"THOSE TWO WHO GAVE ME LIFE

AND

THE MANY WHO FILL IT " ...

A COMPARISON OF MLR WAVEFORMS IN GERIATRICS - MALES VS. FEMALES

Reg.No.M.9012

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT FOR THE FIRST YEAR OF THE MASTERS DEGREE IN SPEECH AND HEARING TO THE UNIVERSITY OF MYSORE, MYSORE 6

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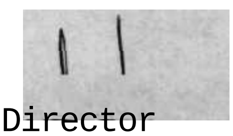
1991

CERTIFICATE

This is to certify that the Independent Project entitled: **A Comparison of MLR Waveforms in Geriatrics - Males vs Females** is the bonafide work in part fulfilment for M.Sc., in speech and Hearing, of the student with Reg. No.M9012.



Mysore
1991

Director
All India Institute of
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Mysore-6

CERTIFICATE

This is to certify that the Independent Project entitled: **A Comparison of MLR Waveforms in Geriatrics - Males vs. Females** has been prepared under my supervision and guidance.

Mysore
1991

Dr.(Miss)S.Nikam,
GUIDE

DECLARATION

This Independent Project entitled: **A Comparison of MLR Waveforms in Geriatrics - Males vs. Females** is the result of my own study undertaken under the guidance of Dr.(Miss) S.Nikam, Prof, and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at Any University for any other Diploma or Degree.

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1991

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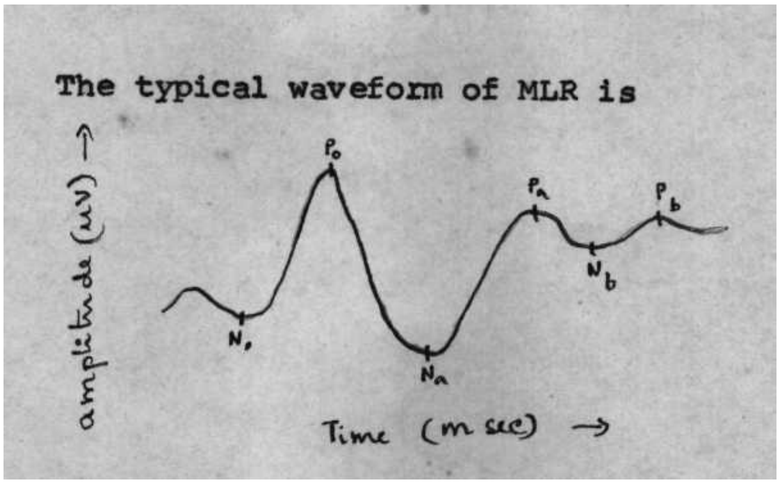
INTRODUCTION

The capacity of hearing in an individual can be tested subjectivity or objectively. The test results give us an indication as to how essential audition is as a link to the outside world. But assessment of auditory function through voluntary response in cases of emotional disturbance, mental retardation and central disturbance is not always possible- This difficulty is present in both children and adults. In such cases, the study of evoked potentials recorded from the scalp have appeared successful. The decade of the eightees is called the era of evoked potential measurements by Reneau and Hnatiow in Evoked response audiometry - a topical and historical review (1975). This is because a hoarde of studies concerning evoked potentials have come up in the last ten years.

One such electrophysiological measure is the middle latency response (MLR). It is nothing but the waveform obtained 8-50msec. after the onset of stimulus with an amplitude of 0.5 /uV - 3.0 /uV. Pioneers in this area were Geisler, Rosenblith and Frishkopf (1958). They named these waves "early" responses. Later they were renamed "MLR" by Picton, Hillyard, Krausz et al (1972) and Davis (1976b) to differentiate them from the brain stem evoked response (BSER) which occurs in the first 10 msec. after onset of stimulus.



Peak	Trough	Latency
-	N_o	8-10 msec.
P_o	-	10-13 msec.
–	N_a	18-22 msec.
P_a	-	30-35 msec.
-	N_b	40-60 msec.
P_b	-	55-80 msec.

Earlier components of the MLR waveform that is N_o, P_o N_a may arise from the median geniculate body and poly-sensory nuclei of thalamus. Later portions are found distributed over wide areas of association cortex (Geisler et al. 1958; Picton, Hillyard, Krausz et al. 1974; Davis, 1976b). The later parts especially P_b and N_c are noticed with a longer time base of 10-80 msec. The origin of MLR is still a matter of controversy as several investigators have pointed out that it may be myogenic and not neurogenic (Bickford, et al. 1963a; 1963b). The field is still open for more studies to shed light on the real nature of responses.

The maximum amplitude of response is at the vertex and symmetrical around the point. MLR is usually recorded from the vertex (C_Z) referenced to the mastoid or ear lobe with a narrow band filter of 3-100 Hz (Mendel and Goldstein, 1969a).

The stimuli which evoke MLR are clicks, tone bursts, tone pips and logons (Zerlin, Mowry, Naunton, 1971; Zerlin, et al 1973). Clicks evoke longer latencies with greater amplitude change. Tones are frequency specific and give a very good indication of hearing sensitivity at low frequencies. The commonly used range of frequency is 500 Hz - 2000 Hz.

The number of stimuli needed to evoke a response is around 1000 - 2000 (Goldstein, 1967). The response is noted by averaging. Repetition rate of stimulus is also one important variable. Mendel (1973) suggests a rate of 10 stimuli/sec. The effect of rise time of stimulus on MLR has been summarized by Davis (1976). He called the MLR an "on response" as it mainly elicited by onset of the stimuli. Skinner and Antinoro (1961) found that rise time greater than 25 m.sec. is not effective.

It is well established in electrophysiological tests that the amplitude of the waveform is greater and latencies are reduced at higher intensities. At near threshold the waveform morphology is not well defined though the latencies remain almost stable.

MLR appears to be stable over conditions such as reading, sitting in a dark room with eyes closed and sitting in a lighted room with eyes open (Mendel and Goldstein 1969a, 1969b). No changes have been noticed on the application of muscle relaxants (Harker, et al. 1977). Mendel and Hosick (1975) also reported that the waveforms do not change due to natural or drug induced sleep. But when complete annesthesia is achieved, the MLR waveform, may disappear as noticed by Picton et al. (1977). Freeman (1965) has reported that hypoxia, hyperventilation, body acceleration through space have the affect of increasing latency and decreasing the amplitude of the waveform.

The effect of aging on MLR is a matter of controversy. Davis and Hirsh (1973) have reported successful evaluations of hearing sensitivity in the elderly and not in the infants. McRandle et al (1974) have reported clear waveform at near pure tone threshold levels in neonates also.

Test procedure:

The individual is tested while lying down or sitting comfortably. The neck and shoulder movements are to be minimized to reduce muscle artefacts. The duration of the test depends on the number of threshold estimations taken in each ear. If the three frequencies (500 Hz, 1000 Hz, 2000 Hz) are tested, then the test will take 2-2 1/2 hours. The identification of peaks and troughs especially the N_o , P_a and N_a with their latencies help us in evaluation (Beagley, 1979).

Uses:

1. MLR can be used as a threshold detecting device (Giesler et al. 1958; Goldstein, Rodman, 1967).
2. As an indicator of the integrity of the auditory pathway.
3. Used as one of the tests in a neurological test battery.

With the advent of MLR in electrophysiological testing, accuracy in detection of auditory pathway lesions has increased tremendously - Confirmation of hearing loss has become a practical reality in infants leading to early intervention. Use of MLR should be considered as a mandatory procedure of current audiological test battery.

As we already know, the process of aging brings about anatomical as well as physiological changes. The pure tone responses, speech understanding, impedance and acoustic reflexes show a difference with age. So we can suspect an age factor in MLR also. At the same time in some instances, we have noticed difference with sexvariations. This is also an important factor to be considered.

Purpose of the study:

Purpose of the present study was to find out whether waveform latency differences were seen in normal adults due to sex variations. It aims to detect the affect of sex variation on MLR in geriatrics. Also an estimation of the relationship between MLR and behavioural thresholds was done.

1. Is there a relationship between pure tone and MLR thresholds?
2. Is there any difference in the MLR waveform latencies of normal males and females?
3. Is there any difference in the MLR waveforms latencies of male and female geriatrics?

REVIES OF LITERATURE

Monitoring of spontaneous bio-electric activity from the central nervous system and recording this from the human scalp was first described by Berger (1929). These random bio-electric activities comprise the electroencephalogram (EEG). The process of extracting stimulus related bio-electric events from the ongoing EEG activity set the stage for future clinical development in various aspects of what is called as electric response audiometry (ERA), by Davis (1976).

Classification: (Davis and Owen, 1985)

Response	Latency range	Origin
Cochlear	0-4 msec.	Cochlea
Early	2-15 msec.	Cranial nerve VIII and Brain stem.
Middle	15-50 msec.	Brain stem, mid-brain and cortex.
Late	50-300 msec.	Primary and secondary auditory cortex.

One of the important auditory evoked responses is the middle latency response. The recording of this response actually preceded the recording of ABR by about 10 years (Mendel, 1977). In 1958, these waveforms were first reported by Geisler, Frishkopf and Rosenblith who called them the "early responses". Later, as information became available as to the presence of responses which occur earlier than 10 m.sec, the waves were called "middle latency" responses (Picton, Hillyard, Krausz et al. 1974; Davis, 1976b). The MLR occurs at a latency of 10-50 m.sec. with amplitudes ranging from 0.5 - 3.0 /uV. According to Museik and Geurkink (1981), the latency range is 8-50 m.sec.

