Noise Induced Hearing Loss in Hard Rock Miners of Kadapa, A.P. India.

Challa Venkata Subbaiah[1], R. Ananth[2]
[1]Associate Professor, Dept of ENT, RIMS Hospital, Kadapa, A.P.
[2]Audiologist and Speech Pathologist, Dept of ENT, RIMS Hospital, Kadapa, A.P.

ABSTRACT

Background: Noise is excessive, unwanted sound stimulus in the atmosphere produced by extraneous sources resulting in permanent pathological changes in the inner ear, the cochlear nerve and its ganglia. It is one of the constituents of atmospheric pollution. Noise in the vicinity of workplaces is termed as occupational noise trauma which is imminent in workers in certain industries and unavoidable in them, but preventable to some extent. The present study is to measure such audiological threshold values to correlate the pathological changes in the workers with the help of audiometry. The aim of the study is to measure the noise levels in the industry and its effect on hearing capabilities of miners working there with audiological data and to formulate effective preventive measure for them. **Methods:** Miners from a Hard Rock cutting industry near Kadapa, A.P. are chosen and divided into 2 groups depending upon their work experience between 3 to 14 years. Audiometry is performed to record their Air Conduction thresholds in both ears at all the frequencies, before and after working hours. The data are analyzed and looked for statistical significance. **Results:** Miners with less than 7 years work experience had smaller temporary threshold shifts compared to miners above 7 years experience. The base level A.C threshold values were higher compared to miners with less than 7 years experience. The threshold shift was mostly observed in the frequency 6000KHZ, in both the ears. The average of mean thresholds of Air Conduction was found to be higher in the higher frequencies. **Conclusion:** Prolonged exposure to noise levels above 85dB for 8 hours in a day, 6 days per week for 3 to 14 years results in hearing loss due to permanent changes in the inner ear. Higher frequencies are more affected than the lower frequencies with higher base level thresholds. All the frequencies showed temporary threshold shifts ranging from 1.69 to 4.37dB when recorded immediately after the working periods. There was statistical significance observed for all frequencies in both ears for the threshold shifts with a P value less than 0.05.

Keywords: Noise Exposure, hearing loss, pure tone audiometry, PTA, SRT.

INTRODUCTION

The word "Noise" is derived from the Latin word "Nauseas", which means sea sickness. Noise is any unwanted, irritating, distracting or unpleasant sound which causes atmospheric pollution. The sources of noise vary from Mining industry, aeroplanes, moving trains, construction work, vacuum cleaners, and machines in a factory, car alarms, shouting people, sirens, vehicular traffic, snow motor bikes, horns, fireworks, barking dogs and loud music. The acceptable noise levels, according to the US Environmental Protection Agency are between 55 and 65 Db.[1]

Name & Address of Corresponding Author
Dr. Challa Venkata Subbaiah
Associate Professor,
Department of ENT,
RIMS Hospital,
Kadapa, A.P., India.
E mail: venkatasubbaiahent@gmail.com

Noise has a significant impact on the quality of life resulting in a health problem wherein according to World Health Organization's (WHO) health[2] is defined as physical and mental well-being and mere absence of diseases. In 1971 WHO working group stated: "Noise must be recognized as a major threat to human well-being."[3] Noise-induced hearing loss (NIHL) is defined as hearing loss (HL) resulting from exposure to excessive noise over a number of years and resulting in bilateral and symmetrical impairment of hearing. NIHL is always of the sensory-neural type due to permanent changes in the cochlea developing over a prolonged period of hazardous noise exposure.[4] The noise can be either consistent or impulsive of over 80 dB resulting in diminished ability to hear speech and loss of intelligibility of speech.[5] NIHL is technically also termed as 'permanent hearing threshold shift that usually takes years to develop. Hearing loss due to injurious noise at the workplace is referred to as Occupational Noise Induced Hearing Loss (ONIHL). It begins with selective loss of hearing at around 4000 KHZ, which is recognized as a dip in the air conduction curve at around 4000 KHZ and though not pathognomonic, is the characteristic audiometric pattern. The notch deepens and widens with the continuous exposure to noise. Later on persistent noise exposure progressively encroaches on the middle frequencies also. NIHL also results in few non-auditory effects and predominant among them is development of tinnitus.[6] The prevalence of tinnitus has been reported in between 30 and 65% of cases with a history of noise exposure, around twice the prevalence in the general population.[7] Other non-auditory effects of noise pollution are symptoms related to the autonomic nervous system, such as increase skin temperatures, increased pulse rate, increased blood pressure and a narrowing of blood vessels, abnormal secretion of hormones and tensing of muscles.[8] NIHL reduces the ability to communicate and as a result reduces the quality of life, increased fatigue, frustration, stress, anger, embarrassment, isolation, negative self-image and reduced autonomy.[9] Few authors have listed symptoms related to higher brain functioning which include interference in thought processing, task execution and disturbances in sleep patterns that result in decreased appetite.[10] Excessive noise exposure is reported to reduce job performance and can cause high rates of absenteeism.[11] Nearly 16% (4 millions) of the causes of HL are attributed to ONIHL all over the world. It ranges from 7% to 21% in various sub regions. In Indian scenario very few surveys are done on the effects of hard rock miners. The present study was conducted to evaluate the Hard Rock miners of Kadapa of Andhra Pradesh by the department of ENT of RIMS Kadapa.

