" Help forgotten children

to become happy children "

To

My Mother

ACOUSTIC REFLEX THRESHOLDS AT DIFFERENT AIR PRESSURE LEVELS

An Independent Project in Audiology

Presented to the University of Mysore

In Partial Fulfilment for the First M.Sc Examination

In Speech and Hearing - May 1981

CERTIFICATE

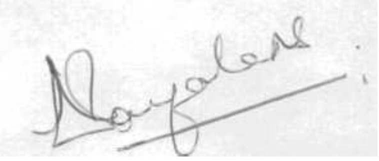
This is to certify that the independent project in Audiology entitled **" Acoustic reflex thresholds at different air pressure levels "** is the bona fide work, in partial fulfilment for the M.Sc First Year Examination, of the student with Register No.13.

All India Institute of Speech & Hearing

Mysore-6.

CERTIFICATE

This is to certify that this independent project in Audiology has been prepared under my supervision and guidance.



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DECLARATION

This Independent Project in Audiology is the result of my own study undertaken under the guidance of Mr.Jesudas Dayalan Samuel, Lecturer in Audiology, All India institute of Speech and Hearing, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore

May,1981 Register No.13.

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Chapter I

INTRODUCTION

The development of impedance audiometry during the past decade has enhanced the diagnoistic sensitivity of the audiological test battery and also added new scope and dimension to the clinical audiology.

The modern impedance audiometry includes atleast three separate types of measurements (Jerger,1975).

1. tympanometry
2. absolute or static compliance and
3. stapedius reflex threshold.

Of the three measures, the stapedius reflex tnresh-olds are most useful individually (Jerger,1970). Usually the reflex thresholds were measured at the relative middle ear pressure, that is, at the most compliant pressure level.

In the measurement of acoustic reflex threshold, the electroacoustic bridge is used to show relative changes in impedance. These changes in impedance can occur only when the contraction of the stapedius muscle is strong enough to cause a movement of the ossicular chain which creates a perceptible stiffening at the tympanic membrane. Therefore, it follows that the muscle may be stimulated, at lower intensity levels, but it does not contract enough at that point to cause a stiffening at the tympanic membrane (Wilber,1976). Many investigators have shown that as the stimulus intensity increases, there will be increased stiffening of the tympanic membrane (Dallos,1964; Peterson and Liden,1972; Beedle and Harford,1973) and viseversa.

Need for the study

Many text books as well as instruction manuals, accompanying commercial electroacoustic impedance bridges and meters recommedd that when testing middle ear muscle reflex thresholds, the tympanic membrane should be at it's position of greatest compliance (Martin,1974; Jerger,1975). This is because, these instruments are constructed so as to detect even small changes in impedance with the muscle contraction. Therefore,less compliant the tympanic membrane, the greater the impedance.

Many investigators have studied the acoustic reflex thresholds with an hermetic seal (Jerger,1970; Jepsen,1963 Klockhoff,1961; Chiveralls and Fitzsimous,1973; Peterson and Liden,1972). Only few investigators have studied without an hermetic seal (Surr and Schuchman,1976; Basu, 1977; Kaplan,Babechiand Thomas,1980). But nobody, except Martin and Coombes (1974) studied the acoustic reflex thresholds at different air pressure levels in the external auditory meatus.

Martin and Coombes (1974) have tested 20 normal hearing individuals to determine the relationship between positive and negative air pressure in the external auditory meatus and the intensity required to elicit the acoustic reflex at 1KHz. They varied the pressure from +240 to -240mm H_2O, in 40mm H_20 step, and at each level, determined the acoustic reflex threshold level. The magnitude of differences was smaller than they might have been anticipated. They also recommended to study the reflex threshold at frequencies other than l000Hz, by varying the air pressure levels in the external auditory meatus.

Because of the above mentioned reasons, the present study was undertaken.

Purpose of the study:

The purpose of the present study was to determine the effect of air pressure variations in the external auditory meatus on the sound pressure level required to elicit stapedius muscle reflex.

