Imperial Journal of Interdisciplinary Research (IJIR)
Vol-2, Issue-5, 2016
ISSN: 2454-1362, http://www.onlinejournal.in

Co-Relation between Pure Tone Threshold and Acoustic Reflex Threshold in Normal Hearing Population

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Abstract

Introduction

The main components of routine audiological test battery are pure tone audiometry as well as immittance audiometry. The purpose of the present study was to find the correlation between acoustic reflex threshold (ART) and pure tone threshold (PTA) in normal adults.

Method

Thirty subjects in the age range of 20 to 25 years with normal hearing sensitivity were selected with equal number of both the genders. All the participants underwent otoscopic examination, Weber test and tympanometry which revealed to be normal. All the subjects with otological symptoms, hearing loss and neurological symptoms were excluded from the study. Modified Hughson Westlake (1959) procedure was followed using pure tone stimulus in calibrated GSI-61 Audiometer. Ipsilateral ART was taken in calibrated GSI Tympstar middle ear analyzer, using a probe stimulus to monitor admittance changes elicited by a reflex-activating stimulus.

Subjects were asked to be seated in a well illuminated sound treated audiometric room. Calibrated headphone TDH-49 was used and pure tone average was calculated using the modified Hughson Westlake procedure. Frequencies measured were 250HZ, 500Hz, 1 KHz, 2 KHz, 4 KHz and 8 KHz. All the subjects' tympanograms revealed to be type 'A'. ART was measured in frequencies 500Hz, 1 KHz, 2 KHz, and 4 KHz.

Results

The statistical evaluation revealed that the lower limit is 68.62 in right ear and 71.60 in left ear. The upper limit is 90.11 in right ear and 87.52 in left ear, i.e. approximately 70-90 dB HL in both the ear. There is a slight difference between the thresholds of right and left ear.

Discussion

PTA and ART findings are correlating according to the theoretical norms.

Conclusion

Co-relation between acoustic reflex thresholds and pure tone thresholds for tones in subjects with normal hearing and normal middle ear function are 70-90 dB HL.

***Key words**: pure tone threshold, acoustic reflex threshold, immittance, middle ear*

Introduction: Hearing is a process of perception and detection of different sound waves received by the ear. If we can hear a sound without any difficulty and recognize what it is, we have normal hearing. For the adequate development of speech and language skills, normal hearing is very important right from our birth.

There are various subjective and objective methods to evaluate the hearing status of an individual. The most widely used behavioural procedure is pure tone audiometry and objective procedure is immittance audiometry.

Pure Tone Audiometry is a procedure which is used to check the hearing sensitivity of an individual, by producing pure tones at different frequencies, control the level of these tones and deliver them to the patient's ear. Hearing threshold can be obtained by presenting the test signals through air conduction, bone conduction or in the sound field. ASHA (1978) recommended following Modified Hughson Westlake (1959) procedure to check the hearing sensitivity in all the clinical setup. The audiometric results obtained enables to determine the type, degree and configuration of the audiogram.

Acoustic Immittance is a general term used to describe the acoustic admittance, which refers to the easy flow of sound energy and impedance, which refers to opposition to the flow of sound energy. Immittance audiometry provides information regarding the middle ear system. The three major techniques which are clinically used are Tympanometry, Reflexometry and Eustachian tube function test.

Acoustic reflex testing helps to check the function of the middle ear muscles. Contraction of the stapedius muscle in response to an acoustic activating signal is known as acoustic reflex. Ipsilateral reflex pathway includes the cochlea, eight nerve, ventral cochlear nucleus, superior olivary complex, the facial motor nucleus and motor branch of seventh cranial nerve.where as a contralateral reflex pathway includes contralateral superior olivary complex and contralateral facial motor nucleus. Ipsilateral acoustic stapedial activaters are slightly stronger than the contralateral activators. An acoustic reflex threshold is the lowest intensity level at which an acoustic reflex is elicited at each frequency for each

ear.Acoustic reflex test helps in the differential diagnosis of conductive, cochlear and retrocochlear pathology. It is used to check the contraction of the middle ear muscles and helps to detect functional hearing loss and facial nerve disorders.