MATERIALS AND METHODS

Aim of the study: To evaluate the effect of noise exposure on hearing acuity of miners employed in hard Rock mines, to correlate the symptoms with audiological data and to formulate effective preventive measure for them.

Objectives: To measure the noise level in an around the mining area. To determine the presence of hearing loss, know the magnitude of the hearing loss among the miners and make the miners aware of the hazards of noise.

Null Hypothesis: There is no effect of hearing on miners who works in hard rock mines.

Methodology: The present study aims to investigate the effect of hard rock mining on hearing acuity of miners. Identify the early onset of hearing loss among them and bring awareness and further rehabilitation. It also aims to measure the noise levels in mines. The miners were divided in to two groups.

Group I: Consisted of 24 miners aged between 25 and 45 years with work experience of 3 to 7 years.

Group II: Consisted of 28 miners aged between 25 and 45 years with more than 7 years experience.

Inclusion criteria. Adult males aged between 25 and 45 years. 2. Miners with noise exposure duration more than 6-8 hours per a day. 3. Miners with normal pre employment hearing acuity. 4. Miners with normal Tympanic membrane. 4.

Exclusion Criteria: 1. Miners with previous history of Ear discharge. 2. Miners with history of loss of hearing. 3. Miners with history of early onset of HL in the family. 4. Miners with history of Hypertension, Diabetes Mellitus, neurological problems, ototoxic drugs intake, history of head trauma. The participants were subjected to detailed case history, otoscopic examination and Pure tone audiometry.

Test environment: Audiometry tests were carried out in a sound proof room with the specific limits (ANSI 1998).

Pure Tone Audiometer: Clinical diagnostic audiometer (Elkon Multi) with TDH 49 supra aural headphones and B-71 (Radio Ear) bone vibrator is used to estimate the hearing sensitivity for all the groups.

Sound Level Meter (SLM): RadioShack 33-2055 Digital SLM was used to measure the noise levels.

Procedure: Otoscopic examination: All the participant's ear canal and tympanic membrane were examined. Individuals with normal tympanic membrane appearance were included. Any cerumen if present was removed.

Audiological Test: Miners of the two groups were tested for air conduction, Bone conduction and speech audiometry thresholds.

Pure tone Audiometry: The hearing sensitivity was estimated for two groups using the Hughson-Westlake ascending descending method. Elkon Multi diagnostic audiometer was used which was calibrated. Pure tone air-conduction thresholds were measured at 0.25, 0.50, 1, 2, 3, 4, 6, 8, 10 and 12 kHz with TDH49p headphones. Bone conduction thresholds were measured at 0.25, 0.50, 1, 2, 3, 4, 6, and 8 kHz. All audiometric thresholds were measured with adequate masking and were expressed in dB HL according to standards of diagnostic Audiometry.

Noise measurements: A calibrated integrating sound level meter (SLM: RadioShack 33-2055 Digital SLM) with half inch microphone was used for used to measure the noise levels in an around the mines. A-weighting network was selected in order to suppress the responses of the high and low frequencies. The response time was set to "Slow" to reduce the likelihood of an overestimation of sound levels and to smooth out the noise fluctuations. The dynamic range of the SLM was set to 50-130 dB (A). Noise measurements were done during the daytime by placing the microphone near the ear level in two conditions, i.e. with engine on but cutter off and with the engine and cutter on position. These measurements were repeated during the night time. All the subjects were subjected to hearing test before and after their work.