Statement of the problem:

1. Can acoustic reflex thresholds be obtained at various pressure levels, ranging from +500 to -600mm H_20 inside the external auditory meatus?
2. Will there be difference in acoustic reflex

threshold at various pressure levels?

3. Will there be differences in acoustic reflex threshold for different frequencies (500,1000 and 2000Hz) at various pressure levels?
4. Which pressure level (positive or negative air pressure level inside the external auditory meatus) produces maximum elevation in the acoustic reflex threshold level?

Hypothesis:

1. Acoustic reflex thresholds can be obtained at various pressure levels, ranging from-+300 to -600mm H_2O inside the external auditory meatus.
2. There will be difierences in acoustic reflex threshold at various pressure levels.
5. There will be differences in acoustic reflex threshold for different frequencies (500,1000 and 2000Hz) at various pressure levels.
4. Both positive and negative air pressure levels inside the external auditory meatus produce similar elevation in acoustic reflex levels.

Definiton of the terms used:

1. Reflex: is a regulatory and control process in all living organisms (Borg,1972).

2. **Compliance**: An expression of ease or magnitude of movement of the ear dum and middle ear system (Feldman and Wilber,1976).
3. **Impedance**: An expression of the difficulty of flow of energy measured at the surface of ear drum (Feldman and Wilber,1976).
4. **Contralateral(crossed) reflex**: The acoustic reflex monitored in one ear and stimulated in the contra-lateral ear (Feldman and Wilber,1976).
5. **Ipsilateral(uncrossed)reflex**: An acoustic reflex monitored on the same side as the reflex inducing stimulus is presented (Feldman and Wilber,1976).
6. **Probe**:tube inserted and sealed in the ear canal that carries the incident and reflected acoustic signal and variable air pressure from the instrument (Feldman and Wilber,1976).
7. **Probe tone**: the acoustic signal introduced into the ear canal whose properties are compared with the signal resulting as a consequence of reflection off the ear drum (Feldman and Wilber,1976).
8. **Static measurement**: a measure of the steady state of impedance or one of it's components or their reciprocals- usually accomplished with electroacoustic instruments by comparing the flow measured with the

the ear drum stiffened by air pressure introduced into ear canal and flow measured with the ear drum relaxed (Feldman and Wilber,1976).

9. **Tympanogram:** display of changing energy flow through the middle ear (Feldman and Wilber,1976).

Chapter II

REVIEW OF LITERATURE

During the past decade, impedance audiometry has affected the practice of clinical audiology profoundly (Jerger,1975). Within a very short span of time, measurement of impedance characteristics of middle ear has been progressed from a sophisticated research tool to a clinical procedure applicable to all patients.

Recent literature demonstrates that the reflex measurement can be used to assess the degree and slope of sensorineural hearing loss(Neimer and Sesterhenn, 1972; Jerger and Jerger,1972), confirming the presence of middle ear disorder (Shallop,1976; Jerger and jeger, 1974), select the gain and maximum power output characteristics of hearing aids (McCandles,1973), to validate non-organic hearing loss, to evaluate difficult-to-test patients, to predict the degree of hearing loss, to help localize facial nerve lesion (Jerger,1970), to findout cochlear and retrocochlear pathology (Klockoff, 1961; Alberti and Krietensen,1970), to detect central auditory disfunction (Jerger and Hall,1978) and in the evaluation of phonatory and speech disorders (.McCall, 1976)Hall and Jerger,1976; Shearer and Simmons,1965).

Wollston, in 1820 gave descriptive effects of abnormal pressure in the middle ear on hearing. He described a maneuver later attributed to Toynbee, that created negative pressure within the middle ear by closing the nose and then attempting to inhale strongly (Shallop,1976).

Politzer (1869), an Austrian Surgeon recognized the importance of air pressure within the middle ear and suggested that contraction of the tensor tympani muscle could cause further inward movement of the tympanic membrane in case of negative pressure (Shallop,1976).

According to Shallop (1976), Eysell (1870) reported the movement of stapes due to positive and negative air pressure in the external ear canal.