Determination of pure tone threshold and acoustic immittance findings are an important aspect of the clinical audiological test battery. Reports on the present study of the co-relation between pure tone threshold and the acoustic reflex threshold measures in normal hearing individuals are few. There are very few Indian studies on the recent scenario.

REVIEW OF LITERATURE

Pure Tone Audiometry helps to establish hearing threshold sensitivity across different frequencies. The obtained threshold is purely based on the subject's response. Lacae (1867) performed the first attempts at objective assessment of middle ear functions using acoustic impedance. Acoustic immittance of normal and abnormal ears was systematically evaluated by Otto Metz in 1946.In early 1970s, immittance measurements began to be a part of the routine audiometric test battery. The use of acoustic immittance techniques in screening for middle ear diseases was recommended by ASHA in 1990.

Wiley, Oviatt and Block (1987) did a study which was investigated on 77 women and 50 men on the relationship between mean auditory (hearing) thresholds and acoustic reflex thresholds for young adults with normal hearing and normal middle ear function. Their study provided norms for hearing thresholds, ipsilateral and contralateral acoustic-reflex thresholds, tympanometry, static acoustic-admittance measures, and middle-ear (tympanogram peak) pressure. Sesterhenn and H. Breuninger (2010) did a study on determination of hearing threshold for single frequency from the acoustic reflex. This study revealed that the hearing threshold can be determined for every single frequency from 0.125 to 4 KHz if the reflex is elicitable up to 8 KHz.Blood & Greenberg (2009) did a study on low level acoustic reflex thresholds and found that these thresholds can be detected at lower than normal sound pressure level by means of facilitation.Niemeyer and Sesterhenn (2009) did a study which dealt with the relation between the stapedius reflex threshold (SRT) for pure tones, white noise and 24-tone mixture (one single tone at every critical bandwidth) in normal hearing population. Their study revealed that stapedius reflex threshold for pure tones was measured at 70-85 dB (73-105dBSPLl) above the normal hearing threshold in free field, the stapedius reflex threshold for white noise (average) at 46.5 dB (68.5dBSPL), and stapedius reflex threshold for the 24-tone mixture at 47.0 dB (67.2dBSPL).

AIM OF THE STUDY

The aim of this study is to quantify the co-relation between pure tone threshold and acoustic reflex threshold in normal hearing population.

METHODOLOGY

Subjects: Participants were selected based on the inclusion and exclusion criteria for this study. The inclusion criteria were as follows:

a. All the participants were to be in the age group of 20-25 years.
b. All the participants presented a negative otologic history.
c. All the participants passed normal otoscopic examination and Weber test.
d. All the participants had hearing sensitivity within normal limits.
e. Normal tympanometric findings in both the ears.

Participants who had otologic symptoms, hearing loss and neurological symptoms were excluded from the study. A total of thirty participants with equal number of both the genders were selected based on the above criteria.

PROCEDURE

The tests were carried out in a well sound treated room with minimal electrical and mechanical interference and the temperature of the room was controlled and maintained with an air conditioner. The instruments used in the present study were calibrated Grason Stadler Incorporate-61 (GSI-61) Diagnostic Audiometer. The transducer used for air conduction testing was calibrated headphone TDH-49. The subjects were asked to be seated comfortably. Subjects were instructed to respond even to the faintest stimulus presented through the headphone by raising their finger when the sound is heard. Modified Hughson and Westlake procedure was followed in this test. Hearing threshold was tested at frequencies 250Hz, 500Hz, 1 KHz, 2 KHz, 4 KHz and 8KHz. Pure tone average was calculated by the frequencies 500Hz, 1KHz and 2KHz.

Calibrated GSI Tympstar, middle ear analyzer was used to check the middle ear function.This instrument is totally automatic and was calibrated according to the manufacture's specifications. Acoustic reflex threshold testing involves finding the lowest level of a stimulus which causes a measurable change in the acoustic immittance. This test is measured clinically by monitoring acoustic immittance in the probe ear as the tester presents acoustic activating signals at specified levels. This activating signal level is varied up or down in prescribed steps (eg: 5dB) and the lowest activator level is searched which produces a noticeable change in acoustic immittance. To obtain the ipsilateral acoustic reflex threshold, the stimulus and probe tip is given to the same ear. A hand held probe assembly with a soft rubber tip is fitted and pressed gently into the ear canal. The probe tip was pressed into the ear canal sufficiently to achieve an airtight seal. The reflex thresholds were obtained at frequencies 500Hz, 1 KHz, 2 KHz and 4 KHz with the presentation level at 80dB and were increased at 5dB steps till the reflex was noted.