Statistical analysis: All statistical analyses were performed using *Statistical Package for Social Sciences* (SPSS 17.0).

OBSERVATIONS

Preliminarily Noise levels of the work place are measured at day time with only engine on position (P1) and the values were 85.84±1.89 dB and 88.63 ±2.83 dB for the right and left ears respectively. The day time measurements with engine and cutter on position (P2) were 100.20±2.35 dB and 103.3±3.21 dB for the right and left ears respectively. The night time measurements with only engine on position (P1) were 83.7± 2.97 and 86.7±2.65 for the right and left ears respectively. The night time measurements with engine and cutter on position (P2) were 95.6±3.77 dB and 99.55±5.51 dB for the right and left ear respectively [Table 1]. It can be noted from the above mentioned values that the noise levels consistently higher than the 85 dB (A) levels which is the highest permissible noise according to OSHA. It can be noted from the above results that the noise levels during the night were slightly lower probable because extraneous noises like traffic noises etc were less during the night. .

Table 1: Showing the noise levels during Day and Night in both the ears.

S. No	Status of the Machinery & side of the Ear	During day time		P value	During Night time		P value
		Mean	S.D		Mean	S.D	
1	P1R	85.84	1.89	P<0.001	83.66	2.97	P<0.001
2	P1L	88.63	2.83		86.66	2.65	
3	P2R	100.26	2.35	P<0.001	95.76	3.77	P<0.001
4	P2L	103.21	3.21		99.8	5.51	

Summary of the results of Air conduction thresholds in both ears for the group I from 250 Hz to 12000 Hz before and after the exposure to the noise showed the average of mean values ranged from 12.29 to 32.29 at 250 to 120000 Hz respectively. There was a shift of threshold values in all the frequencies after exposure to noise during the work compared to before work. The shift of the threshold was ranging from 1.69 dB to 4.37 dB and the shift was highest at 6000KHZ frequency and lowest at 250KHZ [Table 2]. With general observation the thresholds compared higher at the higher frequencies to lower frequencies. The threshold values were higher after exposure than before work.

Pure tone Audiometry: Air conduction thresholds

Table 2: Showing the mean threshold values of Air Conduction with standard deviation for different frequencies in group I subjects for both ears (n=24).

	GROUP I- 24									
Frequency KHZ	Right Ear					Left Ear				
	Before Work		After Work		P value	Before Work		After Work		P value
	M	S.D	M	S.D		M	S.D	M	S.D	
250	12.29	2.54	13.96	3.6	<0.001	13.33	3.18	15.42	4.14	<0.001
500	13.75	3.04	16.04	3.89	<0.001	16.67	3.8	20.21	4.77	<0.001
1000	14.79	4.53	18.13	5.27	<0.001	19.17	6.01	23.33	5.83	<0.001
2000	15.42	4.4	18.75	5.16	<0.001	18.54	5.8	23.54	5.8	<0.001
3000	17.71	4.88	21.67	5.24	<0.001	26.25	7.974	31.46	7.86	<0.001
4000	21.25	10.95	25.42	11.5	<0.002	25.63	8.63	29.79	9.02	<0.001
6000	20.42	10.09	24.79	10.47	<0.009	29.17	7.79	16.67	7.89	<0.001
8000	16.67	4.34	20.42	4.87	<0.001	22.92	7.79	27.71	7.93	<0.001
10000	19.79	5.8	22.92	6.59	<0.001	25.42	9.19	29.58	8.83	<0.001
120000	18.54	4.77	21.46	5.61	<0.003	28.13	3.18	32.29	4.14	<0.001
Avg	17.06	20.35				22.52	25.0			

Average Hearing Thresholds: In group I miners with less than 7 years work experience showed average A.C. threshold of 17.06 dB for all the frequencies tested before work and 20.35 dB after work for the right ear. For the left ear it was 22.52 dB and 25 dB before and after the work respectively [Table 2]. Miners of Group II having more than 7 years work experience showed an average A.C threshold of 25.71 dB for all the frequencies tested before work and 29.97 dB after work for the right. For the left ear, it was 36.41 dB and 40.93 dB before and after the work respectively [Table 3]. There was a tendency for threshold increase after work probably due to temporally threshold shift phenomenon in both the groups and in both the ears. The differences between the thresholds before and after the work were compared in each frequency and they were subjected to pair T-Test and found to be statistically significant as the P values were less than predicted P value of 0.05.