Nature of the response:

The researchers argue over the fact that MLR may be of neurogenic or myogenic origin. Bickford (1972) said that various muscle reflexes are present as a response to loud acoustic stimuli in the 10-50 m.sec. latency range. The myogenic nature of the response is also supported by Bickford, Jacobson and Galbraith (1963). When 'myogenic' response is to be taken into account, the inion response has to be considered. The inion is nothing but a small bony protruberance in the midline of the skull immediately above the neck muscle. The inion response depends on vestibular connections rather than cochlear connections

(Townsend and Cody, 1971). The unilateral reflex of post auricular muscle is elicited by cochlear stimulation. The bilateral reflex is recorded from mastoid process at the level of external auditory canal. (Yoshi, Okudaina, 1969; Dauek, et al. 1973; Streletz, et al. 1977). All these muscle responses may distort the MLR. But Streletz et al. (1977) also report that MLR is free of myogenic contamination during sleep. The relative contribution of muscle response has been measured in 1974 by Picton, et al. and is found to be not significant.

Comprehensive study of scalp distribution of MLR suggests that they are neural in origin, especially for low to moderate intensity (Goff, Allison et al.1977; Goff, Allison, Lyons et ai. 1977) and when electrode is not overlying the inion. (Mast, 1963, 1965; Picton, et al. 1977). Jarcho (1949) and Chang (1950) also support the neural origin. It was also noticed that inion response could be obtained even on stimulation of a deaf ear acoustically, providing vestibular function was intact (Cody et al. 1964). Goldstein and Rodman (1967) say that stimuli intensity nearer threshold results in response which are predominantly neurogenic. Ruhm and Flanigan (1967) suggest presence of cochleo-neurogenic response to low intensity and vestibulo-myogenic response to high intensity.

Dispute about the myogenic versus neurogenic origin of MLR initiated by Bickford and his associates has not been resolved yet. studies in animals, the hearing impaired and normal subjects using multiple scalp electrodes and intracranial recordings have accumulated data which support the contemporary view that the MLRs consist both myogenic and neurogenic components.

Origin of the response:

General consensus is lacking regarding the origin of MLR in humans (Celesia, 1976; Goff et al. 1977; Picton, et al 1974; Vaughn and Ritter, 1970; Wood and Woolpaw, 1952; Cohen, 1982; Ozdamar and Stein, 1982; Ozdamar et al. 1982) or animals (Arezzo, et al. 1975; Kaga, et al. 1980a; Norman, et al. 1981).

According to Geisler (1958), the MLR originates from the cortex. This conclusion was based on the following factors.

1. Same results are obtained in a subject for repeated evaluation.
2. MLR can be recorded from a wide area of scalp.
3. Even a monoaural stimulation evokes a bilateral response.
4. Same responses are obtained for symmetrical placement of electrodes.
5. Latencies of MLR are comparable to onset latency of somatosensory and visual system.

Geisler et al (1958); Picton et al. (1974), Davis (1976b) report origin of earlier components of MLR that is N_o, P_o, N_a to be the medium geniculate body and polysensory nuclei of thalamus while later portions originate from a wide area of association cortex. Okitsu et al (1977) say that origin of peak P_o may be different from that of the later N_a and P_a, Picton and Smith (l978) found similarity between animal cortical responses and human MLRs which reflect activation of thalamus and cerebral cortex. A rhesus monkey showed P_{12} which originated from primary auditory cortex. Other peaks like N_{70}, P_{110}, N_{140} arise from ether parts of cortex as reported by Arezzo et al. (1975). Buchwald et al (1981) localized origin of P_a to medial rostral, mid brain reticular formation and projection of thalamus. P_o was localized to primary auditory cortex. Hashimoto (1982) attributed the origin of N_o, P_o, N_a or SN_{10} to post synaptic activity from inferior colliculus. When multiple coronal electrode array was used, P_a was found to be at the level of sylvian fissure. This is suggestive of a dipole source in the superior temporal plane (Cohen, 1982). Kaga et al (1980) in an experiment with animals showed the anterior part of contralateral primary auditory cortex to be the generator site of P_a. Eventhough P_a is widespread over human scalp, latencies may slightly differ for different electrode locations. If hemispheric asymmetry is seen, it may indicate some diagnostic condition (Kraus , et al. 1982). Amplitude of N_a and N_o were found tobe eventy distributed across surface of head by Paccioretti, et al. 1987).

Uchida, et al. (1979) conducted an experiment in cats under general anaesthesia. The effect of unilateral and bilateral median geniculate body destruction was noted. According to them, the generation of MLR is from upper level of superior colliculus. The N_a component is due to contra-lateral median geniculate body (MGB) while P_a is a compound response from a wide area. Parving et al (1980) while studying a patient with auditory agnosia due to temporal lobe lesion found a normal peak of P_a . Kraus et al (1982) also found normal N_a and P_a in unilateral temporal lobe lesions. But Ozdamar et al (1982) noticed a reduction in amplitude of the waveform in bilateral temporal lobe lesions. All these studies indicate that MLR is not exclusively generated from the auditory cortex.

The exact and precise origin of each component of MLR waveform is still a matter of doubt which adds impetus for further research in this area. Rowe (1981) has suggested some reasons as to the non-agreement about site of origin.

- The electrode placement may be away from neural generators.
- Presence of ipsilateral and contralateral pathways.
- All the generators may be simultaneously activated.
- Auditory system has a complex spatial arrangement.
- Multiple sites may show overlapping activity.

All these factors would make it difficult to pin point the exact site of origin of MLR in the brain.

The MLR waveform:

The MLR waveform typically has two major positive peaks (vertex referred to mastoid) and three negative peaks labelled as N_o, P_o, N_a, P_a and N_b (Goldstein and Rodman 1967) Ruhm et al. 1967). They used a filter setting of 25-175 Hz with a slope of 6 dB/octave at an intensity of 60 dB nHL.

Several researchers have given latency values of different components. They are presented in a tabular column below:

Researchers	Year	No	Po	Na	Pa	Nb	Pb
		(in msec)					
Goldstein & Rodman	1967	8-10	10-13	16-30	30-35	40-60	55-80
Mendel & Goldstein	1972	—	11.3	20.8	32.4	45.5	
Lane et al	1974	—	10.7	19.7	29.7	47.2	-

64.0

Suzuki et al (1981) studied auditory evoked potentials for tone pips within 0-25 m.sec. They identified three peaks P_{10}, N_{15} and P_{20}. The number Indicates the latency value of the particular peak. Black et al (1987) carried out a study of MLR in cochlear implant cases. He reported that in a single channel cochlear implant case, electric MLR amplitudes were found to be correlating with behavioural electrical threshold and the discomfort levels. The wave-form morphology showed:Pa - 26 m.sec, p_b - 56 m.sec. P_c - 70-80 msec. However, the responses were not consistant.

Iwara and Potsic (1982) studied MLR waveforms which were measured at the vertex in anaesthesized rat positive peaks which unify at 30 ms with increasing age and two negative peaks were noticed. Walsh et al (1986a, b) report that two positive and two negative peaks were noticed in cats. The latencies of positive peaks fall within 20-30 m.sec. Kraus et al (1985b) noticed a negative component of 7-13 m.sec. latency and a positive component of 25-35 m.sec. in a six months old orangutan and 15 months old macaquil. In an adultgerbil MLR was obtained from the contralateral temporal lobe. Two positive and one negative peak were noticed in this gerbil by Kraus et al (1987a). Kraus, et al (1987) also report that wave B appears first and then wave C in young gerbils.

Mendelson and Salamy (1981) report that latency of P_O was shorter than P_b but longer than as reported by other researchers. These differences in latency as pointed out by different authors may be a result of brief duration stimuli or wide band pass filters or a combination of both.

Factors affecting MLR:

a) Stimulus parameters:

1. Type of Stimuli:

Electrical as well as acoustical stimulation can be used to elicit MLR. Burton, et al (1989) report that there is no (Significant difference between latencies of electrically and acoustically evoked waveforms in guinea pigs. Kemink et al (1987) found electric MLR in profoundly deaf ears. The latency of most prominent positive peak around 26-30 msec. which is similar to the latency of acoustic MLR was noticed. Stimulation of VIIIth nerve to produce electrically evoked MLR can be accomplished via a transtympanic needle electrode on the promontory (Kileny, and Keminck, 1987)rather thana ball electode on the round window membrane (Black et al, 1987).

There are several types of acoustic stimuli used to elicit MLR.

Clicks: They are the most commonly used stimuli. They stimulate the whole of the cochlea. They contain a wide spectrum of frequency and have a rapid onset time which provides good synchronization of nerve impulses.

Tonebursts - These stimuli allow excellent frequency specificity. Mendel (1982) says that the tone bursts should have rise-fall times of about 2-3 msec. and a duration of about 2 msec. with a spread of energy over one octave.

Tone pips - Also frequency specific. They are obtained by passing a sinusoidal wave through a high and a low pass filter. They were developed by Davis and Silverman et al (1952) Eldridge et al. (1962). They have a fast rise time but are not frequency specific above 2 KHz.

Zogons - These stimuli are derived from Gabors (1947) concept of acoustic quantum. Basically they are sine waves modulated by a Gaussean (probability) pulse.

Filtered clicks - A click may be passed through high and low pass filter to eliminate all frequencies except those with a limited bandwidth.

