EFFECT OF EXCESSIVE NOISE EXPOSURE ON GRANITE FACTORY WORKERS

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ABSTRACT

BACKGROUND

Many workers are exposed to noise in their work places, where its level exceeds the permissible level of 90dB (A). Noise Induced Hearing Loss (NIHL) is an increase in threshold of hearing, which first appears in high frequencies, then expands to speech frequencies. Pure tone audiometry is done to assess for any auditory disorder. Factory workers are unaware that they are vulnerable to hearing loss, which has no obvious symptoms. It is necessary to provide information of the future risk to these workers. Hence this study is done to analyze the effect of noise exposure on granite factory workers in Kolar district.

AIMS AND OBJECTIVES

1. To assess the quality of hearing by a questionnaire in granite factory workers who are exposed to continuous noise.
2. To determine the prevalence of hearing loss in these workers.

MATERIALS AND METHODS

Eighty five granite factory workers in the exposed group and eighty five administrative workers in the unexposed group were selected considering the inclusion and exclusion criteria. Taking written informed consent, they were assessed by the questionnaire for the quality of hearing. The auditory thresholds of both ears were recorded using pure tone audiometer and plotted on an audiogram. The resulting data was statistically analyzed.

RESULTS

Noise levels in granite factories were higher than the accepted sound levels; 11% of the exposed group perceived their hearing to be significantly low; 44% had difficulty in hearing over phone and in a crowd; 35% had to keep their TV volume loud and conversed loudly; and 33% had history of tinnitus compared to none in the unexposed group. Exposure to continuous noise showed higher hearing thresholds in both the ears at 4000Hz and 6000Hz compared to the unexposed population.

CONCLUSION

We have found that the granite factory workers were exposed to sound levels as high as 105dB (A). The workers had an increase in auditory thresholds at 4000Hz and 6000Hz. Thus it is suggested to implement the use of personal protective equipments like ear plugs or ear muffs. Periodic health checkups and workshops should be carried out to motivate the subjects for regular usage and duty scheduling has to be done for exposure limitation.

KEYWORDS

Noise Exposure, Auditory Thresholds, Pure Tone Audiometry.

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INTRODUCTION

Noise is an invisible but insidious form of pollutant, which is increasing rapidly with the advancement in industrialization. Physiologically, noise is defined as a signal that bears no information and whose intensity varies randomly in time. Psychologically, noise irrespective of its waveform is unpleasant and unwanted.[1] Excessive noise exposure can cause both auditory and extra-auditory effects.

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The most important of these is hearing damage resulting from prolonged exposure to excessive noise; another undesirable effect is speech interference or interruption of communication. Annoyance is a third undesirable effect of noise.[2] Industrial noise levels not only affects the turnover and the profit margins, but also causes annoyance and contributes to Occupational Noise Induced Hearing Loss (ONIHL). Psychological stresses leads to social isolation, excessive anxiety, irritability and low self-esteem in workers exposed to these noise levels each day and over a period of time.[3,4,5] ONIHL causes problems not only for the individuals concerned, but also for their families and co-workers.[6,7]

ONIHL is defined as partial or complete hearing loss in one or both ears as the result of one's employment. World Health Organization (WHO) describes that exposure to excessive noise is the major avoidable cause of permanent hearing impairment.[8]

Occupational Noise Induced Hearing Loss (ONIHL) is the second most leading cause of hearing loss after age-related hearing loss.[9] A 16% of the hearing loss in adults worldwide is attributed to occupational noise exposure.[10] Various studies have shown that people exposed to noise level above 85dB(A) suffered from ONIHL.[9] Recent estimates indicate that hearing loss greater than 25dB(A) in the human hearing frequencies is regarded as a significant hearing disability by WHO.[11]

The damaging effect on hearing depends on the level and spectrum of the noise, duration of exposure to noise, how many hours in a day they are exposed, over how many years daily exposure is repeated and individual susceptibility to this type of injury.[12] The highest attributable fraction of adult-onset hearing loss resulting from noise exposure in the world comes from Asian countries. ONIHL is a serious health problem in Asia, majority of Asian countries are still developing economies where access to health services and preventive program are limited.[13]

As per Dobie's criteria, ONIHL is a sensorineural and progressive hearing loss with loss always being more at 3000-6000 Hz than 500-2000Hz. [5] Traditionally, loud noise produces an audiometric notch at 4000Hz known as "Aviator's Notch."[13,14] However, few studies showed notch at 6000Hz.[15,16] This notch typically develops at one of these frequencies and affects adjacent frequencies with continued noise exposure.[17,18]

ONIHL is due to destruction of cochlear hair cells or damage to their mechano-sensory hair bundles caused by continuous noise exposure of >85dB(A) for 8 hours at the work place.[19] Granite stone quarrying is the most common occupation of many workers in Kolar district, belonging to Karnataka state in India. In India, NIHL has been a compensable disease since 1948. It is only in 1996 that the first case got compensation.[8] The quality of life of industrial worker is one of the prime factors for production, hence it should not be neglected.