Pohlman and Kranz (1923) reported that the effects of positive and negative pressure for one subject. But their subject had $\pm$100mm H_2O static pressure. Their extended investigations showed that sound transmission was best at 0 mmH_2O pressure (Schallop,1976).

Frenckner in 1939 as reported by Schallop (1976), filmed movement of tympanic membrane of normal and otosclerotic ears while pressure of $\pm$780mmH_20 were applied to the external auditory meatus. Frenckner observed less movement of malleus and surrounding tympanic membrane in cases of otosclerosis.

Dahmann,(1930) after applying $\pm$ 60 mmH_2O pressure in the ear canal reported that outward movement of malleus handle as well as the incus were greater than increased movements (Shallop,1976).

As reported by Schallop (1976) during 1934, Thompson, Howe and Hughson studied the effects of pressure on sound transmission in cats, and found that -65mm of H_2O of pressure was the minimum pressure required to detect a measurable reduction of sound transmission to the cochlea.

Metz, during 1934 and 1939 studied the effect of positive and negative middle ear pressure on temporal bone preparations and concluded that " rather small differences of pressure not only give measurable but even considerable differences of impedance" (Schallop, 1976).

Metz (1946) in his classic monograph gave a complete description of the effect on acoustic impedance measurements caused by contraction of middle ear muscles (Schallop,1976).

In normal ear, the acoustic reflex may be elicited with contralateral stimulation at sensational levels of 65 to 105dB (Metz,1946 (Wilber,1976),Moller,1961; 1962; Jerger et.al,1972).

Acoustic reflex measurement without an Hermetic seal:

Surr and Schuchatan (1976) compared acoustic reflex thresholds with and without a pressure seal on 10 normal adults, 10 sensorineurally impaired adults with normal tympanograms and 10 children with negative pressure tympanograms. They found that for adult groups 95% of the measurements obtained without a pressure seal were within 5dB of those obtained in the sealed conditions. But the same were present in the sealed condition. Surr and Schuchman concluded that when an acoustic reflex was elicited without a pressure seal then the clinician can be confident that the probe ear was free of conductive pathology.

Basu (1977) studied the acoustic reflex thresholds on two groups of subjects. Group I consisted of 15 young adults who had normal hearing, A type tympanogram and middle ear pressure within $\pm 20 mmH_2 0$. Group II consisted of 7 subjects who had C type tympanogram with or without hearing loss and showed acoustic reflex at the point of maximum compliance. He observed that in normal subjects acoustic reflex thresholds were not affected even without airtight sealing. In the 5 subjects, with negative middle ear pressure, the difference between acoustic reflex threshold with and without air tight sealing ranged from 10 to 35 dB. For 2 subje cts with negative middle ear pressure reflex was absent when the pressure seal was absent.

Kaplan, Babeeki and Thomas (1980) compared sealed and unsealed reflex in 30 children with normal middle ears. Their results indicated that: 1. approximately two-thirds of the children demonstrated reflexes in the unsealed condition 2. differences between sealed and unsealed reflex thresholds were not clinically significant. 3. in most cases, unsealed reflexes were measurable at all frequencies or at none. 4. neither size of ear canal volume nor amplitude of the sealed reflex at l0dBSL seemed to be related to the presence of absence of the unsealed reflex. They concluded that reflex thresholds obtained in the absence of an hermetic seal may be considered valid, but the absence of an unsealed reflex should not be considered diagnostically significant.

Impedance audiometry in Indian population:

In 1973, Venkateshamurthy reported a study. which deals about the acoustic reflex and it's clinical application.

Basavaraj (1973) measured the acoustic impedance in 136 Indians.

Mythili (1975) did a comparative study of acoustic reflex thresholds for pure tones, narrow band noise and wide band noise in 100 normal hearing subjects and 15 moderate sensori neural hearing loss cases.

Zachariah (1980) studied the relationship between the acoustic reflex threshold and temporary threshold shift in 70 normal hearing subjects.

Basu (1977) measured the acoustic reflex without airtight sealing in 15 young adults who had no middle ear pathology and in 7 subjects who had C type tympa-nogram.