Table 3: Showing the mean threshold values of Air Conduction with standard deviation for different frequencies in-group II subjects for both ears (n=28).

Frequencies KHz	**GROUP II**									
	Right Ear					**Left Ear**				
	Before Work		**After Work**		**P value**	**Before Work**		**After Work**		**P value**
	M	**S.D**	**M**	**S.D**		**M**	**S.D**	**M**	**S.D**	
250	17.08	2.51	18.75	3.97	<0.001	22.5	4.42	22.5	5.71	<0.001
500	22.5	5.71	25.63	5.95	<0.001	25.21	5.2	30	4.66	<0.001
1000	22.71	2.94	27.7	3.29	<0.001	29.17	4.43	33.96	4.16	<0.001
2000	24.17	4.81	28.75	4.94	<0.001	29.17	4.34	34.17	4.34	<0.001
3000	29.83	10.98	35.21	12.02	<0.001	47.29	11.13	52.29	11.13	<0.001
4000	31.25	10.34	36.04	10.31	<0.002	43.75	12.09	50	9.08	<0.001
6000	28.33	10.07	33.33	10.07	<0.009	43.33	10.7	47.5	9.66	<0.001
8000	26.46	10.37	30	10.42	<0.001	35.21	10.98	40.42	11.5	<0.001
10000	27.92	9.99	32.5	10	<0.001	40.42	11.12	45.42	11.12	<0.001
120000	26.88	12.31	31.88	12.31	<0.004	48.13	11.59	53.13	11.59	<0.001
Average			25.71	29.97					36.41	40.93

In-group I it is observed that there was a tendency for thresholds to increase after exposure to sound in the right ear among all the frequencies this TTS ranged from 1.69 to 4.37 and the highest TTS was seen at 6000 Hz and the lowest at 250 Hz [Table 2]. A paired T-test was done to find out the significant of these differences and they were found to be highly significant in all the frequencies (P<0.001 to P<0.009). Similarly, in-group I there was a tendency for thresholds to increase after exposure to sound in the left ear among all the frequencies this TTS ranged from 2.09 to 5.21 and the highest TTS was seen at 3000 Hz and the lowest at 250 Hz [Table 2]**.** A paired T-test was done to find out the significant of these differences and they were found to be highly significant in all the frequencies (P<0.001). In group II mean A.C. threshold values for right ear before work 25.71 dB and after work 29.97 dB and Mean pure tone threshold values for left ear before work 36.41 dB and after work 40.93 dB respectively. There was statistically significant difference between before work and after work for both the ears for group II. In-group II there was a tendency for thresholds to increase after exposure to sound in the right ear among all the frequencies this TTS ranged from 1.67 to 5.38 and the highest TTS was seen at 3000 Hz and the lowest at 250 Hz. A paired T-test was done to find out the significant of these differences and they were found to be highly significant in all the frequencies (P<0.001 to P<0.006). In-group II miners there was a tendency for thresholds to increase after exposure to sound in the left ear among all the frequencies this TTS ranged from 3.75 to 6.21 and the highest TTS was seen at 4000 Hz and the lowest at 250 Hz [Table 3]. A paired T-test was done to find out the significant of these differences and they were found to be highly significant in all the frequencies (P<0.001) [Table 3].