The workers in the granite factories are victims to the hazards of excessive noise exposure at the work place.[2] Even though ONIHL is preventable, there is no evidence that this is realized in practice. Only few studies regarding the estimation of noise levels in the granite factories and auditory effects in workers due to noise exposure at these granite factories are available. Hence this study is aimed to study the effect of noise exposure on the granite factory workers in and around Kolar district.

METHODS

The data was collected from workers in the granite factory and administrative staff belonging to age group >18 to <50 years after taking informed consent. Age matched exposed and non-exposed groups were selected based on the following inclusion and exclusion criteria. The exposed group consisted of 85 granite factory workers and unexposed group consisted of 85 workers in the administrative section.

Inclusion Criteria:

Exposed Group

a) Male subjects aged >18 yrs to <50 years exposed to noise from the granite factories.

Unexposed Group

a) Male subjects aged >18 yrs to <50 years from the administrative section.

Exclusion Criteria:

Exposed Group

a) History of consuming ototoxic drugs in past 3 months.
b) History of middle ear disease and head injuries.
c) History of hearing difficulty.
d) Use of any hearing aids.
e) Upper respiratory tract illness (Common cold, Eustachian tube block).

All subjects thus selected were given a questionnaire to collect information regarding their exposure status. A general physical and systemic examination was conducted in all subjects. Also a detailed clinical ear, nose and throat examination was carried out to rule out any unidentified pathology. The noise levels at different departments in the granite factory were recorded by using the sound level meter.

An assessment of auditory thresholds was done for different frequencies by using pure tone audiometer (ELKON-GIGA3) for both exposed and unexposed groups in a sound proof room. Descriptive statistical analysis was carried out on this data. Results on continuous measurements are presented as mean±standard deviation and results on categorical measurements are presented in number%. Significance was assessed at 1% and 5% level of significance. The questionnaire data was analyzed by the Chi square test. AC, BC hearing thresholds recording was compared between exposed and unexposed groups by using the student 't' test.

RESULTS

Self-Assessment of Hearing Loss	EXPOSED (n=85)		UNEXPOSED (n=85)		X^2 value	df	P value
	Number of Subjects	%	Number of Subjects	%			
Quality of Hearing							
Excellent	8	9	85	10.0	140.753	3	<0.001**
Above average	40	47	0	80.0			
Average	28	33	0	10.0			
Below average	9	11	0	0.0			
Hearing Over Phone							
Without difficulty	48	56.0	85	100.0	47.293	1	<0.001**
Do miss Some conversation	37	44.0	0	0.0			
Hearing in Crowd							
Without difficulty	48	56.0	85	100.0	47.293	1	<0.001**
Do miss Some conversation	37	44.0	0	0.0			
Sound of TV/Radio							
Usually louder	30	35.0	0	0.0	36.429	1	<0.001**
Usually same loudness	55	65.0	85	100.0			
Do people often indicate that you are talking too loudly?							
Yes	31	36.0	0	0.0	37.914	1	<0.001**
No	54	64.0	85	100.0			
Tinnitus							
More than once a day/work related	28	33.0	0	0.0	33.521	1	<0.001**
No tinnitus	57	67.0	85	100.0			

Table 1: Self-Assessed Questionnaire in the Exposed and Unexposed Group

** Highly significant with a P value <0.01.

Table 1. shows the assessment of hearing by questionnaire method. In the present study, 44% of the exposed population felt that their hearing ability was average or below average compared to 0% in exposed group (p value<0.01); 44% of the exposed population had difficulty in hearing over phone and in a crowd (p value<0.01); 35 % had to keep their TV volume loud and conversed loudly when compared to others in their families (p value<0.01); and 32% had history of tinnitus (p value<0.01) compared to none in the unexposed group.