A case report of negative acoustic reflex was reported by Samuel et.al (1979).

Shukla (1980) did a comparative study on the reflex amplitude and decay time for contralateral and ipsilat-eral stimulation at different sensational levels in normals.

Prediction of auditory sensitivity and slope of the audiometric contour from acoustic reflex measures in 32 normal hearing subjects were carried out by Sudha (1980)

Bhat(l980) did a study on impedance measurement in rheumatoid arthrities.

An objective method of Validating puretone thresholds was found out by Ragunathan (1977).

Kulkarni (1975) discussed about the uses and utility of electroacoustic impedance bridges in the differential diagnosis of middle ear disorder.

An objective method of determining recovery period and asymptotic period from loudness adaptation was carried out by Vidya (1977).

Vyasamurthy (1977) proposed a new approach towards calibration of audiometers termed as the,"objective-biological calibration".

Vyasamurthy and Satyan (1977) studied the effect of Masking and fatigue on acoustic reflex threshold.

Chapter 3

METHODOLOGY

1. Subjects:

The experimental group consisted of 14 males and 10 females, ranging in age from 18 to 24 years. The subjects were selected based upon the following criteria:

1. Normal hearing in both the ears (thresholds no greater than 20dB HL from 350 to 4000Hz).
2. No history of external or middle ear pathology.
3. No history of any neuromuscular impairment.
4. Negative otological findings.
5. A pressure compliance peak within $\pm$20mm of H_2O pressure.
6. A measurable reflex at a level of 115dBSPL, atleast in one ear.

2. Apparatus:

For preliminary screening purposes a commercially available diagnostic audiometer (Maico MA 22) was used. The transducers (TDH-39) of the audiometer were housed in cushions (MX-4l/AR).

Impedance audiometry was carried out by means of an electroacoustic impedance bridge (Madsen Model ZO 73). Contralateral reflex thresholds were elicited using Telex (1470) earphone, enclosed in it's associated ear cushion.

3. Calibration of apparatus:

The diagnostic audiometer used in this research was calibrated so that audiometric zeros at various frequencies were at specified SPL with reference to 0.0002 dynes/cm^2 (ANSI, 1969). The diagnostic audiometer system, including the earphones (TDH-39) with the associated cushion (MX-41/AR) was calibrated periodically during the course of the investigation with an artificial ear assembly (Bruel and Kjaer 4152) using a condensor microphone (Bruel and Kjaer,4144) and a sound level meter (Bruel and Kjaer,2203) with it's associated octave band filter net work (bruel and Kjaer,1613).

2 cc coupler attached to condensor microphone (Bruel and Kjaer, 4141) to sound level meter (Bruel and Kjaer,2203) with octave filter set (Bruel and Kjaer,1613) was used to calibrate probe tone and it's sound pressure level value. 2cc standard cavity (Bruel and Kjaer) and Madsen variable cavity were used to calibrate the compliance scale reading. The earphone output was checked using an artificial ear assembly (Bruel and Kjaer,4152) using a condensor microphone (Brael and Kjaer,4144) and a sound level meter (Bruel and Kjaer,2203) with it's associated octave band filter network (Bruel and Kjaer,1613).

Before testing each patient, the probe tip was fitted to built-in 2cc cavity of the electroacoustic impedance bridge (Madsen Model Z073). After ensuring that these was no pressure leakage, the sensitivity knob was switched to position two, compliance scale was adjusted to read two by rotating compliance knob. At this time, if the balance meter did not read zero, necessary adjustments were made as recommended by the manual.

4. Test Environment:

All testings were performed in the newly constructed sound proof rooms of the All India Institute of Speech and Hearing, Mysore. The noise level in the test room was far below the interference level as measured by a sound level meter (Bruel and Kjaer, 2205).

5. Procedure:

(a) Screening procedure:

All subjects were tested by both conventional and impedance audiometry as a routine part of their clinical evaluation by the Audiology service of the All India Institute of Speech and Hearing, Mysore. Otoscopic examination and impedance screening were performed prior to actual experiment to accurately rule out the influence of any unnoticed external or middle ear pathology.