Comparison between the two groups: The average mean values for thresholds for group I before work was 17.06 dB and after work it was 20.35 dB for the right ear and for the left ear it was 22.52 dB and 25 dB for before and after work respectively. The average mean values for thresholds for group II before work was 25.71 dB and after work it was 29.97 dB for the right ear and for the left ear it was 36.41 dB and 40.93 dB for before and after work respectively. A paired independent T-test was done to compare the hearing thresholds before work in the right ears of the group I and II. A highly statistically significant differences were found at all the frequencies (P<0.001 to 0.003) except for 6000 Hz (P <0.009). A paired independent T-test was done to compare the hearing thresholds after work in the right ears of the group I and II. A highly statistically significant differences were found at all the frequencies (P<0.001 to 0.002) except for 6000 Hz (P <0.006).A paired independent T-test was done to compare the hearing thresholds before work in the left ears of the group I and II. A highly statistically significant differences were found at all the frequencies (P<0.001). A paired independent T-test was done to compare the hearing thresholds after work in the left ears of the group I and II. A highly statistically significant differences were found at all the frequencies (P<0.001)**.** The mean pure tone thresholds of the right ear before work for group I am 17.06 dB and for group II is 25.71 dB. Mean pure tone threshold of the right ear after work for group I am 20.35 dB and for group II is 29.97 dB. Mean pure tone thresholds of left ear before work for group I is 22.52 dB and for group II is 36.41 dB. Mean pure tone threshold of left ear after work for group I is 25 dB and for group II is 40.93 dB. There was statistically significant difference at P<0.05 for mean pure tone thresholds of right and left ear before work and after work between group I and group II and there was also a statistically significant difference at P<0.05 for mean pure tone thresholds of right and left ear after work between group I and group II [Figure 1].

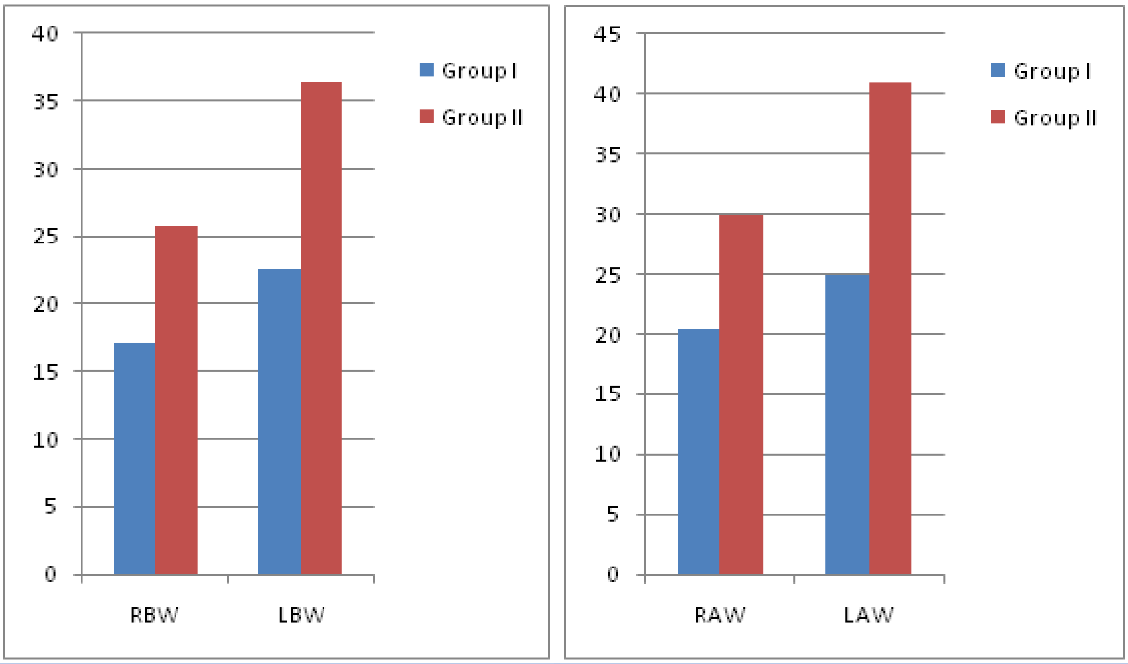

Figure 1: Showing the threshold shift in both ears of group I and II before and after work hours. (n=52).