Zerlin et al (1973) suggest the click stimulus with rise time of 10-100 μsec. as the optimum stimulus. But such a fast rise time limits the frequency specificity. To have a good knowledge of frequency characteristics, usage of tone pips, tone bursts or filtered clicks is suggested (Zerlin, et al, 1973; Zerlin and Naunton, 1975; Kupperman et al. 1973)

Tonal stimuli are found to give reasonably sensitive frequency specific responses (Rupert et al. 1973; Kupperman, and Mendel, 1974; McFarland et al. 1977; Thornton et al. 1977).

Museik and Geurkink (1981) noticed effective responses for click stimuli in awake adults. While Brown and Shallop (1982) found low frequency tone bursts to be more effective compared to clicks. In 1984 a study was conducted by Maurizi et al to compare efficacy of tone pips and clicks in 20 normal subjects of 26-32 years. The results indicate that tone pips are more frequency specific. The p_o , N_a , p_b and N_b show greater latency but smaller amplitude for tone pips. This, the authors attributed to asynchrony of responses evoked by the tone pips.

2. Number of stimuli:

The minimum number of stimuli needed to evoke a clearly recognizable response has been a matter of interest over the years. Since the background physiological activity is to be distinguished the MLR has to be considered only after averaging the ongoing activity. It is noticed that as number of stimuli increased, the amplitude of waveform also increases. At the same time, the background activity reduces, that is to say the response smooths out. But general opinion is that increasing the number of stimuli from 1000 to 4000 does not increase the ease of identification of MLR.

Horowitz et al (1966) say that the waveform is obtained after 400-500stimulus presentations. They used a rate of 3-4/sec. But Vivion et al (1975) obtained clear waveforms after only 125 stimulus. Lane, et el (1974); used 1024 stimuli with a rate of 6.67/sec. to get a clear averaged responses.

3. Stimulus rate:

Stimulus rate is nothing but the number of times it is repeated per unit of time. Mendel (1973) suggested usage of a repetition rate of 10/sec. He said that this rate of repetitions has little influence over the amplitude of the averaged response. Later in 1977, Mendel also suggested a rate of 9/sec. as this has the advantage of being out of phase with common main power frequency. Goldstein, et al (1972); McFarland, et al (l979) agree that a rate of 1-10/sec. does not effect amplitude of the waveform.

McRandle et al (1974) report that 256 stimuli are enough to evoke a response with a rate of 4.5/sec. while 512 stimuli are needed to give clear response at a rate of 9/sec. Lowell et al. (1960) noticed an increase in amplitude is the click rate reduced from 1/63 msec. to 1/100 msec. An increase in repetition rate is supposed to decrease the amplitude of MLR (McFarland, et al. 1977; Geisler, et al 1958; Goldstein and Rodman, 1967). Jerger, et al (1987) say that MLR may undergo rapid adaptation and augmentation at rates 1/sec. and 2.5/sec.

Another important measure is the 40 Hz response which was described by Galambose et al (1981). This is also called the 40/sec. auditory response, 40/sec. response is based on an inter peak latency of 25 m.sec. Galambose says that the subject has to be wide awake during the examination in order to get a clear waveform, The 40/sec. presentation leads to overlapping of responses to successive stimuli. This leads to periodic response which has a constant phase relationship to repeating stimulus. Finally, a sinusoidal waveform is obtained which shows energy from both ABR and MLR. Galambose, et al (1981) say that the 40/sec. presentation effects the basilar membrane location of nerve fibre excitation. They suggest that 40 Hz response can be a promising new approach to clinical applications. Kileny and Shea (1986) report that amplitude of 40 Hz AEP are almost twice as large as MLR amplitude for clicks and only slightly larger than amplitude for 500 Hz tone bursts. So according to them MLR and 40 Hz are equally viable procedures for threshold estimation.

4. Stimulus intensity:

It is generally agreed that there is a direct relationship between intensity and response amplitude. Goldstein and Rodman (1967) support this in terms of MLR waveforms also. They noticed that latencies appear stable but the peaks become less well defined as the stimulus intensity reaches near threshold levels. Mendel (1974) reports that the amplitude of MLR increases and latency decreases slightly with increasing stimulus intensity upto moderate levels. Ozdamar and Kraus (1983) report the levelling off of amplitude at about 50-60 dB HL.

Madell, Goldstein (1972}; Picton et al (1977); Thornton et al (1977) contradict the above reports. Their studies showed a slight decrease in latency as well as increase in amplitude with a rise in stimulus intensity. The rate of latency change of MLR may bear a close relationship to latency intensity function of sonomotor response (Gibson 1978).

Indeed, at higher intensities, the waveform may change quite suddenly and this has been attributed to inclusion of myogenic components (Thornton, 1975).

5. Stimulus frequency:

Not many studies have been done to show the clear effects of frequency on MLR waveforms. This is because fast repetition rates demand different stimulus envelope constituents. The tonal stimuli have not been found effective. Instead, tone pips or filtered clicks have been used. Thornton, et al (1977) say that latency for each peak reduces with increase in stimulus frequency. Amplitude input-output characteristics also vary with stimulus frequency. The characteristic changes are linear for early peaks as well as for an increase in frequency of stimulus.

6. Rise fall time and duration of stimulus:

A fast rise time is very important for elicitation of MLR. But Skinner and Antinoro (1969) found that a rise time greater than 25 m.sec. was ineffective. Since the MLR mainly depends on onset of stimulus, it also has been called the 'on' response.

Lane et al (1970) suggest usage of a stimulus with shorter rise-decay time and longer duration in order to facilitate identification. They used a 1000 Hz, 50 dB SL tone burst. Rise times of 5, 10, 15 and 25 m.sec. with durations of 20-40 m.sec. were used. The results showed that early components were not affected by any combination but later waves showed amplitude increase when 25 m.sec. rise decay time.was used. When the rise-decay time or duration was increased latency rise of 1-3 msec. was noticed for all MLR peaks. At the same time, there was an overall reduction in amplitude at all intensity levels. (Vivion et al 1982).

7. Effect of masking:

Masking is said to occur whan the presence of one sound makes it difficult to hear another sound or the threshold of signal has been elevated by a 2nd signal or noise (Moore, 1983). Presentation of contralateral masking stimuli of moderate intensity does not appear to affect component amplitude (Gutnick et al. 1978). The shift in amplitude is ±.7 dB which is insigficant. The ipsilateral masking noise shows a peak to peak amplitude variation which varies directly with signal to noise (S/N) ratio (Smith and Goldstein, 1973).

C. Monoaural vs. binaural stimulation:

Binaural interaction potential is derived by substracting the sum of the left and right monoaural responses from the binaural response (Parker and Salt, 1962). Peters and Mendel (1974) report of equal response amplitude and latency for monoaural and binaural clicks of equal loudness. Binaural interaction for MLR is reported to be much larger than monoaural response when elicited by 20-40 dB less intense stimuli. This difference may be due to neural mechanism underlying MLR generation. But there are contradictory studies which say the responses for binaural and monoaural stimulations are exactly similar (Denker and Howe, 1982).

Kodobayashi et al (1984) report that early components of MLR have large amplitudes for binaural stimulation. A slight augmentation was noticed between ipsilateral and contralateral side of stimulation by Mendel et al (1987). This was in contrast to the study (Wolf and Goldstein, 1978), which noted latency differences as well. Dobie and Norton (1980) found an overall reduction of amplitude for binaural stimulation et intensities greater than 70 dB nHL. Binaural interaction in cats can be recognized within 20msec. In humans, this is recognized for P_a -N_a complex but patterns of interactions are variable (Harada, et al 1984).

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B. Recording parameters:

1. Filter characteristics:

Filtering refers to cutting off the unwanted frequencies and limiting the band width such that the energy is concentrated in that particular bandwidth. This may lead to distortion of the waveform. Lane, et al (1974) noticed both phase and amplitude distortion. They also suggested that amplitude distortion can be used for threshold estimation while phase distortion serves very little purpose. It was noticed that reducing low pass filter setting leads to prolonged individual latencies. So a band pass filter of 25-175 Hz with a slope of 6 dB/octave is recommended (Mendel, 1977). Mendel et al (1974) also reported that the P wave slits the Na trough into Na_1 and Na_2 with low pass filtering . Kavanagh (1979) says that the P wave mentioned above corresponds to SN_{10} described by Davis and Hirsh. Zerlin et al (1973) studied 4 awake subjects for 1/3 octave clicks centered at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. A latency reduction of 5 ms between 500 Hz and 4000 Hz. was seen.

Digital phase shift filtering does not affect the waveform and latency much. Bat analog filtering shows how early activity of MLR is folded onto later components leading to a much longer late activity than what is present physiologically. So analog filtering should not be used according to scherg (1982). According to Suzuki et al (1983) power spectral analysis and digital filteration far MLR show frequency components located at 30-50 Hz. If activity is below 30 Hz

P_a and N_b are difficult to detect. But if these activities are eliminated using a high pass digital filter, N_a, P_a, N_b and a positive peak at 60-70 m.sec. latency also can be recognized. When the high pass filter is set at 40 Hz, the positive peak disappears and N_b is followed by 2 positive peaks of 50-55 m.sec. and 80-85 m.sec. after onset of stimulus. Izumi (1980), Scherg and Volk (1983) found that large portion of MLR energy la produced by phase shifting response energy from other portions of time bases. Phase shifting reduces amplitude of P_a -N_a complex with augmentation of MLR waveforms Pa and Pb. But peak P_b can be noticed only on analog filtering and not in digital filtering (Kavanagh, Domico, 1987; Suzuki, at al 1989).