Puretone thresholds were determined for both ears using Hughson-Westlake procedure (Carhart and Jerger,1959).

A normal audiogram was defined as one in which no threshold on either ear, exceeded 20dEHL over a range from 250 to 4000Hz.

Electroacoustic impedance bridge (Madsen Model Z073) was used to obtain three impedance measurements on each ear. 1. tympanogram 2. static compliance and 3. threshold of the stapedius reflex for puretones. Tympanometry was performed in each ear. All subjects of this investigation showed normal tympanograms (A type). All subjects also showed maximum compliance in the pressure range $\pm$20mm H_2O.

(b) Test procedure:

For detailed investigations, impedance audiometry was carried out by means of an electro acoustic impedance bridge (Madsen Model Z073). The subject was seated in a comfortable chair and the head band was carefully positioned so that the test earphone covered one ear completely. A probe tip containing two tubeswas then sealed in the external ear canal of the opposite ear, forming a closed cavity bounded by the inner surface of the probe tip, the walls of the external ear canal and the tympanic membrane. Ru bber ear tips supplied with the instrument were used. One tube was used to deliver, into this closed cavity, a probe tone generated by a 220Hz as oscillator, driving a miniature receiver. The same tube was connected to a miniature probe microphone which monitors the sound pressure level of the 220Hz probe tone in the closed cavity and delivers the transduced voltage through an amplifier to a bridge circuit and balance meter. The balance meter was nulled by an SPL of exactly 85dB in the closed cavity. The second tube was connected to an air pump which permits variation in air pressure in the closed cavity over a range from +300 to - 600mm of H_2O. Air pressure was read on an electro-nanometer.

The adequacy of the seal was verified by the introduction of positive and negative air pressure in the external auditory meatus respectively.

The main purpose of this research was to measure acoustic reflex thresholds at different air pressure levels in the external auditory meatus. For this purpose, middle ear pressure was determined and the manometer was adjusted to the middle ear pressure. Then balance meter was set to sensitivity position three and nulled to zero. After this puretones were introduced to the opposite ear. The intensity of the puretone was varied untill the test ear had identified the lowest hearing level at which a deflection of the balance meter synchronous with the onset and offset of the tone could be observed. This level was recorded as acoustic reflex threshold HL. Then air pressure inside the external ear canal was varied in 100mm

H_2O pressure step from +300 to - 600mm H_2O. At each step, balance meter was set to zero, and acoustic reflex thresholds were obtained as explained above. The order of presentation level was counterbalanced to avoid order effects. In this fashion reflex thresholds were measured for signals of 500,1000 and 2000Hz.

When testing had been completed on the first ear, headband, earphone, and probetip were reversed and the entire procedure was repeated on the opposite ear.

Reliability check: To check the reliability of the results obtained in the present study, the experiments were repeated to the four subjects (8ears) and results were statistically analyzed.

Chapter

RESULTS AND DISCUSSION

In this study stapedius reflex thresholds for contralateral stimulation were measured by varying the air pressure levels inside the external auditory meatus.

Data obtained from 24 subjects or 48 ears are given in three tables. The first table gives information about reflex thresholds obtained for 500Hz, at various air pressure levels. Similarly table two has information obtained using 1000 Hz and table three about 2000 Hz pure tone.

First row of each table indicates different air pressure levels, ranging from +300 to -600 mmH_2O, inside the ear canal at which reflex thresholds were measured. Row two indicates number of ears in which reflex thresholds could be measured at respective air pressure levels. Row three depicts the mean intensity required to elicit middle ear muscle reflex thresholds for the respective number of ears. Row four indicates the difference between the mean reflex thresholds at respective air pressure levels when compared to mean reflex threshold at Omm H_2O, middle ear pressure. Last row has standard deviations for reflex thresholds at various pressure levels in the ear canal

All three tables have similar information. Only difference between them is the test tone frequency.