DISCUSSION

Occupational Noise Induced Hearing Loss (ONIHL) is defined as slow hearing loss developing over a long period, as a result of gradual intermittent exposure to continuous loud noise.[12] Loss of hearing due to loud noise is usually equal in both the ears which can be permanent and irreversible, affects one's ability to converse meaningfully and effectively. NIHL affects mostly the higher frequencies from 3000-6000 Hz with the largest effect at 4000 Hz. With continuation of noise exposure, the changes may spread to affect even frequencies as low as 2000 Hz.[13]. The aim of the present study was to investigate the effect of hard rock mining on hearing in cutters and to identify the early onset of hearing loss due to noise exposure so as to bring awareness and prescribe proper hearing protective devices. For the purpose of the study, 52 hard rock cutters were selected and divided into two groups depending on their number of years of exposure to noise. The first group consisted of subjects who were exposed to mining noise for 6 to 8 hours a day in between of 3 years to 7 years of exposure to hard rock mining noise. The second group consisted of subjects who were exposed to noise for 6 to 8 hours a day for 7 to 14 years. The subjects' hearing thresholds from 250 Hz to 12000 Hz were measured before starting their workday and within 15 minutes after their work, (2-minute criteria were used to rule out TTS 2 effects). Results of a retrospective study that explored the association between the risks of occupational noise exposure, the degree of NIHL, and work-related accidents between 1983 and 1998 in Quebec showed that a hearing loss of 20 dB results in a significant increase in accident risk when controlling for age and occupational noise exposure. In the Quebec study, 12.2 % of accidents were found to be attributable to a combination of noise exposure of greater than 90 dB and NIHL.[14] NIHL results in increased safety risks in the miners because noise distracts the worker's attention and drowns out the sound of a malfunctioning machine, alarm signals or warning shouts. The decrease in communication in conditions of high levels of noise can also cause annoyance, disputes and stress.[15] Noise affects human health in several ways. It has various non-auditory effects, such as annoyance, sleep disturbance, cardiovascular diseases, mental health and social behaviour problems, etc. Nonetheless, noise has deleterious effects on the auditory system. Intermittent or continuous intense sound stimulus affecting the ear results in an alteration in the hearing acuity temporarily or permanently in an individual, a period which may be measured in seconds, hours, days or even months after cessation of the initial sound. Temporary Threshold Shift (TTS). Permanent Threshold Shift (PTS) and Acoustic trauma are the main auditory effects of noise. TTS is a non-permanent hearing loss, in which the hearing thresholds get elevated due to continuous exposure to loud noise. It may results in permanent or irreversible type of hearing or PTS if the. These types of gradual changes occurring in hearing sensitivity associated with noise exposure is named as Noise Induced Hearing Loss (NIHL) and is mostly seen in the industrial workers or those exposed to continuous loud level of occupational noise. It is also termed as Occupational Noise Induced Hearing Loss (ONIHL). On the other hand the sudden loss of hearing due to noise is called as acoustic trauma e.g. in blast or explosion. Noise annoyance is a global phenomenon. A definition of annoyance is "a feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them."[16] However, apart from "annoyance", the people may feel a variety of negative emotions when exposed to community noise and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety and exhaustion. There are different types of noise present in the industrial environment *viz.*, steady state, fluctuating, intermittent or impulsive. Steady-state noise can be described as continuous daily exposures in which the overall level do not vary more than 5 dB.[17] Fluctuating noise is continuous, but level rises and falls more than 5 dB during a particular exposure period and is most frequent type of noise encountered in industries. Intermittent noise is described as one or more short, transient, acoustical events those less than 0.5 seconds. A single impulse is usually heard as a discrete event occurring in otherwise in quite conditions or super imposed on background of steady-state ongoing noise.[18] It has been observed by many of the researches that noise of any type has deleterious effect on auditory system and has various non-auditory effects on person's overall health. The National Institute on Deafness and Other Communication Disorders (NIDCD), National Institute of Health (NIH0, the National Institute on Environmental Health Sciences (NIEHS0 and the National Institute of Occupational Safety And Health (NIOSHO) have noted that hearing loss appears much earlier in life due to noise exposure. The present study confirms the fact that miners working in an atmosphere with loud noise levels above 85 dB develop permanent auditory changes resulting in raised Air Conduction thresholds ranging from 25 dB to 54 dB in higher frequencies. Temporary threshold shifts ranging from 2.09 dB to 5.21 dB and the highest TTS was seen at 3000 Hz and the lowest at 250 Hz among the miners with experience up to 7 years. Similarly, TTS ranging from 1.67 to 5.38 and the highest TTS was seen at 3000 Hz and the lowest at 250 Hz in miners with experience above 7 years. Present study showed these TTS values for all the frequencies to be statistically significant with a P value ranging from 0.001 to 0.009 (P value at 0.05). In view of the findings observed in the present study, miners are advised to undergo periodical audiometry to record threshold shifts every 6 months. Miners with hearing loss more than 50 dB at speech frequencies (500, 1000, and 1500) are advised alternate jobs. As avoidance of noise is not possible as it affects the livelihood, suitable use of mufflers are recommended which diminishes the loud noise to an extent within permissible noise levels.