With low pass analog filtering with a cut off frequency of 100 Hz, the first positive peak has a ltency of 11.75 m.sec. If open recording filter is used, P_o shows a reduction in latency and will be recorded in ABR time domain (Kavanagh, Domico, 1987). Barajas, et al (1985) studied MLR with different filter settings like 10-100 Hz, 10-250 Hz, 10-1500 Hz, 10-3000 Hz, 30 -100 Hz. The stimuli were 500 Hz tone pips with a rise decay time of 4 msec. and repetition rate of 9.3/sec. MLR for all settings were found at a level of 8-11.5 dB nHL.

2. Place of electrodes:

There are basically 2 kinds of electrodes arrays. Ipsilateral mastoid (-) to high forehead (+) and ipsilateral mastoid (-) to vertex (+). According to Kavanagh and Clark (1989), both these arrays have equal efficacy in recording ABR and MLR in open as well as closed filter conditions.

The forehead placement is usually preferred because -

- it eliminates placement of electrode get and adhesive in hair.
- it moves electrodes away from ear phone head band which can cause discomfort and dislodgement of electrode.
- it allows easy achievement of low electrode impedance.

Mastoid to high forehead array was preferred by several authors (Beattie et al. 1986; Bettie, 1984; Davis, and Hirsh 1979; Hall et al. 1984; Suzuki, et al 1981). Beatti et al (1986) say that this array results in 34% reduction in response amplitude. The mean P_o - N_a amplitude is found larger in forehead electrode array. Mean N_a -P_a and P_a -N_b amplitude is larger in vertex array. The amplitude of N_b -P_b was small and ill defined in both cases. Cohen (1982) and Wood and Woolpaw (1982) also report that the maximum evoked amplitude is obtained on the midscalp anterior to C_z. But very little difference in waveform or magnitude between these two electrodes has been reported by Suzuki et al (1981).

C. Subject parameters:

1. Subject conditions:

MLR is studied under different states of consciousness to find out how it is influenced by them. Latencies of major peaks remain constant across different stages of sleep. Amplitude are larger during rapid eye movement, (REM) 1 and 2 stages than 3 and 4 (Mendel and Goldstein, 1974). In an earlier study (1969b) they also noticed that sleep deprivation has little effect on MLR. Light sedation does not seen to influence the response (Kupperman, Mendel, 1974; Mendel, Hosick, 1975; Mendel et al. 1977). Mendel and Hosick (1975) also say that MLR is fairly stable during early stages of sleep. They did not find any change due to drug induced sleep. The components remain constant in latency and amplitude even after medication (Mendel and Goldstein, 1969a; Goldstein et al 1972; Thornton, Mendel, 1974).

The amplitude of P_b and P_c of MLR are reduced during sleep (Brown and Shallop, 1982). As stages of sleep deepens, latencies of peaks except P_o gradually increase and amplitude reduces. During deep sleep, N_b and P_p tend to disappear. N_a may show one of the double peak N_{a1} and during wakefulness N_{a2} is seen. Effect of sleep on MLR is not much in adults as in children (Okitsu and Shibahara, 1981). P_a can be easily detected in awake children and during stage-1 sleep. During stage-4,detectability is poor (Kraus, et al. 1985). The MLR threshold is found to be 40 dB higher in Children who were asleep than their threshold when they were awake (Kankkumen and Rosenhal, 1985).

Change in the Muscle tone affects MLR (Gibson , 1978) But no change is noticed in configuration,latency and amplitude for temporarily induced muscle paralysis (Harker, et al. 1977). Complete anaesthesia may eliminate MLR completely (Goff et al 1977). Conditions like hypoxia hyperventilation, body acceleration through space all have effect of increasing latency and reducing amplitude (Freeman, 1965). But no changes are noticed in the ongoing EEG activity. Thus change in waveform may be a sensitive indicator of increased stress (Mendel and Goldstein, 1969a).

Effect of endogenous factors on MLR are minimal. They remain essentially unchanged with attention to the stimulus train or ignoring the stimulus as in reading a book or sitting with eyes closed in a dark room or with eyes open in a bright room (Picton, Hillyard, 1974; Mendel and Goldstein, 1971; Mendel and Kupperman, 1979).

2. MLR in disorders:

The hearing impaired show a slight increase in amplitude and reduction in latencies of MLR. According to McFarland, et al.(1977), Robinson and Rudge (1977) reported significant latency delays but no amplitude, abnormalities in multiple sclerosis patients. A normal P_a component was noticed in bilateral temporal lobe infarction (Parving et al. 1980). The bilateral lesion noted in Alzheimers disease is not generally sufficient to disrupt P_a potential. But absence of P_a in such cases was noticed by Ozdamar et al. (1982).

Kileny and Berry (1983) studied 15 subjects from 6 weeks - 15 years with evidence of neurologic involvement. They obtained unclear waveforms. They say that MLR in such cases is better suited to determine the function rather than threshold or specific site of lesion, MLR in mentally handicapped doesnot show any significant differences in detectability of N_a and P_a but ABR has better repeatability in such cases (Smith et al. 1985). Harker and Backoff(1981) while studying acoustic neuroma cases, noticed a general increase in latency. The cases with large tumors showed low false negative responses compared to cases with small tumors. So these researchers suggest that MLR can be used as a predictive tool for size of tumors.

3. Maturational changes

Inexorably the development and wear of daily life take their toll on the brain. As evidence, most aged brains show a group of structural changes which are progressive in nature. The electric potentials picked up from the brain may be excellent indicators of such changes in terms of waveform morphology and latencies. In order to find out if this assumption is true, study of differences in MLR as a function of aging is very important.

MLR in adults and to a lesser extent also in young children are reported to be remarkably stable and to be insensitive to changes in the state of vigilance and age (Mendel, 1980 and 1982). Several authors (Mendel et al. 1977; Mendelson, Salavy, 1981) have shown interest in the latency and amplitude differences in infants and adults. Mendel (1977) reported significant changes in morphology between infant and adults. Mendelson and Salamy (1981) reported a significant reduction of latency for P_o between infancy and adulthood.

Normative data for new boms and infants have been obtained By few researchers (Engel, 1972, McRandle et al. 974; Mendel et al. 1977; Wolf and Goldstein, 1978; Ozdamar and Kraus, 1983). In neonates, it is difficult to obtain reasonably clear waveforms (Engel, 1971; Davis et al. 1974; Skinner and Glattke, 1977). But Mendel et al (1976) reported successful threshold estimation in all but one of the 28 infants between 1 month to 2 years of age. Rotteveel et al. (1986) say that identifiable P_o N_a and P_a peaks were obtained from 64 premature infants as early as 25 weeks of chronological age. This indicates an early functioning structure in auditory pathway with most prominent changes in latency and amplitude occuring before and after term date.

Some other studies note little difference between adult and infant morphology of MLR waveform as a function of intensity or rate of presentation (McRandle, et al. 1974; McRandle and Goldstein, 1974; Mendel, et al 1977; Frye-Osier, et al. 1982). As neonatal age increased from 1-8 months, there was an increase in latency of P_a (Mendel et al. 1977).

Wolf and Goldstein (1978) say that the neonates demonstrate slightly shorter latency and smaller amplitudes than do adults. They also report of no significant activity after 60 msec. According to them, ipsilateral stimulation pro-duces more well defined waveforms than contralateral stimula-tion. Goldstein and Madell (1972) noticed consistent responses with similar latencies and slight amplitude differences at different occasions. So MLR can be used as an auditory diagnostic tool for the very young children (Davis, 1976a, Mendel, 1977; Vivion, 1980; Wolf and Goldstein, 1980).

McRandle et al (1974), Madell et al (1977); Mendelson and Salamy (1981) noticed some differences in latencies of P_o and N_a eventhough they were not significant always in different age groups. This may be due to bandpass character-istics selected for the studies (Lane et al. 1974; Goldstein et al 1979; Scherg, 1982). In terms of amplitude, signifi-eant differences were noticed in different age groups. Mendelson and Salamy (1981) report that amplitudes of P_o, P_a and P_b increase till 3-4 years and then reduce in the adult. Kraus et al (1985) say that detectability of P_a increases systematically from birth to adolescence. But MLRs of children are found to differ substantially from that of adults also (Suzuki, et al. 1983; Kraus, et al 1984b).

Not many studies have been done in MLR in the geriatric population. A study done in 1989 by Lenzi et al. reports of certain changes in morphology, latency and amplitude. The subjects were 70-90 years of age. The morphology was different from that of normal adults. Latencies of different frequencies were increased. Amplitudes were considerably reduced in the geriatrics. The reproducibility of waveform was poor. Further the shorter latencies noticed in 30 years old males compared to females were not observed in the elderly subjects.

Allison et al (1983) studies sex differences as a factor affecting latencies of ABR. They say that differences due to age are more stronger in males. They explain the latency differences with respect to the difference in the auditory pathway length such difference may also be seen in MLR wave-forms. The main aim of the present study is to find out if such a difference exists between male and female geriatrics.

D. Clinical utility of MLR:

- **Threshold estimation** - MLR is used as a means of establishing threshold because of its frequency specificity and easy recognizability in infants and stability during sleep.