The results indicate that higher intensities were required to elicit middle ear muscel reflex threshold as pressure levels inside the external auditory meatus were either decreased or increased. The mean differences between the aooustic reflex thresholds obtained by changing the pressure within the ear canal when compared to mean reflex at middle ear pressure ranged from 6.47dB at l00mmH_2O to 29.5dB at -500mmH_20 for 500 Hz; From 5.64dB at -100 mmH_2O to 27.26dB at -400mmH_20 for l000Hz and from 4.05dB at-100 mmH_20 to 23.57dB at 300 and -400 mmH_2O for 2000 Hz.

Results of the present study indicate that higher intensities were required to elicit the middle ear muscle reflex thresholds as pressure levels inside external ear canal were either decreased or increased. This increase in intensity was said to be slight by Martin and Coombes (1974), not exceeding a mean of 5.1dB at -240mmH_20. But the present study showed greater variations even with the l00mmH_2O change inside the ear canal in both directions. Martin and Coombes (1974) changed the pressure only from 240 to -240mmH_20, where as in the present study, pressure was changed from +500 to -600mmH_20. This difference could be directly attributed to the differences in the instrument used. (Martin and Coombes,(l974) used Madsen Model Z070 electro acoustic impedance meter, whereas in the present study Ladsen Model Z073 electroacoustic impedance bridge was used). They varied air pressure in 40 mmH_2O step, but in the present study pressure was varied in $l00mmH_2O$ step. Present study used three test frequencies, that is 500,1000 and 2000Hz whereas Martin and Coombes (1974) used only one test frequency, that is l000Hz.

The difference between the mean reflex thresholds at different air pressure levels when compared to mean reflex threshold at Middle ear pressure ($0mmH_20$), can be seen in the forth row of each table. Comparison of results obtained by Martin and Coombes (1974) with the present study indicates that higher intensities were required to elcit reflex threshold when air pressure inside the ear canal was changed.

Results of the present study suggest that the reflex could be obtained even if the pressure was nchanged from +300 to $-400mmH_2O$ except for 500Hz, where reflex was measured in only one ear at $-500mmH_2O$.

An interesting point observed in this study was that, the unmber of ears in which reflexes could be observed was not same at all air pressure levels, and at all three frequencies. Almost all subjects did exhibit reflexes when the air pressure was varied in between $\pm$l00mmH_2O. When air pressure was further decreased or increased, from middle ear pressure, the number of middle ears exhibiting reflexes grew small. This was observed in all three test frequncies.

Mean acoustic reflex threshold for l000Hz, at middle ear pressure was 94.5dB according to Martin and Coombes (1974). But in the present study mean acoustic reflex threshold for l000Hz, at middle ear pressure (OmmH_2O) was 96.74dB; for500Hz mean acoustic reflex threshold at middle ear pressure was 95.48dB and for 2000Hz, it was 96.63dB.

Many investigators have reported that in normal ear at middle ear pressure the acoustic reflex are elicited at sensational levels of 65 to l05dB (Metz, 1946;Moller,1961 and Jerger et.al,1972). Mythili (1975) observed mean acoustic reflex threshold of 90.12 dBSPL for pure tones in normal at middle ear pressure. Raghunathan (1977) elicited reflex thresholds at SPL of 85 to ll0dB. Sudha (1980) reported that the acoustic reflex may be elcited at SPL of 73 to 105dB. In the present study acoustic reflex was elicited at SPL of 80 to 115dB at middle ear pressure. Mean acoustic reflex threshold for 500Hz at middle ear pressure was 95.48dBSPL For l000Hz it was 96.74 dBSPL and for 2000 Hz it was 96.65dBSPL.

Martin and Coombes (1974) observed feflexes in all of the 20 normal hearing subjects, when pressure inside the ear canal was varied from $\pm$230 to -240mm$H_2$0. In the present study as the pressure inside the ear canal was either decreased or increased, the number of ear exhibiting reflex as monitored by the impedance bridge decreased.

Number of ears in which reflex could be monitored at +300mmH_2O was 11 for 500Hz, 12 for l000Rz and 12 for 2000Hz. Similarly number of ears in which reflex could be monitored at -400mm$H_2$0 was 4 for 500Hz, 5 for l000Hz and 3 for 2000Hz.