Frequency	Auditory Thresholds(dB)		P value
	Exposed	Unexposed	
250 Hz	17.24±6.10	16.76±5.96	0.612
500 Hz	19.06±6.39	18.53±6.21	0.584
1000 Hz	16.59±8.14	16.24±8.05	0.777
2000 Hz	17.29±8.71	16.88±8.63	0.757
4000Hz	21.59±10.50	12.76±6.20	<0.001**
6000 Hz	22.06±10.16	11.59±4.95	<0.001**
8000 Hz	16.47±10.11	15.53±8.31	0.508

Table 2: Comparison of Auditory Thresholds for Air Conduction (AC) in Right Ear Among Exposed and Unexposed Group

** Highly significant with a P value <0.01.

Frequency	Auditory Thresholds(dB)		P value
	Exposed	Unexposed	
250 Hz	10.71±5.68	10.82±5.34	0.889
500 Hz	11.18±5.81	11.00±5.66	0.841
1000 Hz	10.94±7.09	11.29±6.82	0.741
2000 Hz	10.88±8.42	10.94±8.15	0.963
4000Hz	12.88±8.43	5.76±3.90	<0.001**

Table 3: Comparison of Auditory Thresholds for Bone Conduction (BC) in Right Ear Among Exposed and Unexposed Group:

** Highly significant with a P value <0.01.

Frequency	Auditory Thresholds(dB)		P value
	Exposed	Unexposed	
250 Hz	18.53±5.39	18.12±5.29	0.616
500 Hz	18.76±6.17	18.24±6.01	0.572
1000 Hz	18.35±8.84	17.94±8.50	0.757
2000 Hz	18.65±8.67	18.18±8.34	0.719
4000Hz	22.06±10.59	13.06±5.88	<0.001**
6000 Hz	23.59±11.33	12.29±5.43	<0.001**
8000 Hz	17.71±9.93	16.41±8.61	0.365

Table 4: Comparison of Auditory Thresholds for Air Conduction (AC) in Left Ear Among Exposed and Unexposed Group

** Highly significant with a P value <0.01.

Frequency	Auditory Thresholds(dB)		P value
	Exposed	Unexposed	
250 Hz	10.41±5.78	10.59±5.42	0.838
500 Hz	10.53±5.62	10.41±5.19	0.887
1000 Hz	11.41±7.10	11.88±6.50	0.653
2000 Hz	10.76±8.22	10.88±7.84	0.924
4000Hz	13.59±8.58	5.88±3.95	<0.001**

Table 5: Comparison of Auditory Thresholds for Bone Conduction (BC) in Left Ear Among Exposed and Unexposed Group

** Highly significant with a P value <0.01.

Table 2, 3, 4, 5. shows the comparison of hearing thresholds between exposed and unexposed group in both the ears. It is evident that in the exposed group, the mean thresholds at frequencies 4000Hz (AC and BC), 6000Hz (AC) are increased compared to that in the unexposed with the significant P value of <0.001 at frequency of 4000Hz (AC and BC) and 6000Hz (AC) in the left ear and also in the right ear it was statistically significant with a P value of <0.001 at 4000Hz (AC and BC) and 6000Hz (AC) respectively.

DISCUSSION

Chronic noise exposure is an important risk factor for NIHL. The workers engaged in the granite factories are victims of NIHL. However, data with respect to occupational health are scanty in our country. The industrial authorities as well as pollution control boards do not consider the need to prevent the hazards of noise pollution, because it does not jeopardize the employee's lives immediately after exposure. However, prolonged exposure which is the cause of many auditory and extra-auditory effects cannot be neglected.

The damaging effects on hearing depend on the level and spectrum of the noise, duration of exposure and individual susceptibility to this type of injury.[20] Relatively, little data exists on the continuous noise exposure in the granite factories as a risk factor for hearing loss, although the link was established over several years ago. Hence, this was an attempt to study the association between chronic noise exposure and changes in hearing thresholds in granite factory workers of Kolar.

The subjects recruited from the granite factories were age matched with the unexposed group. Quality of hearing in the granite factory workers was assessed by using a self-assessed questionnaire; 11% of the exposed group perceived their hearing to be significantly lower than the unexposed group; 44% had difficulty in hearing over phone and in a crowd; 35 % had to keep their TV volume loud and conversed loudly when compared to others in their families; 33% had history of tinnitus compared to none in the unexposed group.

