A COMPARATIVE STUDY OF REFLEX THRESHOLDS FOR PURETONE-NARROW-BAND NOISE AND WIDE-BAND NOISE IN NORMAL HEARING AND SENSORINEURAL HEARING LOSS CASES

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Introduction

Middle Ear muscle reflex is one of the feed back systems in the hearing organ Erik Borg, 1972).

Middle Ear muscles are : stapedius and tensor tympani. When they are stimulated by acoustic or non-acoustic sensori stimuli they contract. Reflex is brought about by contraction of these muscles. The non-acoustic stimuli eliciting the reflex are tactile stimulation of various regions of the face and ear canal, somatic functions, head movement, swallowing, electrical stimulation of the wall of the meatus etc., when the stimulus is acoustic stimulus reflex elicited is called Acoustic Reflex.

A unilateral acoustic stimulus results in bilateral reflex contraction. That is when one ear is stimulated with an intense sound there is contraction of the muscles of both the ears. Contraction of the muscle brings about stiff ossicular chain thereby attenuating the sound transmission. Maximally active muscles produce reductions in the middle ear transmission upto 20-30 dB.

The assumption was that both the middle ear muscles are activated during acoustic stimulation. Now there is increasing evidence that the acoustic reflex in man is primarily dependent on intact and functional stapedius muscle. Tensor tympani contributes very little to the total. The experiment of the Alan S. Feldman (1967), reported this finding where he restricted the responses of each muscle and analysed the differences in recordings.

Reflex is dependent upon the intensity and frequency of the stimulating sound. The effect of reflex is most pronounced between 200 and 600 Hz., while it becomes less above 1500 Hz. Effective feed back chains gain changes with stimulus frequency (Dallos, 1964). Duration of stimulus presentation is also a factor. Djupesland and Zwislocki (1971) reported that the intensity required for a criterion response had to be lowered by about 25 dB when the signal duration was increased from 10 to 100 M. Sec.

The middle ear muscle reflex has a protective function against auditory fatigue, noise induced hearing loss and permanent injury within low frequency region. But Perlman says that there is no effective protection against intense stimuli with steep wave fronts.

To elicit a reflex an intact reflex arc is essential. Reflex arc is comprised of a different neuron, a synapse and an efferent neuron. Reflex is absent if nerves inervating the muscle are injured from any cause.

There are several methods to measure the acoustic reflex. They are electro myography, direct observation, extra tympanic manometry, measurement of cochlear microphonics and determination of changes in the impedance of the ear.

Reflex threshold is the minimum intensity of sound stimulus required to initiate reflex. The reflex is normally elicited at a hearing level between 75 and 90 dB for puretone stimuli.

The thresholds of reflex are comparatively less for noise stimuli than for tones. The thresholds for noise stimuli are found to be significantly more stable (Deutsch, 1972).

The reflex thresholds for puretones and noise were compared in the attempt of testing sensori-neural hearing loss cases. Reflex test being a supra threshold test, it is more a reliable test than threshold tests. It is comparatively more objective than threshold tests.

In the present study reflex thresholds were obtained as change in the acoustic impedance of the ear. One is justified in studying the middle ear muscle reflex this way. because, (Borg, (1972) found linear relation among the findings of middle ear muscle activity through EMG, changes in cochlear microphonics and changes in acoustic impedance).

Niemer and Sesterhenn (1972) and et al (1974) reported that the stapedial reflex threshold for wide band noise is lower than that for pure tones. They used the difference between the acoustic reflex thresholds for tone and noise as a factor for predicting the audiometric thresholds, amount of hearing loss and slope of loss.

The present study was conducted with the aim of finding the differential effect of middle ear muscle activity, on puretones and noise in normal being subjects and sensori-neural hearing loss cases. Attempt was made to see if there is any significant difference between reflex threshhold for tone and noise in normal hearing subjects sensori-neural hearing loss cases. It was aimed to see whether the differences could be used as a diagnostic tool.

It was hypothesized that the threshold of reflex varies, as the stimulus eliciting refllex varies; that the reflex threshold for wide band noise is significantly lower than that of narrow band noise and puretone and that the normal relationship of the reflex thresholds for various acoustic stimuli is altered in cases of sensori-neural hearing loss.

Experimental Procedure

Subjects

The study included 100 normal hearing subjects free from any otologic complaints and audiometric loss. This comprised the normal population of the study. Fifteen moderate sensori-neural hearing loss subjects who had no conductive component of hearing loss constituted the clinical population of the study. Their age ranged between 13-27 years.

Methodology

Pure tone audiograms were obtained for all subjects. Then reflex thresholds for pure tones, narrow bands of noise and wide band noise were obtained.

Pure tones of frequency 540 Hz, 1000 Hz and 2000 Hz, narrow bands of noise centered around those frequencies and wide band noise were utilized as acoustic stimuli for elicting reflex.

Calibrated audiometer 70) Arphi Mark IV satisfying ISO standards with TDH 39 earphone with MX 41/AR ear cushion was used for obtaining pure tone audiogram. As clinical diagnostic audiometer (Amplivox model 103) with TDH 39 with MX 41/AR ear cushion was used along with a Madsen ZO 70 Electro Acoustic Impedance bridge to measure the stapedial reflex.