Sur and Schuchman (1976), reported that the acoustic reflex could be measured consistently at the point of maximum compliance (middle ear pressure) in case of the subjects who exhibit negative middle ear pressure. But they did not observe reflex without a pressure seal. Basu (1977) reported that it was possible to observe reflex in five out of seven subjects who exhibited negative middle ear pressure. With and without air tight sealing.

The present study indicates that it is possible to observe reflex in those cases whom negative middle ear pressure is induced.

In the present study an attempt was made to determine the effect of varying external ear canal pressure on the stapedius muscle reflex thresholds. It was observed that change in pressure inside the external auditory meatus will effect middle ear muscle thresholds considerably. Air tight sealing is essential to avoid any influence of negative or positive middle ear pressure on reflex thresholds and caution should be exercised in interpreting results without an hermetic seal.

In table five,four and six mean and standard deviations values and interpretations are presented for the acoustic reflex thresholds at different air pressure levels inside the external auditory meatus forl000,500 and 2000Hz,resp-ectively. The analysis of the data shows that there is no significant difference between test and retest scores.

Table 1

Test Frequency: 500Hz

Means and standard deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal

(Total = 48ears; Absent = 6ears)

Air Pressure (mmH_2O)

	+300	+200	+100	0	-100	-200	-300	-400	-500	-600
Number of ears	11		41	42	42	38	19	^ 4	1	
SPL for reflex (dB)	117.73	112.7	101.95	95.48	102.5	110.79	116.59	123.75	125	—
Increase above reflex threshold with minimum tympanic membrane impedance (mean indB)	22.25	17.22	6.47	0	7.02	15.31	21.11	28.27	29.52	-
Standard deviations	8.59	9.68	9.31	8.32	8.88	9.21	7.45	2.17	0	-

Table 2

Test Frequency: 1000Hz

Means and standard deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal

(Total = 48 ears;Absent = 5 ears)

Air pressure (mmH_2O)

	+300	+200	+100	0	-100	-2'00	-300	-400	-500	-600
Number of ears	12	32	42	43	42	38	21	5	-	-
SPL for reflex (dB)	115.42	112.19	102.5	96.74	102.38	108.82	116.67	124	-	—
Increase above reflex threshold with minimum tympanic membrane impedance (mean in dB)	18.68	16.16	5.76	0	5.64	12.08	19.93	27.26	-	-
Standard deviations	7.98	9.32	7.58	6.61	8.96	8.87	7.24	2	-	-

Test Frequency: 1000Hz

Means and standard deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal (N=20)

	Air Pressure (mmH_2O)												
	-240	-200	-160	-120	-80	-40	0	+40	+80	+120	+160	+200	+240
SPL for reflex (dB)	99.6	99.0	99.0	97.9	96.9	96.2	94.5	95.8	96.5	97.7	98.3	98.6	99.3
Increase above reflex threshold with minimum tympanic membrane impedance (mean in dB)	5.1	4.5	4.5	3.4	2.4	1.7	0	1.3	2.0	3.2	3.8	4.1	4.8
Standard deviations	2.93	2.14	2.29	1.96	1.19	1.34	0	1.57	1.45	1.64	2.78	1.99	1.76

(ref.: Martin and Coombes, 1974. effect of external ear canal pressure on the middle ear muscle reflex threshold, Journal of Speech and Hearing Research, 17,529).

Table 3

Test Frequency: 2000Hz

Means and standard deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal

(Total = 48ears;Absent= 8ears)

	Air Pressure(mmH_2O)									
	+300	+200	+100	0	-100	-200	-300	-400	-500	-600
Number of ears	12	24	38	40	. 37	32	17	3	-	-
SPL for reflex (dB)	120	108.13	103.42	96.63	100.68	108.28	118.24	120		-
Increase above reflex threshold with minimum tympanic membrane impeda-nce (mean indB)	23.37	11.5	6.79	0	4.05	11.65	21.61	23.37	-	-
Standard deviations	5	10.73	10.53	11.53	11.48	13.342	7.58	7.07	-	-

