probability for susceptance at tympanic membrane between 226 Hz and 678 Hz, 678 Hz and 1000 Hz and 226 Hz and 1000 Hz in males and females for both adults and children.

	F 226 and 678 Hz			678 and 1000 Hz			226 and 1000 Hz		
	't" value	Prob. level	Slgnif i cance	't' value	Prob. level	Signifi cance	't' value	Prob. level	Signifi cance
Adults									
Males	12.66	0	S	-9.51	0	S	13.73	0	s
Females	16.89	0	S	3.22	0.0036	S	4.22	0.0003	s
8 years									
Males	7.97	0	S	-4.39	0.0017	S	6.96	0.0001	s
Females	16.34	0	S	-5.08	0.007	S	11.92	0	s
10 years									
Males	13.49	0	S	-6.81	0.001	S	21.51	0	s
Females	20.59	0	S	-13.22	0	S	22.58	0	s
12 years									
Males	12.34	0	S	-5.82	0.0003	S	11.47	0	s
Females	9.62	0	S	-6.74	0.0001	S	11.11	0	s

Table-lO shows that the susceptance at the tympanic membrane ranges from 1.42 - 3,25 mmhos in adult males and in females from 0.78 . 2.9 mmhos at 226 Hz.

Table-11 shows that the admittance at the tympanic membrane ranges from 0.4 - 2.2 at 226 Hz in male children and 0.1 - 1.2 mmhos in female children.

Table- 11 shows that the susceptance at the tympanic membrane ranges from 1.11 - 2.99 mmhos at 226 Hz in male children and in female children from 0.75 -2.38 mmhos.

Jerger (1972) reported that women consistently showed a lower average compliance and less variance than men at all ages.

The present study is in agreement with this statement.

As seen in Table-12 paired 't' test showed that at 226 Hz and 678 Hz there was significant difference between adults and children. But at 1000 Hz there was no significant difference between adults and children.

As shown in Table-13, unpaired 't' test, found no significant difference between males and females in the 8 year and 12 year age group at 226 Hz, 678 Ha, and 1000 Hz. In the 10 year group, males and females showed significant difference in susceptance at tympanic membrane at all the.

3 frequencies. In the adult males and females, significant difference was found at 226 Hz and 1000 Hz but at 678 Hz ao significant difference was found.

Table-14 shows that as the probe tone frequency increases the susceptance at the tympanic membrane increases. This difference was statistically significant between 226 Hz and 678 Hz, 678 Hz and 1000 Hz, 226 Hz and 1000 Hz in adults and children in both males and females.

SUMMARY

The present study was done on 30 normal hearing adults 15 males and 15 females age ranging from 18-26 years and 30 normal hearing children of 3 age groups (8, 10, and 12 years) consisting of 5 males and 5 females in each age group. Using Grason-Stadler-33 Version 2 Middle Ear Analyzer, Physical volume, Peak pressure and susceptance at tympanic membrane were obtained and normative data for admittance and susceptance tympanograms were established.

Statistical analysis was done for the above mentioned parameters using paired and unpaired 't' test.

CONCLUSION

The following conclusions were drawn from the present study:

1. As the probe tone frequency was increased, the tympanograms showed notches. The notches were more frequent for susceptance tympanogram compared to admittance tympanogram.

2. As the age increase, the physical volume increases.

3. In susceptance tympanogram at 226 Hz, the middle ear peak pressure ranged from -90 to 50 dapa in males and -35 to 95 dapa in females. In children, range was from -50 to 20 dapa.

4. Regarding susceptance at the tympanic membrane at 226 Hz, the range for adult males was from 1.42 - 3.25 mmhos and 0.78 - 2.9 mmhos in females. For male children the range was 1.11 - 2.99 mmhos and 0.75 - 2.38 mmhos for female children.

5. The susceptance at the tympanic membrane increased as the probe tone frequency was increased.

6. There was significant difference between adults and children in susceptance at the tympanic membrane at 226 Hz and 678 Hz but not at 1000 Hz.

Limitations of the present study;

The present study has limited domain, in the following aspects:-

1. Eventhough simple random sampling was done for selection of subjects, the number of subjects were less.
2. Children less than 8 years of age were not considered in the study.

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