The level for MLR agree closely with behaviour threshold (Goldstein. Rodman, 1967; Madell and Goldstein, 1972;

Kupperman, Mendel, 1974; Mendel et al. 1975). Goldstein, and Rodman (1967) using click stimuli got responses within 30 dB SL of behaviour threshold. But difficulty in identifying responses nearer to threshold innormal hearing subjects than in partial hearing loss cases wes also reported (Horowitz, et al. 1966). At near threshold, Scherg, Volk (1983) and Ozdamar, Kraus (1983) found consistent N_a, P_a and N_b. The MLR threshold will be within 10-30 dB SL of behaviour measure (Madell and Goldstein, 1972; Mendel et al. 1975; Vivion et al. 1977; Skinner and Glattke, 1977; Vivion et al. 1979; Frye-Osier, et al. 1980). The idea that a just detectable wave P_a is a better measure of auditory threshold than the exact latency of the component is supported in literature (Maurizi et al. 1984). Uehara, et al (1982) studied stability of MLR at just above threshold levels of 0, 10, 20 and 30 dB. P_o, N_a and P_a were fairly stable at 20 dB SL. Complete reversability is not possible even at 30 dB SL.

- **Frequency specific response** - Mendel (1977) says that frequency specific information within a range of 500 Hz - 8000 Hz can be obtained within 10-20 dB of psychoacoustic threshold in adults. MLR is called one of the most useful low frequency threshold estimation (Thornton et al. 1977; McFarland, et al.1977; Kavanagh, et al. 1984). Clinical use at 500 Hz and 1000 Hz stimuli in adults also is reported (Museik, Geurkink, 1981; Scherg, Volk, 1983; Zerlin and Naunton, 1974; Maurizi et al. 1984; Kavanagh, et al. 1984).

- As a means of neurootoloaical diagnosis:- MLR gives information about the integrity of auditory pathways when considered along with other auditory evoked potentials. 12% of cases with multiple sclerosis demonstrated abnormal latencies eventhough ABR responses were normal. These abnormalities also help in distinguishing the active and quiescent disease status (Robinson and Rudge, 1978). Other neurological applications also have been reported (Rapin and Cohen, 1978). MLR for otoneurological diagnosis needs an intensity not below 30 dB as is the general agreement. MLR as a means of assessing higher levels of auditory pathway is supported by many researchers (Celesia et al. 1968; Picton, et al. 1974; Goff et al. 1977; Kraus, et al. 1980, 1982; Kileny, et al.1983, Musiek, et al 1984; Scherg, and Von Cammon, 1986).

- It can also be used as an objective index of cochlear implant function (Gardi, 1985).
- It also can be used as an indicator of different arousal states of the subjects (Kileny, 1983; Hall, 1985; Erwing, Buchweld, 1986).
- Assessment tool for psudohypacusis.

It seems unfortunate that, this almost stable and easy to elicit response whose threshold bears a close relationship to behaviour threshold has been neglected as a useful clinical tool. Once, mote information becomes available on effects of different variables, usefulness ought to increase. As an accurate electrophysiological measure of low frequency threshold it is a boon to the appropriate management of the hearing impaired. In a country like India, where general consensus is lacking in the usage of language, MLR can be used as a diagnostic test easily since it does not need complicated instructions. Since it is an objective test it does not need the active participation of the subjects. This study has been undertaken to provide normative data, of MLR in geriatrics. It tries to find out whether sex variations are seen in MLR in normal adults as well as normal geriatrics.

METHODOLOGY

The methodology of the present study is discussed under the following heads.

- Subjects
- Equipment
- Test environment
- Procedures.

Subjects:

The normative data for MLR waveforms in normal adult population was the first priority. For this purpose, twelve subjects (6 males and 6 females) in the age range of 18-23 years (mean age 20 years) were selected. This was on the basis of their threshold of hearing for pure tones being within 20 dB according to ANSI-1969. This data was used as base line for studying MLR waveforms in the geriatrics.

The present study made use of ten geriatrics. The age range was 50-62 (mean age 56 years). The subjects included 5 males and 5 females within the specified age range. They had to satisfy certain criteria before being included in the study.

1. The subject should have hearing levels within 40 dB for the octave range of 250 Hz - 8000 Hz in both ears.

2. The subject should not have any history of acute or chronic ear disease, headache, tinnitus, vertigo or any other otological problems.
3. The subject should not have any psychological problems.
4. The subject should not have any neurological problems.
5. The subject should report of good general health at the time of testing.
6. The subject should be able to relax with the electrodes in position for the duration of the testing.

Equipment:

The two instruments used for the testing were -

1. Diagnostic audiometer (OB 822)
2. Electrophysiological test equipment (Nicolet Compact Auditory System).

- This was used in the assessment of pure tone thresholds for the 250 Hz - 8000 Hz range. The instrument was calibrated for air conduction and bone conduction and speech audiometry. Daily calibration, using the tester's own hearing threshold level as baseline was also done.

- This was used to obtain MLR waveforms from the subjects. It can be used for other electrophysiological measures also.

NICOLET COMPACT AUDITORY SYSTEM

Test environment:

1. The tests were conducted in the sound treated room which met the ISO (1969).
2. Power source was the main AC supply.
3. Humidity was maintained at the specified levels.
4. Temperature was also at the required level.
5. The instrument was kept away from bright light as well as from noisy areas.

Procedures:

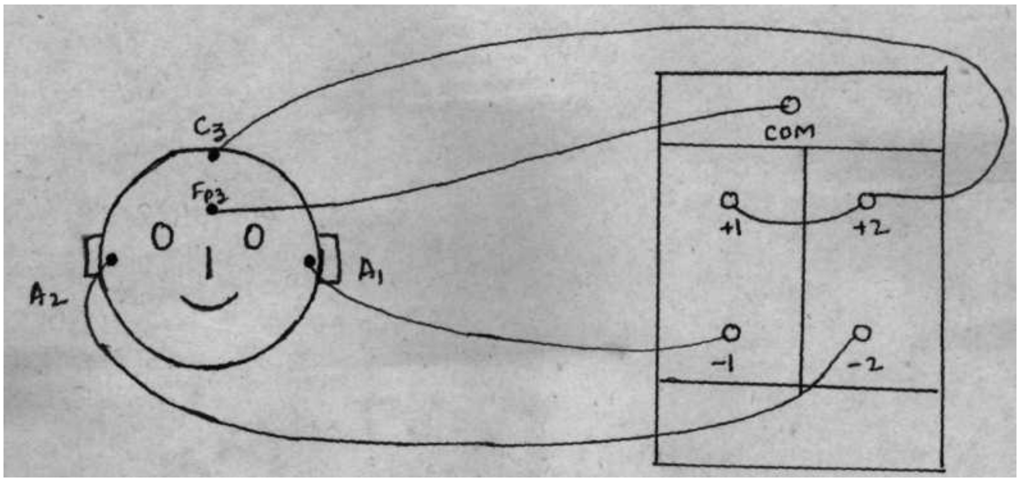
The subject was seated in a comfortable chair.

Instructions - The subject was asked to sit comfortably - "Now, I shall place the electrodes at the proper places. You have to relax. You need not indicate the presence of any sound. The test will take about 45 minutes. Please do not move your arms, shoulders and neck. Also please tell me if you are uncomfortable in this position".

The instructions were given in Kannada, English, Tamil, Malayalam according to the mother-tongue of the subject. Instructions were repeated once to make sure that the subject has understood them.

Electrode placement - The area of placement of electrode was cleared by rubbing the surface with cotton dipped in rectified spirit. This was done till the surface appeared red indicating vascularity. Electrodes were checked for continuity. Appropriate amount of gel was used to stick the electrodes in their respective positions. They were secured by a piece of plaster.

The electrode sites used were the vertex (C_z) as positive and forehead (F_{pz}) as common and the medial- side of ear lobes as negative.



- Channel-1 - A_1 - left ear
- Channel-2 - A_2 - right ear
- Cammon-F_{pz} - forehead
- Jumper C_z - vertex

After placing the electrode the Nicolet Compact Auditory System was powered up. Impedance matching was carried out as directed in the manual which says all values should be less than 5000 Ohms and be within 3000 Ohms of each other.

Earphone placement - The patient had proper head support to make noise free recording easy. Earphones were placed without dislodding electrodes. Blue earphone was used for the left ear and red to the right. Earphone diaphagm was directly over the ear canal so that accurate stimulus intensity levels were delivered to the ear.

Stimulus Parameters

Stimulus	-	tone burst
Frequency	-	500 Hz
Rise time	-	Instantaneous
Fall time	-	Instantaneous
Plateau	-	2 m.sec.
Rate	-	9.7/sec.
LFF	-	10 Hz
HFF	-	100 Hz
Sample number	-	2000
Polarity	-	alternative
Artefacts allowed	-	20%

The MLR waveform was found out only for one ear which was randomly selected. The test was carried out according to Nicolet Biomedical auditory manufacturers manual. The test was begun at an intensity of 60 dB nHL. The lowest intensity at which clear waveform could be obtained was found out. If the artefacts exceeded 200 in number the waveform was rejected. The MLR waveforms obtained by the subjects were stored and later analyzed for their latencies of peaks N_o, P_o N_a , P_a, N_b and P_b at different intensities.