Analysis:

The collected data was given for the statistical analysis, in which co-relation between pure tone thresholds and acoustic reflex thresholds across ears (right and left) and across frequencies were calculated.

RESULT

The present study was conducted to find the co-relation between pure tone threshold and stapedius reflex thresholds in normal hearing individuals.
The data analyzed is discussed below:

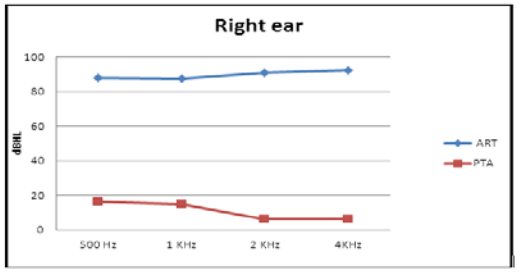

Figure 1 : showing the pure tone thresholds and acoustic reflex thresholds of Right ear.

The pure tone threshold across the frequencies, better averaged pure tone threshold was obtained at 2 KHz (5.83 dB) preceded at 4 KHz (6dB), 1 KHz (14.67dB), and at 500Hz.The average ipsilateral acoustic reflex threshold, better averaged at 500Hz (88dB), preceded at 1KHz (87.33dB), 2KHz (91dB) and at 4KHz (92.5dB).The result shows that the averaged acoustic reflex threshold is 72dB above the averaged pure tone threshold at 500Hz, preceded by 72.66 dB at 1KHz, 85.17dB at 2KHz, and 86.5 dB at 4KHz.So the obtained data shows that the co-relation between pure tone threshold and acoustic reflex threshold is 70-85dB above the pure tone threshold in the right ear for all the frequencies.

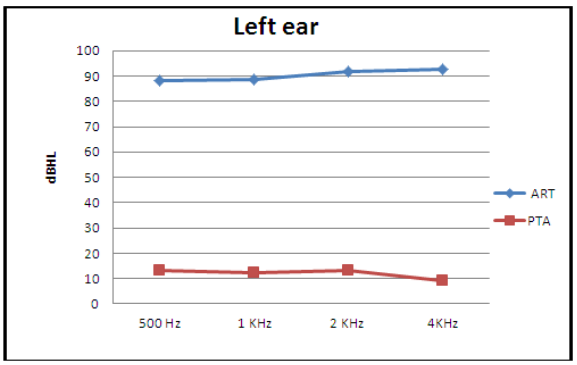

Fig 2: showing the pure tone thresholds and acoustic reflex thresholds of left ear.

The average pure tone threshold across the frequencies, better averaged pure tone threshold was obtained at 4 KHz (9dB) preceded at 1KHz (12.5dB), 500Hz (13dB), and at 500Hz(13.16dB).The average acoustic reflex threshold, better averaged at 500Hz (88.16dB), preceded at 1KHz (88.67dB), 2KHz (91.83dB) and at 4KHz (92.5dB).The result shows that the averaged acoustic reflex threshold is 75.16dB above the averaged pure tone threshold at 500HZ, preceded by 72.66 dB at 1KHz, 78.67dB at 2KHz, and 83.5 dB at 4KHz. The obtained data shows that the co-relation between pure tone threshold and acoustic reflex threshold is 70-85dB above the pure tone threshold in the left ear for all the frequencies.