Reflex threshold was measured in terms of SPL. The maximum noise level generated by Amplivox model 103 is 90 dB SPL. This was not enough to elicit reflex in moderate sensori-neural hearing loss cases who comprised the clinical population of the study. So, a booster was incorporated in the circuit, to boost the signal to the required level. The booster made by Madsen Electronics, Denmark, Type K 371 was used to boost the noise. The frequency response of the amplifier was flat from 50 Hz to 6 KHz. The complimentary symmetry circuit used in booster helped to eliminate the transformers in the circuit.

With the booster in the circuit noise dial was calibrated for its output and linearity. Calibration of the audiometers was maintained using Bruel and Kjaer calibration unit. The booster helped to boost the signal to an average of 20 dB above the maximum output of the audiometer.

All the tests were conducted in sound treated room. The procedure given in Madsen manual was adopted in reflex test. During testing, subjects were asked to sit relaxed and were instructed not to swallow, move the head or jerk the body in any fashion. Reflex thresholds were obtained using ascending technique. The intensity of the stimuli was changed in 5 dB steps till an observable reflex was produced.

Results and Discussion

As norms for reflex of middle ear muscles is not available for Indian population for different acoustic stimuli establishing norm was the primary aim of the study. On testing 100 subjects who exhibited 10 dB threshold of audition for frequencies 250 through 4000 Hz and statistically computing the results of the reflex test, means of the reflex thresholds for pure tone, narrow band noise and wide band noise obtained are presented in Table I.

TABLE I Normal

Stimuli	Frequency	Threshold (dB SPL)
Pure tone	500 Hz	93.25
	1000 Hz	88.75
	2000 Hz	88.35
Narrow band noise	500 Hz	76
	1000 Hz	72.97
	2000 Hz	72.65
Wide band noise	—	66.7

To test the significance of difference between the reflex responses for different acoustic stimuli, distribution free test for Ordered Alternatives was used. Analysis showed highly significant difference at 0.01 level of confidence for various acoustic stimuli viz., pure tones, wide band noise and narrow band noise.

The thresholds of reflex for noise are less than that of pure tones and the variation among the group was less for noise stimuli. This indicates that the reflex activity is stable for noise stimuli.

The threshold of reflex for wide band noise was least. Reflex threshold for narrow band noise was higher than that of wide band noise but less than that of pure tones. That is WBN $<$ NBN $<$ Pure tone.

To find if similar relationship of reflex thresholds exist in the clinical population also, cases having moderate sensori-neural hearing loss were tested similarly. The means of reflex thresholds of clinical population are presented in Table II.

TABLE II Clinical Population (SN LOSS CASES)

Stimuli	Frequency	Threshold (dB SPL)
Pure tone	500 Hz	114.4
	1000 Hz	110.73
	2000 Hz	110.73
Narrow band noise	500 Hz	109 66
	1000 Hz	106.66
	2000 Hz	106.33
Wide band noise	—	105.33

In clinical population the means are elevated due to the hearing loss. The condition WBN < NBN < PT was observed in clinical population also. But the gap between these thresholds is compressed in clinical population. Table III presents the difference between normal and clinical population.

TABLE III Difference between normal and clinical population

Sample	PTA (1)	NBNA(2)	WBN (3)	1-3	1-2	2-3
Normal	90.12	73.84	66.7	23.42	16.28	7.14
Clinical	111.95	107.55	105.33	6.62	4.4	2.22

The gap between the responses of different stimuli may be noted.

Reduction of gap in clinical population may be explained by the slope of loss in the cases of moderate sensorineural hearing loss. In these cases when ear is stimulated with noise, the loudness contributed by all the critical bands is not equal due to the slope of loss. In order to obtain a threshold the level of noise is to be increased such that the loss, due to slope is compensated. So, the threshold for noise is increased compressing the difference between the thresholds for tone and noise.

The reduced difference between tone and noise reflex may also be explained on the basis of reduced number of critical bands available for the loudness contribution when the ear is stimulated with noise. In sensori-neural hearing loss cases there are less number of critical bands, due to the process of widening of the critical bands. (Flottorp and Djupesland, 1971).

The study supports the hypothesis that the threshold of reflex for noise is less and that the threshold of reflex varies as the eliciting stimuli varies. The hypothesis that the relationship between the reflex thresholds for different acoustic stimuli is altered in subjects with sensori-neural hearing loss, when compared to normal subjects is also accepted. The study of Jerger, et al., (1974) supports this.

By testing 10 randomly selected subjects from original population reliability was checked.

The reflex thresholds of female (43) and male (57) subjects were analysed. Result showed no significant difference in the middle ear muscle activity between the two groups. The norms obtained in this study do not apply to groups of population above 29 years and below 17 years of age.

This test is of diagnostic significance. It is a more reliable test. But time consuming. The difference between the reflex thresholds for pure tone and noise acts as a factor for diagnosis. The effect of various acoustic stimuli on the middle ear muscle action can be understood.

The main limitation of this study is that in this the reflex is measured through the contra-lateral ear which is less sensitive than ipsilateral reflex. Latency period of initiation of muscle contraction may influence the reflex threshold. Severe sensori-neural hearing loss cases could not be tested due to audiometric limitation. Reflex could not be elicited in those cases.

In future ipsilateral and contralateral reflex may be investigated in different population and effect of critical bands of noise on acoustic reflex threshold may be studied.

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