Patient: VARADA ID:

Sex: M Birth day: 56

Today: 05/92/:

Examiner: IMSC

Case History:

N

Diagnostics:

N

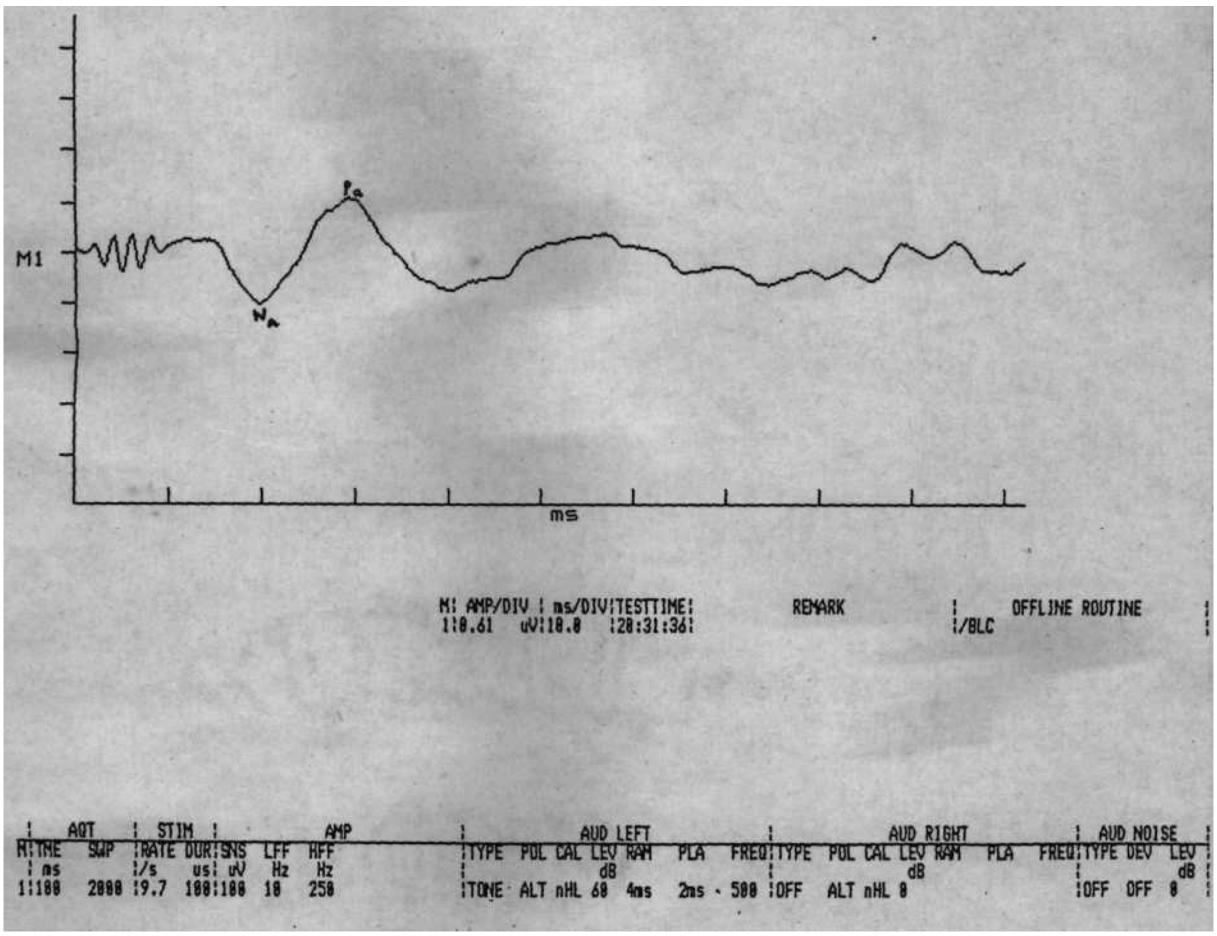


Fig. MLR waveform of a male geriatric at 60 dB nHL for tone bursts.

Patient: PAVKUTTI ID:
Sex: F Birth day: 50
Today: 06/87/:< Examiner: DIRC
Case History:
N
Diagnostics:
N

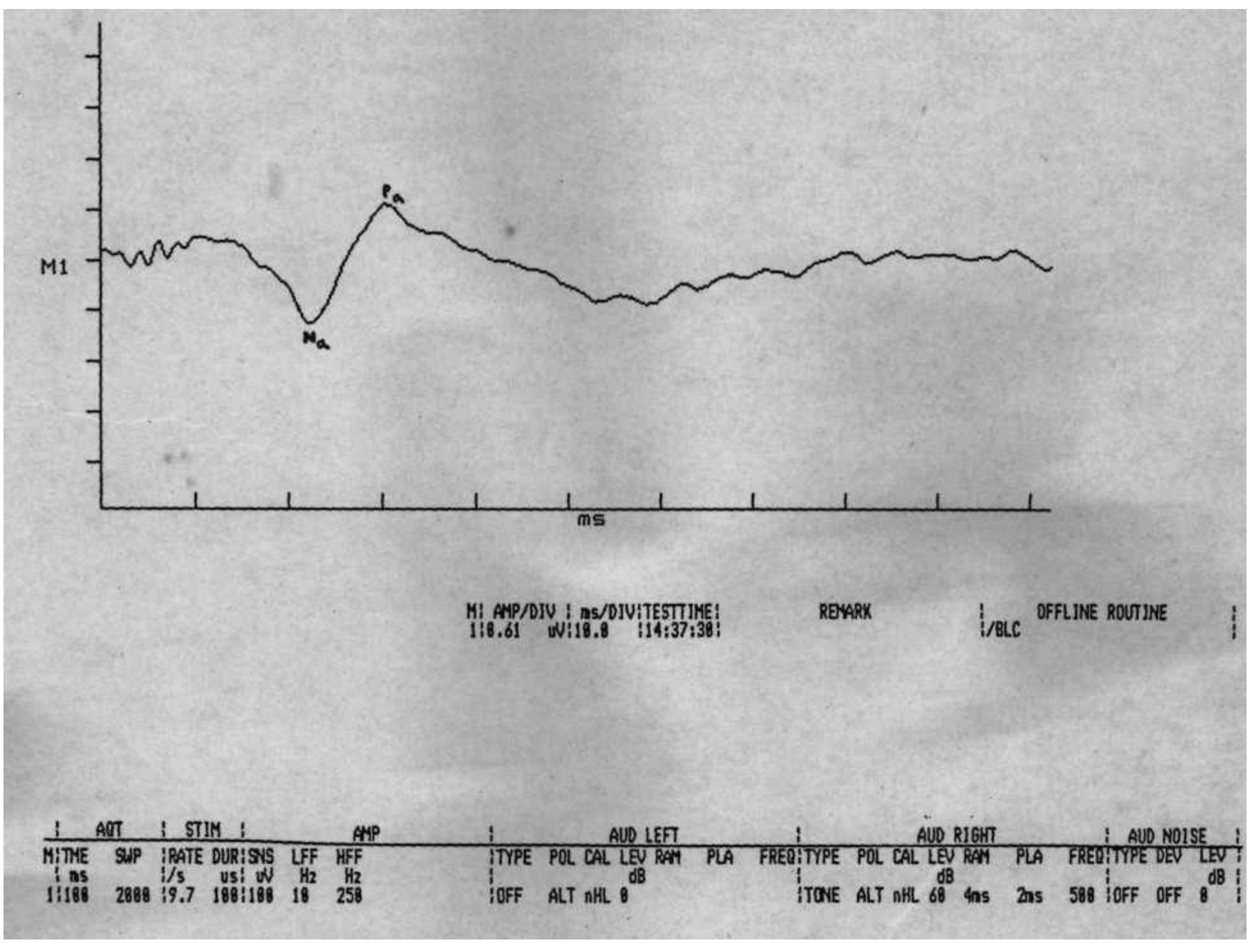


Fig. MLR waveform of a female geriatric at 60 dB nHL for tone bursts.

RESULTS AND DISCUSSION

The subjects were chosen based on their pure tone average on pure tone audiometric testing. The twelve adult normals as well as the ten geriatrics who underwent testing showed a pure tone average within normal limits ie within 0-20 dB for 500 Hz, 1000 Hz, 2000 Hz. Since the stimulus used in this particular study was 500 Hz tone burst, only the 500 Hz pure tone threshold was considered to estimate the relationship between pure tone threshold and MLR threshold.

Table-1: Pure tone thresholds for 500 Hz and intensities at which a clear Pa peak was obtained for normal adults.

Subjects	Pure tone for 500 Hz	Intensity of clear peak Pa in dB nHL
1	15	40
2	10	30
3	10	40
4	10	30
5	10	30
6	5	30
7	5	30
8	10	30
9	15	30
10	15	40
11	10	30
12	15	30

Table-1 shows a comparison between 500 Hz thresholds and MLR thresholds for peak P_a . Only the P_a latency value was taken in this study, following the observation that the clarity of peak P_a is a better estimation of threshold and the absolute latency is not very important (Maurizi, et al. 1984). In normal adults, the pure tone thresholds range from 5-15 dB. The peak P_a was clear for 9 subjects at 30 dB nHL. In this case, MLR threshold is about 15-25 dB SL above the behavioural threshold. In the remaining 4 subjects, the peak P_a was clear at an intensity of 40 dB nHL. This indicates that the MLR threshold lies 25-35 dB SL of behaviour thresholds in those 4 subjects.

Table-2: Pure tone threshold for 500 Hz and intensities at which clear peak Pa was obtained in normal geriatrics.