CONCLUSION

Prolonged exposure to industrial noise above prescribed levels above 85dB for 8 hours in a day, 6 days per week for 3 to 14 years results in hearing loss due to permanent changes in the inner ear. The Hearing Loss is sensory neural type affecting the higher frequencies from 6000 KHZ to 12000 KHH initially later on the damage could spread to the lower frequencies affecting the intelligibility of speech. All the frequencies showed temporary threshold shifts ranging from 1.69 to 4.37 dB when recorded before and after working hours. There was statistical significance observed for these threshold shifts for all frequencies in both ears with P value ranging from 0.001 to 0.009 with predicted P value at less than 0.05.

REFERENCES

1. US Environmental Protection Agency EPA press release - April 2, 1974]
2. World Health Organization. Grades of hearing impairment. [Last accessed on 2012 May 02]
3. OSHA's Advisory Committee for Construction Safety and Health (ACCSH). March 15, 2001, Washington, DC.
4. NOHSC. Management of Noise at Work. Control Guide. Canberra, Commonwealth of Australia. 1991 ISBN: 0 644 12866 6
5. McBride DI, William S. Audiometric notch as a sign of noise induced hearing loss. Occup Environ Med. 2001;58:46-51.
6. Celik O, Yalçin S, Oztürk A. Hearing parameters in noise exposed industrial workers. Auris Nasus Larynx. 1998;25(4):369-375
7. Axelsson, Borchgrevink, Hamernik, Hellstrom, Henderson, Salvi. 1996; Edwards, 2002
8. Monley P, West A, Guzeleva D, Dinh DA, Tzvetkova J. Hearing Impairment in the Western Australian Noise Exposed Population. Aust J Audio. 1996;6(2):57-71.
9. Michael K, Tougaw E. Wilkinson R. Role of continuous monitoring in a hearing conservation program. Noise Health. 2011;13:195–199.
10. Palmer KT, Griffin MJ, Syddall HE, Coggon D. Cigarette smoking, occupational exposure to noise, and self reported hearing difficulties. Occ environ med. 2004;61:340-4.
11. Daniel E. Noise and hearing loss: a review. The Journal of school health. 2007;77: 225-31.
12. Le Prell CG, Yamashita D, Minami SB, Yamasoba T, Miller JM. Mechanisms of noise-induced hearing loss indicate multiple methods of prevention. Hear res. 2007; 226: 22-43.
13. Sataloff R, Sataloff J. Occupational hearing loss. New York: Marcel Dekker; 1993:833:2343-7. .
14. Berglund B, Harder K, Preis A. Annoyance perception of sound and information extraction. J Acoust Soc Am. 1994;95:1501–1509.
15. Prince MM, Gilbert SJ, Staner LT. Evaluation of the risk of noise- induced hearing loss among unscreened male industrial workers, The Journal of the Acoustical Society of America. Pub advanced abstract 02 24. Industry wide Studies Branch, Division of Surveillance, Hazard Evaluations and Field Studies, National Institute for Occupational Safety and Health. 4676 Columbia Parkway, http://www.biowebpin.com/puadvanced/article/12597181.
16. Dineen R. Noise and Hearing in the Building and Construction Industry: A Study on Workers' Views on Noise and Risk. Video. Causes and Prevention of Hearing Loss. Colloquium (NAL). 23 October 2001.
17. Lindvall T, Radford E. Measurement of annoyance due to exposure to environmental factors. Environ Res. 1973;6:1–36.
18. Guignard JC. A basis for limiting noise exposure for hearing conservation. Issued jointly as: Report EPA-550/9-73-001-A, 1973. US Environmental Protection Agency, Washington DC.
19. Melnick W. Hearing loss from noise exposure. In: Harris C (ed). Handbook of acoustical measurements and noise control. Woodbury, NY: Acoust Soc Am; 1998:18.1-18.19.

How to cite this article: Subbaiah CV, Ananth R. Noise Induced Hearing Loss in Hard Rock Miners of Kadapa, A.P. India. Ann. Int. Med. Den. Res. 2016;2(1):135-41.

Source of Support: Nil, **Conflict of Interest:** None declared