

Significance of 6 khz in noise induced hearing loss in Indian Air Force personnel

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ABSTRACT

Noise is the most pervasive hazardous agent at industrial workplaces. Generally, noise induced hearing loss (NIHL) is a sensorineural hearing deficit which begins at higher frequencies (3000 to 8000 Hz) and gradually extends to lower / speech frequencies with chronic exposure to noise. The involvement of various high frequencies in the Indian Air Force (IAF) personnel with NIHL was analysed to evaluate the significance of involvement of 6 kHz. A study of the assessment of noise environment and audiometric analysis of IAF personnel was carried out at an operational IAF base. 229 personnel with audiometric evidence of NIHL were analysed for the distribution of hearing loss in the various frequencies. The study revealed that the maximum noise level exceeded the safe limit indicating that the noise environment is hazardous with the potential for adverse effects on the personnel. The IAF personnel in this study with NIHL showed a significantly higher involvement of 6 kHz as compared to other frequencies. A large proportion of personnel presented with audiometric notch at 6 kHz (57.3%) as compared to 4 kHz (34.3%). The classical audiometric notch at 4 kHz (Aviator's Notch) as mentioned in the literature as pathognomic of NIHL was seen replaced by 6kHz notch in a significantly large number of personnel. This study emphasizes the importance of early involvement of 6 kHz in the present noise environment in detecting NIHL.

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Key words: NIHL, High frequency hearing loss, Aviator's notch

The causal association between occupational noise exposure and hearing loss is well documented. In spite of the various preventive measures in vogue to reduce the effects of noise, it is still one of the most prevalent occupational diseases [1].

Noise induced hearing loss (NIHL) is a major problem in the personnel serving in the Armed Forces as their profession exposes them routinely to extreme noise levels that affect their hearing. The soldiers, airmen and sailors are exposed to high levels of noise produced by aircraft, ships, heavy mechanical transports and the weaponry they use [2]. Aviation industry is one such area where the personnel are exposed to high intensity of noise. The inherent noise environment of military aviation consists of several types of continuous, transient and partly impulsive noise.

We conducted an audiometric survey at an

operational Indian Air Force (IAF) base to study the effects of high intensity noise on the personnel. Among the personnel with NIHL we analysed the involvement of various frequencies affected. In the aviation industry, loud noise is traditionally known to produce an audiometric notch at 4 kHz known as the "Aviator's Notch" [3,4]. Various studies have indicated an audiometric dip at 6 kHz to be significant in diagnosis of NIHL [5-7]. This study aimed at determining the significance of 6 kHz in the personnel with NIHL in the present noise environment.

Material and Methods

The study was carried out at an operational IAF base. The analysis of noise levels in various

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operational and functional areas of an IAF base as well as the residential areas around the base was carried out using Precision sound level meter. Spectral distribution of sound energy was analyzed using a frequency analyzer. Analysis of noise was done both during the time of minimum noise i.e., prior to commencement of flying or during off-duty hours, and also during maximum noise when the aircraft is taking-off, taxiing, ground-run, etc. Repeated measurements were made at various areas and the average was taken to determine both the maximum and minimum noise levels.

An audiometric survey of the personnel at the IAF base revealed 229 personnel with audiometric evidence of NIHL. The involvement of various frequencies among the personnel with NIHL was analysed. Prior to pure tone audiometry, a detailed history was taken to exclude the individuals with previous history of Ear, Nose and Throat (ENT) diseases, head injury and medication with ototoxic drugs. Audiometric testing was conducted in a sound treated room at the base using Hortmann digital audiometer. Hearing thresholds were obtained for each ear at 250, 500, 1000, 2000, 4000, 6000, and 8000 Hz. A threshold of above 25 dB was considered to be a hearing loss in any of the above frequencies.

The audiometric data was analysed for involvement of the various frequencies. Hearing loss at 250, 500, 1000 and 2000 Hz were considered as low / speech frequency loss whereas 4000, 6000, and 8000 Hz were high frequency loss. The high frequency involvement among the personnel was analyzed for their distribution and statistical significance. The audiograms were assessed for presence of dip / notch. A notch was considered in the audiogram if there was presence of a dip at a particular frequency with recovery in the adjacent frequencies. The audiograms with sloping / flat pattern or without the characteristic dip were not

included in the analysis of audiometric notch. The IAF personnel were also categorized as per their length of service and the effect of duration of exposure to noise on the various frequencies was analysed. The data was tabulated in an MS Excel® spreadsheet which was then exported to SPSS V 10.0 for analysis. Statistical analysis of the data was performed using the student t-test to compare the patients of various exposure groups. The statistical significance was set to $p < 0.05$.

Results

Sound levels. Average of the minimum noise levels recorded was 34 dB which was found at off duty hours and also before flight schedule started. The maximum noise level 109.3 dB was at the tarmac of during ground running of aircraft. The other areas showing higher levels of noise include the workshop (105.3 dB), hangar (97.3 dB) and the Air Traffic ----- (ATC) (90.3 dB). The maximum noise levels at the class / training room (62.3 dB), domestic area (59.6 dB) and children’s school (52.3 dB) were well below the critical level of causing deleterious effects (Table I). The distribution of sound in various frequencies showed a significant increase in intensity at 3 kHz (mean 94.3dB) and 4 kHz (mean 98.6 dB) as compared to 2 kHz (81.7dB) and 6 kHz (mean 83.2 dB) especially in the operational areas of the base ($p < 0.05$).