Subjects	Pure tone threshold for 500 Hz	Intensity at which clear Pa was obtained in dB nHL
1	15	30
2	5	40
3	20	30
4	0	40
5	20	30
6	10	40
7	10	30
8	15	30
9	15	30
10	10	30

Table-2 shows the relationship between pare tone thresholds for 500 Hz and clear peak P_a at different intensities in normal geriatrics. The pure tone thresholds range from 0-20 dB in the geriatrics. Six subjects showed a clear peak P_a at 30 dB nHL. From this, it was concluded that the MLR threshold lies 10-30 dB SL above the behavioural threshold. For the remaining 4 subjects, the peak Pa was clear at 40 dB nHL. This indicates a relationship of 20-40 dB SL between the pure tone threshold and MLR threshold.

Based on the above data, it can be concluded that in both the adults and geriatrics, the MLR threshold lies within 20-30 dB SL of the behavioural threshold on an average. A better estimate however could be obtained whan more subjects are involved.

The main purpose of the study was to find out the sex variations in MLR peak latencies for normal adults as well as the geriatrics. Using the Nicolet Compact Auditory System, MLR waveforms were obtained for 500 Hz tone bursts. Peaks N_o, P_o, N_a, P_a, N_b and P_b were considered for the study.

The latencies were considered when -

- a sharp peak was obtained
- a sharp peak was not obtained, the mid point of the peak was taken for latency.

- a gradual slope was obtained, again mid point of the slope was noted.
- a double peak was obtained, then mid point was considered.
- the waveform was fuzzy, that was rejected and another clear waveform was tried to obtain.

The peak latency values were then subjected to statistical analysis. Wilcoxon test for independent samples was used to analyse the peaks N_a and P_a only. This was done because these two peaks were obtained from all the subjects consistently. The other peaks did not emerge, clearly and consistently in all the subjects to require extensive statistical analysis. However all the peaks were subjected to detailed descriptive analysis also. The stimulus frequency considered was 500 Hz according to Brown and Shallop (1981), Naurizi et al (1984) who reported that tone bursts of 500 Hz gives frequency specific response. The test was started at 60 dB nHL following the report that at moderate intensities, the amplitude of MLR waveform levels off (Ozdamar and Kraus, 1983).

Table-3: MLR peak latency at 60 dB nHL for 500 Hz tone bursts in normal adults.

Sub-jects	Sex	Ear tested	No	Po	Na	Pa	Nb	Pb
1	M	L	16.6	19.4	24.0	32.4	48.6	-
2	M	R	-	13.0	21.2	34.4	48.4	-
3	H	R	-	-	20.0	29.4	44.4	-
4	M	R	-	-	21.8	30.0	46.2	-
5	M	R	-	-	22.6	28.4	-	-
6	M	L	-	10.4	20.6	31.4	47.2	-
7	F	R	-	16.4	24.4	38.4	48.4	-
8	F	L	-	-	22.6	32.8	40.8	59.8
9	F	L	-	-	22.2	35.0	-	-
10	F	R	-	-	21.8	29.2	41.0	-
11	F	L	-	-	22.1	33.4	41.4	-
12	F	L	-	-	17.0	28.2	42.6	-

M - Indicates Male; F - Indicates Female

R - Indicates right; L - Indicates left.

Table-3: In normal adults, consistent values were obtained only for peaks N_a and P_a. Statistical analysis was performed for these two values. Mean latency for N_a in males is 21.7 m.sec. with the range of 20-24 m.sec. and in females 22.1 m.sec. with the range of 19.4-24.4 m.sec. It was noticed that in females the mean as well as range of latency was increased slightly though it was not statistically significant. The peak P_a mean latency in males is 31.00 m.sec. with a range of 28.6 - 34.4 m.sec. and in females 32.10 m.sec. with the range of 28.2 - 38.4 m.sec. Again females showed slightly increased mean and range of latency at 60 dB no significant difference exists between normal males and females for N_a and P_a.

On descriptive analysis it was noticed that only one mean out of 12 subjects showed a peak N_o at a latency of 16.6 m.sec. Peak P_o was found in 4 (1 female,3 male) subjects. The range of latency was from 10.4 m.sec. to 19.4 m.sec. Peak N_b was obtained in 10 (4 males and 6 females). The latency ranged from 40.8 - 48.6 m.sec. P_b peak was found at a latency of 59.8 m.sec. in one female out of 12 subjects. No N_c peak was noticed in any of the subjects.

Table-4: MLR peak latencies at 40 dB nHL for 500 Hz tone bursts in normal adults.

Sub-jects	Sex	Ear tested	No	Po	Na	Pa in msec.	Nb	Pb	Nc
1	M	L	-	19.8	24.4	36.2	49.2	60.8	-
2	M	R	-	-	18.2	34.8	-	-	-
3	M	R	-	-	22.0	29.0	42.8	-	-
4	M	R	-	-	21.4	33.2	47.0	-	-
5	M	R	-	10.0	23.4	31.4	40.6	-	-
6	M	L		11.2	24.0	33.6	48.2	-	-
7	F	R	-	16.2	24.5	41.2	51.0	-	-
8	F	L	-	-	24.2	34.0	47.4	-	-
9	F	L	-	-	23.8	35.0	-	-	-
10	F	R	-	-	24.0	30.8	43.6	53.4	67.0
11	F	L	-	13.0	21.4	32.6	42.2	-	-
12	F	L	-	10.0	19.2	35.4	42.8	-	-

M - Indicates Male; F - Indicates Female

R - Indicates Right; L -Indicates left.

Table-4: shows peak latencies at 40 dB nHL in normal adults. Statistical analysis was done for latencies of N_a and P_a. For peak N_a males showed a mean latency of 22.93 m.sec. with a range of 21.4 - 24.4 msec. while female showed a latency of 22.9 m.sec. with a range of 19.4 m.sec. to 24.6 m.sec. Only the range of latency showed slight increase in case of females which was not statistically significant. The peak P_a showed a latency of 32.4 m.sec. with a range of 29.0 - 34.8 m.sec. in males and a latency of 34.6 m.sec. with a range of 30.8 - 39.8 m.sec. Again females showed increase in both factors but differences between males and females were not significant statistically.

On descriptive analysis no N_o peak in any of the subject was noticed. Six subjects (3 males and 3 females) showed the P_o peak at a latency range of 10.0 - 19.8 m.sec. Ten subjects (5 males and 5 females) showed the N_b peak with a range of 40.6 - 51.0 m.sec. P_b peak was seen in only one male at a latency of 60.8 m.sec. but the peak was not very clear. In one female it was seen with a latency of 53.4 m.sec. Here a double peak was noticed. Peak N_c was seen only in one female at a latency of 67.0 m.sec. which was a double peak. In this case as intensity reduced the latency value appeared to increase also the wave form showed reduced clarity.

Table-5: MLR peak latencies at 30 dB nHL in normal adults for 500 Hz tone bursts.

Sub-jects	Sex	Ear tested	No	Po	Na	Pa	Nb	Pb	Nc
						in msec.			
1	M	L	-	-	No clear peaks - -				
2	M	R	-	-	22.2	38.2	-	-	-
3	M	R	-		No clear peaks -				
4	M	R	15.8	19.4	22.8	33.6	52.2	-	-
5	M	R	-	10.8	24.4	33.4	-	-	-
6	M	L	-	11.2	25.0	34.6	48.2	-	-
7	F	F	8.6	17.2	24.2	-	No clear peaks		-
8	F	L	-	-	26.2	36.2	45.8	-	-
9	F	L	-	-	24.0	37.0	47.2	-	-
10	F	R	-	20.0	25 .2	36.2	54.6	55.4	69.0
11	F	L	9.6	13.4	24.0	34.4	48.4	-	-
12	F	L	-	14.6	19.4	----			

M - Indicates male; F - Indicates female

L - Indicates left; R - Indicates right.

Table-5 shows peak latencies of MLR at 30 dB nHL in normal adults. In this case statistical analysis was not done since none of the peaks were consistent in all the subjects. On descriptive analysis it was noticed that ten subjects (4 males and 6 females) gave clear waveforms. Two subjects did not show any of the peaks. One subject showed only 2 (22.2 m.sec. and Pa, 34.2 m.sec) peaks. Peak N_o was noticed in three subjects (1 male and 2 females) with the latency range of 8.6 - 15.8 m.sec. P_o was noticed in seven subjects (3 males and 4 females) with the latency range of 10.80 - 19.4 m.sec. N_a was noticed in ten subjects (4 males and 6 females). The latencies ranged from 19.4 - 26.2 m.sec. P_a was noticed in nine out of twelve subjects (4 males and 5 females). In this case the latency was from 33.4 - 37omsec. Only six subjects (2 males and 4 females) showed peak N_b with range of 44.6 - 52.2 m.sec. Peak P_b at a latency of 55.4 m.sec. was seen in only one female subject. Peak N_c was also seen in the same subject. Its latency was 69 m.sec. Generally it was noticed that at 30 dB nHL very sharp peaks were not present, instead more double peaks were seen.

Table-6: MLR peak latencies at 60 dB nHL for 500 Hz tone burst in geriatrics.

Sub-jects	Sex	Ear tested	No	Po	Na	Pa in msec.	Nb	Pb	Nc
1	M	L	-	14.8	22.0	30.0	40.4	52.6	-
2	M	R	14.8	18.6	22.8	30.2	43.2	-	-
3	H	L	-	14.2	19.8	29.2	40.2	-	-
4	M	R	12.0	16.6	22.6	31.2	-	-	-
5	M	L	12.0	14.8	23.4	32.1	41.4	52.1	-
6	F	R	-	12.4	20.0	30.8	-	-	-
7	F	R	-	13.6	22.2	30.6	-	-	-
8	F	L	-	17.0	21.0	32.8	44.4	55.4	-
9	F	L	-	16.0	22.6	34.0	45.6	-	-
10	F	R	-	-	19.2	29.0	42.2	-	-

M - Indicates male; F - Indicates female

R - Indicates right; L - Indicates left.