Table 4

Test Frequency: 500Hz

't' test results

		Air Pressure (mm H_2O)									
		+300	+200	+100	0	-100	-200	-300	-400	-500	-600
Number of ears	Test	11	30	41	42	42	38	19	4	1	
	Retest	4	5	5	8	7	6	3	2		—
SPL for reflex (in dB)	Test	117.73	112.7	101,95	95,48	102,8	110.78	116.59	123.75	125	-
	Retest	120.5	114.5	110.4	94.50	105.5	115.4	114.40	120.5	-	-
Standard deviations	Test	8.59	9.68	9.31	8.32	8.88	9.21	7.45	2.17	—?:	
	Retest	10.54	12.40	10.20	5.45	12.40	8.45	9.45	4.43		-
t values		0.52	0.37	0.89	0.30	0.78	1.15	0.44	1.45	-	
0.05		NS	NS	NS	NS	NS	NS	NS	NS	-	-
0.01		NS	NS	NS	NS	NS	NS	NS	NS	-	

(Note: NS = not significant)

Table 5

Test Frequency: lOOOHz

't' test results

		Air Pressure (mm H_2O)									
		+300	+200	+100	0	-100	-200	-3000	-400	-500	-600
Number of ears	Test	12	32	32	13	42	38	21	5	-	-
	Retest	5	6	7	8	8	5	4	2		
SPL for reflex (in dB)	Test	115.42	112.19	102.5	96.74	102.38	108.82	116.67	124		-
	Retest	118.30	117.51	105.40	94.50	101.41	106.59	118.85	123		
Standard deviatioats	Test	7.98	9.32	7.58	6.61	8.96	8.87	7.25	2		
	Retest	10.40	8.50	10.34	8.85	10.4	10.45	6.86	1.25	-	
t values		0.62	1.30	0.89	0.83	0.27	0.52	0.56	0.64	-	
0.05		NS	NS	NS	NS	NS	NS	NS	NS	-	-
0.01		NS	NS	NS	NS	NS	NS	NS	NS	-	

(Note: NS = not significant)

Table 6

Test Frequency: 2000Hz

't' test results

Air Pressure (mm H_2O)

		+300	+200	+100	0	-100	-200	300	-400	-500	-600
Number of ears	Test	12	24	38	40	37	32	17	3 -		—
	Retest	3	4	5	8	7	5	3x	1 -		-
SBL for reflex (in dB)	Test	120	108.13	103.42	96.63	100.68	108.28	118.24	120 -		—
	Retest	1222	115.20	103.25	95.40	102.24	110.54	120.30	125 -		-
Standard deviations	Test	5	10.73	10.53	11.53	11.48	13.42	7.58	7.07 -		-
	Retest	4.5	1T.54	9.45	8.59	15.58	10.25	10.40	0 -		
t values		0.68	1.21	0.64	0.26	0.31	0.36	0.42	- -		-
0.05		NS	NS	NS	NS	NS	NS	NS	--		-
0.01		NS	NS	NS	NS	NS	NS	NS	-	-	-

(Note: NS = not significant)

Chapter 5

SUMMARY AND CONCLUSIONS

Twentyfour normal hearing individuals served as subjects in this present study designed to determine the effect of positive and negative air pressure in external auditory meatus and the intensity required to elicit stapedius muscle reflex. Pressure was varied from +300 to -600 mmH_2O in l00mmH_20 step. Following conclusions were drawn from the results obtained.

1. As the air pressure was varied in the ear canal, systematic increase in the intensity required to elicit acoustic reflex threshold were noted.
2. Acoustic reflex thresholds could be obtained at various pressure levels ranging from +300 to -400 mmH_2O inside the external auditory meatus.
3. There were differences in acoustic reflex thresholds at various pressure levels.
4. There was not much difference in acoustic reflex thresholds for different frequencies (500,1000 and 2000Hz) at Various pressure levels.
5. Both positive and negative air pressure levels inside the external auditory meatus produce similar elevation in acoustic reflex threshold levels.

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