The first difficulty patients usually noticed was trouble understanding speech when a high level of ambient background noise was present. Impairment of hearing at high frequencies will initially cause a loss of clarity in perceived speech and then interfere with daily activities as hearing loss progresses. As ONIHL progresses, individuals may have difficulty understanding high-pitched voices (e.g., women's, children's) even in quiet conversational situations. Symptoms like difficulty in normal and telephonic conversation, turning up TV and radio volume and tinnitus occur early.[21]

Difficulty in listening to conversation in these factories may be due to the fact that the noise emitted from the machines is more than 85dBA in the human frequency range. Therefore, it is difficult to distinguish between machine noise and human noise.[22]

The results of the subjective response to noise in the workers of the granite factories illustrate that there is a risk of decrease in hearing ability due to working in the predominantly noisy zone.[22] A study among traffic cops in Gujarat showed that 2.3% of the subjects felt that their hearing ability was below average.

A similar study done on traffic police men in our institution also revealed that the traffic police had a subjective response of difficulty in hearing and the cause being excessive noise exposure and non-usage of ear plugs/ear muffs.[23] A questionnaire based study done on oil mill workers in Kharagpur, West Bengal, showed that 63% of the total workers felt that noise interfered with their conversation; 16% were of the opinion that noise interfered in their work and harmed their hearing; about 5 % stated that the work room noise gave them headaches.[22]

A national telephone surveillance for prevalence of hearing loss done in Michigan reported that 29.9% of the population who had hearing loss was attributed to noise exposure at work. A large US analysis of self-reported hearing impairment in industrial sectors showed that highest number of employees with hearing difficulties attributable to the occupation was found in the construction industry, which includes the granite factories.[24]

Pure tone audiometry which is a simple, inexpensive, qualitative and quantitative procedure was used to record auditory thresholds. In our study, there was a statistically significant increase in air conduction thresholds at 4000Hz and 6000Hz in the exposed group compared to the unexposed group with a P value of <0.001 in both the ears. There was also a statistically significant increase in the bone conduction threshold at 4000Hz in the exposed group compared to the unexposed group with a P value of <0.001 in both the ears.

The presence of 4000Hz notch is a classical sign of ONIHL. The presence of 4000Hz notch may be attributed to many factors, the human hearing is more sensitive at 100-500 Hz due to the fact that the tympanic reflex attenuates loud noise below 2000Hz and also due to the resonance characteristics of the external ear to loud sound. This hard walled tube, closed at one end amplifies acoustic energy in the upper frequencies by about 10 decibels.

In addition, individual variation in the acoustic transfer characteristics of the external ear is a factor in the large variability in people's susceptibility to noise. Hair cells in the basal coil of the cochlea are the most sensitive to noise damage. They are responsible for transducing higher frequencies and this accounts for the high frequency hearing loss found in ONIHL.[25,26,27]

The threshold increase at 6000Hz seen in our study was also seen among air force personnel, musicians, traffic policemen.[23,28,29] The probable cause for the 6000Hz notch could be regular exposure to broadband frequencies of continuous noise.[28] Various studies have shown that ONIHL affected higher frequencies and mainly concentrated at 4000Hz or 6000Hz.[30,31]

CONCLUSIONS

Thus it is suggested to implement the use of PPE's (Personal Protective Equipments) like ear plugs, ear muffs and not only should these PPE's be made available, but also periodic health checkups (Audiometry) and workshops should be carried out to motivate the subjects for their correct and regular usage, and duty scheduling has to be done for exposure limitation.

Ear protectors (Ear plugs or ear muffs) should be used where noise levels exceed 90dB (A). They provide protection up to 35dB.[24] The occupational exposures to noise could be minimized by efficient control measures through engineering controls, administrative controls, and the use of personal protective devices.

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ANNEXURES

CLINICAL ASSESSEMENT OF QUALITY OF HEARING	
Quality of hearing Excellent, Above Average, Average, Below Average.	
Hearing over phone Without difficulty, Do miss some conversation, Miss a lot of what is said.	
Hearing in crowd Without difficulty, Do miss some conversation, Miss a lot of what is said.	
Sound of TV/radio Usually louder, Usually same loudness, a little louder.	
Do people often indicate that you are talking too loudly? Yes No	
Do people often have to talk louder? Yes/no	
Tinnitus; almost all the time, >once a day, about a day, about once a week, >once a year. Is it work related?	