Table-6: shows MLR peak latencies of geriatrics at 60 dB nHL for 500 Hz tone bursts. Statistical analysis was done only for peaks N_a and P_a which were the only consistent peaks seen in the geriatric waveforms of MLR. For peak N_a, the males showed a latency of 22.1 Ω m.sec. (range of 19.8 - 23.4 m.sec) while females showed a latency of 21.omsec. (range of 19.2 - 22.6 m.sec). In this case females showed slight reduction in the mean latency as well as the range. This observation is different from what was seen at 60 dB nHL in normal adults. But this difference is not significant statistically. For peak P_a the males showed a latency of 30.54 m.sec. (29.2 - 32.1 m.sec. range) while females showed a latency of 31.44 msec. (29.0 - 34 m.sec range). In this case a slight increase was noticed for the mean latency as well as the range of latency which was not statistically significant.

On descriptive analysis it was noticed that peak N_o was seen in only three males with the latency range of twelve to fourteen-eight m.sec. Peak P_o was seen in all but 1 female out of the ten subjects the latencies ranged from 12.4 - 18.6 m.sec. Seven subjects (4 males and 3 females) showed peak at 40.20 - 45.6 m.sec. Peak P_b was seen in 3 subjects (2 males and 1 female) with a latency of 52.1 - 55.4 m.sec. No N_c peak was noticed.

Table-7: MLR peak latencies at 40 dB nHL for 500 Hz tone bursts in geriatrics.

Sub-jects	Sex	Ear tested	No	Po	Na	Pa (in m.sec.)	Nb	Pb
1	M	L	11.6	13.4	23.6	31.6	43.2	-
2	M	R	-	19.2	22.8	31.6	43.8	-
3	K	L	-	-	20.4	33.0	41.8	-
4	M	R	-	17.2	24.4	35.0	-	50.8
5	M	L	-	19.6	24.2	33.6	-	-
6	F	R	-	-	21.8	30.0	-	-
7	F	R	-	18.6	24.6	33.6	44.4	53.0
8	F	L	-	21.0	23.2	32.0	43.6	-
9	F	L	-	-	22.2	35.2	44.2	-
10	F	R	-	11.2	23.8	31.0	43.8	52.0

M - Indicates male; F - Indicates female

L - Indicates left; R - Indicates right.

Table-7 shows MLR peak latencies at 40 dB nHL in geriatrics for 500 Hz tone bursts. Peaks N_a and P_a were subjected to statistical analysis. Peak N_a at a latency of 22.8 m.sec. (20.4 - 24.2 m.sec.range) was seen in males while females showed Peak N_a at a latency of 23.10 m.sec. (21.8 - 24.6 m.sec). A slight increase which was seen in the female for both these factors was not significant. Peak P_a was seen in males at 32.80 m.sec. with the range of 31.20 - 35.0 m.sec. In females it was seen at a latency of 32.30 m.sec. (30 - 35.2 m.sec. range).

At 40 dB nHD the latencies of the various peaks appeared to increase. 11.6 m.sec. was the latency of peak N_o which was seen only in 1 male out of the ten subjects. Peak P_o was noticed in seven subjects (4 males and 3 females) with a range of 11.2 - 21.0 m.sec. Peak N_b was clear in seven subjects (3 males and 4 females) with the latency range of 41.8 - 44.4 m.sec. Only three subjects (1 male and 2 females) showed peak P_b ranging from 50.8 - 53.0 m.sec. No N_a peak was noticed in any of the subject.

Table-8: MLR peek latencies at 30 dB nHL for 500 Hz tone bursts in geriatrics.

Sub-jects	**Sex**	**Ear Tested**	**No**	**PO**	**Na**	**Pa**	**Nb**	**Pb**
						in msec.		
1	M	L	- -		23.8	34.8	-	-
2	M	R		- clear wave form -				
3	W	L	11.8	14.6	19.6	36.2	-	-
4	H	R		No clear wave form				
5	H	L		- 20.0	23.8	35.4	-	-
6	F	R		No clear wave form				
7	F	R	-		26.2	34.2	46.2	52.6
8	F	L		No clear wave form				
9	F	L	- -		27.0	34.8	49.4	-
10	F	R		- 17.0	27.0	33.2	43.2	-

M - Indicates male; F - Indicates female

R - Indicates right; L - Indicates left.

Table-6 shows MLR peak latencies at 30 dB nHL for 500 Hz tone bursts in geriatrics. Since at this intensity all the subjects did not show consistent peaks no statistical analysis could be done. In four subjects no clear wave forms were obtained. At a latency 11.8 m.sec, only one subject showed the peak N_o. Three subjects (2 males and 1 female) showed peak P_o at a latency range of 14.60 - 20.0 m.sec. Peak N_a was seen in six subjects (3 males and 3 females) at 19.60 - 27.0 m.sec. The same six subjects showed P_a at 33.20 - 36.20 m.sec. Peak N_b was seen in 3 female subjects at a range of 45.20 - 49.4 m.sec. Peak P_b was seen at 52.6 m.sec. in only one female subject out of the ten subjects. In none of the subjects peak N_c was observed. But at this intensity the peaks were unclear. More double peaks were noticed.

DISCUSSION:

According to results obtained no consistency was found between MLR and pure tone threshold so as to indicate the relationship between them as a single number. So a range has been used to express this relationship. The level of MLR was found to be 20 - 30 dB SL above the behavioural threshold. As the stimulus intensity reached near threshold levels the peaks were seen to become distinct. Most of the normal adults as well as geriatrics showed clear peak P_a at 30 dB nHL. But at this level latencies of the peak were increased. In some cases double peaks and fuzzy wave forms were also obtained.

The peak P_a was found to be the stablest. This observation is an agreement with Maurizi et al (1984) who say that detectable P_a is a more significant measure of auditory threshold. That is why the peak P_a was considered for comparing with MLR threshold. It was also noticed that there was a slight increase in the latency for N_a and P_a peaks as the stimulus intensity was reduced. This agrees with the studies done by Madell and Goldstein (1972), Picton et al (1987), Thornton et al (1977).

There were no statistically significant latency differences between males and females in both groups of subjects for peaks P_a and N_a . This may reflect the supposition that there is no physiological difference existing between males and females. This study does not reflect the findings of Allison et al (1983) whieh says that differences due to age are more stronger in males for ABR measurements. They try to explain this difference on the basis of auditory pathway length. The differences between males and females in this study for absolute latency as wall as latency range were not statistically significant. These two values were slightly increased in females of both the adult and the geriatric group.

The waveform clarity reduction may be because of movement of the head and neck by the patient. It is also noticed that as a subject began to sleep, the muscle increased. This may be because of the nodding of head. As they were made to sit properly, but relaxed the waveforms became clearer.

This study can be considered as one of the first in terms of normative data for MLR wave forms in the geriatric population. Along with indication of absolute latency values for the different peaks, it also emphasises on the variations existing between males and females, which is an important aspect of normative data.

SUMMARY AND CONCLUSION

The present study was designed with the aims of finding out

a) Whether any relationship exists between behaviour thresholds and thresholds for MLR in normal adults as well as geriatric subjects.

b) Whether any sexvariation is noticed for thresholds of MLR in adult normals.

c) Whether any such sex variation exists for thresholds of MLR in geriatric subjects.

Twelve normal adults (age range of 18-23 years) and ten geriatrics (age range of 50-62 years) were selected. Their threshold levels for pure tones were obtained for the frequency range of 250 Hz - 8000 Hz which was within 0-20 dB for normals and 0-40 dB for the geriatrics. MLR waveforms for tone bursts at 500 Hz for intensities 60 dB, 40 dB, 30 dB nHL were found put. The latency values for peaks N_o, P_o , N_a , P_a , and N_b and in some cases P_c and N_c were noted for 2000 stimuli at a rate of 9.7/sec. The values were statistically as well as descriptively analysed. Wilcoxon test for independent samples was used for analysing peaks N_a and P_a as they were the only consistently obtainable peaks.

The results indicated that,

a) In normals, the MLR thresholds lie within 20-30 dB SL of behaviour thresholds. In the geriatrics, they lie within 20-30 dB SL of behaviour thresholds on an average.

b) There were no significant differences between normal males and females for N_a and P_a peak latencies of the MLR waveform.

c) Also no sginificant differences were present between male and female geriatric subjects for N_a and P_a peak latencies of the MLR waveform.

d) The stimuli used ie tone bursts seemed to elicit less earlier peaks N_o and P_o as compared to click stimuli. This is reported by Sujatha (1991).

e) Latencies of different peaks for tone bursts were increased compared to those elicited by click stimuli (Sujatha, 1991).

f) No significant age difference was noticed in two groups of geriatric subjects (Bhuvaneshwari, 1991).

Limitations:

- Less number of subjects in adult as well as the geriatric group so that generalization is not possible.
- Since the case was seated on a chair absolute neck muscle relaxation may not have been possible.
- Only one frequency was tested.

Recommendations:

- To use more number of subjects.

- To change the testing position to a lying down position with proper head rest so that muscle artefacts reduce.
- To confirm efficacy of MLR as a sensitive measure of low frequency hearing, using 1000 Hz and 2000 Hz frequencies also.

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