		Paired Differences						
				95% Confidence Interval of the Difference				
Ear		Mean	Std. Deviation	Lower	Upper	t	P	
Right	500Hz ART - 500Hz PTA	72.00	9.06	68.62	75.38	43.532	P<0.001	HS
	1KHz ART - 1KHz PTA	72.67	7.16	69.99	75.34	55.589	P<0.001	HS
	2KHz ART - 2KHz PTA	85.17	8.36	82.05	88.29	55.835	P<0.001	HS
	4KHz ART - 4KHz PTA	86.50	9.66	82.89	90.11	49.033	P<0.001	HS
Left	500Hz ART - 500Hz PTA	75.17	9.51	71.61	78.72	43.280	P<0.001	HS
	1KHz ART - 1KHz PTA	76.17	12.23	71.60	80.73	34.125	P<0.001	HS
	2KHz ART - 2KHz PTA	78.67	10.25	74.84	82.49	42.038	P<0.001	HS
	4KHz ART - 4KHz PTA	83.50	10.76	79.48	87.52	42.505	P<0.001	HS

Table 1: showing the statistical results obtained for both the ear.

The results show that there is a highly significant difference across ears and across frequencies. The statistical evaluation revealed that the lower limit is 68.62 in right ear and 71.60 in left ear. The upper limit is 90.11 in right ear and 87.52 in left ear, i.e. approximately 70-90 dB HL in both the ear. There is a slight difference between the thresholds of the right and left ear.

DISCUSSION

Hearing is the main sense responsible for acquiring speech and language in children as well as understanding the spoken language for the purpose of communication. Impairment of this function may compromise not only language, but also emotional, social, educational and cognitive aspects. (Tiensoli et al, 2007). Finding the hearing sensitivity by providing a pure tone has more significance importance in audiological test battery, which is also called as a true test of hearing among the behavior tests. Audiogram provides the information about the amount of hearing loss and nature of hearing loss adequately. Because of all the advantages of pure tone audiometry, it has been recommended to do all the hearing clinical setup. Immittance Audiometry is also the focused test battery in hearing test. Reflexometry is one of the validated test to

check the middle ear muscle functioning by giving the acoustic reflex activator signal. Ipsilateral acoustic reflex threshold was calculated in the study. Stapedius muscle function was checked rather than tensor tympanic muscle. The present study aims to find the co-relation between the pure tone threshold and acoustic reflex threshold in 30 normal hearing population aged 20-25 yrs. And the result reveals that the co-relation between pure tone threshold and acoustic reflex threshold is approximately 70-85dB above the pure tone threshold in the right ear for all the frequencies and approximately 70-85dB above the pure tone threshold in the left ear for all the frequencies. The statistical evaluation revealed that the lower limit is 68.62 in right ear and 71.60 in left ear. The upper limit is 90.11 in right ear and 87.52 in left ear, i.e. approximately 70-90 dB HL in both the ear. There is a slender difference between the thresholds of right and left ear.

SUMMARY

Pure Tone Audiometry is a procedure which is used to check the hearing sensitivity of an individual, by producing pure tones at different frequencies. Threshold obtained from pure tone audiometry, plotted in a graph which is called as a audiogram. Degree and type of hearing loss can be determined from audiogram. For the adequate development of speech and language skills, normal hearing is very important right from our birth. Immittance audiometry provides information regarding the middle ear system. Acoustic reflex testing helps to check the function of the middle ear muscles. Contraction of the stapedius muscle in response to an acoustic activating signal is known as acoustic reflex. The present study attempted to find the co-relation between pure tone threshold and acoustic reflex threshold in normal hearing population. Thirty subjects were selected in this study and the subject selection was based on inclusion criteria of the study. All the participated were undergone otoscopic examination, Weber test for the screening purpose. Pure tone threshold was calculated frequencies at 250Hz, 500Hz, 1 KHz, 2 KHz, 4 KHz, and at 8 KHz in both the ears. Tympanometry was done for all the subjects. Ipsilateral acoustic reflex threshold was measured frequencies at 500Hz, 1 KHz, 2 KHz and 4 KHz in both the ears. The obtained data was given for the statistical evaluation. The results show that Co-relation between acoustic reflex thresholds and pure tone thresholds for tones in subjects with normal hearing and normal middle ear function are 70-90 dB HL.

Limitations:

- The study is carried out in only 30 Normal Hearing adults.
- Male and female categorization is not studied.
- The subjects were included between the aged 20 to 25 years.

Further suggestions:

- More number of subjects can be included.
- Gender categorization can be study.
- This study could be done in other age groups.

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