Table I: MeanMaximum Noise levels (in dB)

| | |
|-------------------------------|------------|
| i. ATC | : 90.3 dB |
| ii. Hangar | : 97.3 dB |
| iii. Tarmac | : 109.3 dB |
| iv. Workshop | : 105.3 dB |
| v. Crew / technical rest room | : 80.3 dB |
| vi. Class / trg room | : 62.3 dB |
| vii. Domestic area | : 59.6 dB |
| viii. Children school | : 52.3 dB |

Involvement of speech frequencies. Speech frequency involvement was found to be in 18.8% of the personnel evaluated. The personnel with speech frequency involvement in the exposure group 20 – 29 years (24.09%) and 30 years and above (30.76%) were found to be statistically higher than the 0-9 years (8%) exposure group. ($p < 0.05$) (Table 2).

High frequency involvement. The high frequency which was maximally involved in our series was 6 kHz in 172 (75.1%) personnel followed by 4 kHz in 140 (61.13%) and 8 kHz in 48 (20.96%) personnel ($p < 0.05$). Of the 229 personnel with NIHL, 143 (62.5 %) had the characteristic dip in their audiograms as compared to 86 (37.5%) who had either sloping or flat pattern. Among the 143 personnel with the dip, it was noticed that dip at 6 kHz was in 82 (57.3 %) personnel and it was significantly higher than the dip at 4 kHz in 49 (34.3 %) and 8 kHz in 12 (8.4 %) ($p < 0.05$). The involvement of high frequencies did not have a statistically significant change with duration of noise exposure (Table 2).

Discussion

NIHL is a significant occupational health problem and has been extensively studied in various industries. While any individual may be at risk to NIHL at the workplace, workers in industries like aviation, military, mining etc. are exposed to dangerous levels of noise.

Various studies have been conducted in India and abroad to evaluate NIHL in the armed forces [8-11] In our study the overall noise environment in the IAF base and the surrounding residential areas were analysed to determine the risk levels of the personnel. The noise levels recorded in this study showed an average minimum level of 34 dB which was found during off duty hours. In a study by Deshmukh et al a minimum level of 30.9 dB was recorded at an IAF base [12]. The maximum noise level in this study was found to be 109.3 dB at the tarmac of during ground running of aircraft. The other areas showing higher levels of noise include the workshop (105.3 dB), ATC (90.3 dB) and the hangar (97.3 dB). Deshmukh et al in a study on aircrew recorded similarly high levels of noise (113 dB) in certain IAF bases [13]. The noise levels at these areas were found to be much higher than the prescribed limit and were potentially hazardous to the personnel working in these environments. The maximum noise levels at the class / training room, domestic area and children's school were found to be below the critical level which leads to NIHL. The location of schools and training area were also far enough so that the noise from the base did not interfere with speech and aviation related activities at the communication. Various noise abatement measures used at the base were sound reflectors, sound treated rooms and personal protective measures like ear defenders of muff type.

In our analysis we have considered the length

Table 2: Speech frequency involvement with duration of exposure

| Service / exposure | No. of personnel with hearing loss | Involvement of speech frequency | Loss(%) |
|--------------------|------------------------------------|---------------------------------|---------|
| 0-9 Yr | 25 | 2 | 8 |
| 10-19 Yr | 82 | 9 | 10.97 |
| 20-29 Yr | 83 | 20 | 24.09 |
| 30 Yr | 39 | 12 | 30.76 |

of service to be equal to the duration of exposure. We found the higher frequencies to be involved early with a significant increase in the involvement of speech frequencies with increase in duration of exposure. So in the early stages of NIHL the individual usually has no symptoms and is unaware of the deleterious effects of sound [14]. In our study only few personnel complained of hearing loss, tinnitus and discomfort or fullness in the ear (Table 3). These symptoms were transient and lasted for 10–30 minutes after exposure to loud sounds. The involvement of speech frequencies was only seen in 18.8% of the personnel. Probably because of the transient nature of the symptoms and the speech frequencies not being involved during early exposure, very few personnel had any symptoms.

Table 3: Major Complaints of the IAF personnel studied (n=229)

| Hearing loss | Tinnitus | Discomfort in ear |
|--------------|------------|-------------------|
| 37 (16.15%) | 13 (5.67%) | 48 (20.96%) |

Noise damages the hair cells at the basal end of the organ of Corti, where high frequencies are detected. [15] As per the literature, classical audiometric dip that is a pathognomic sign of NIHL is the 4 kHz involvement (Aviator's Notch). In the early studies on NIHL done on jute workers, it was confirmed that a dip at 4 kHz was the first sign seen on exposure to broad band, steady loud noise [16]. The various theories on the pathogenesis of dip at 4 kHz attributed it to vascular insufficiency at the 4kHz region of cochlea, high amplitude of the traveling wave at that region of cochlea [17], resonance characteristic of ear canal to loud sound [18], weak attachment of basilar membrane at that region of cochlea, paraossicular conduction to basal turn of cochlea etc.

The significance of dip at 6 kHz was first described by Salmivalli [5] and Axelsson [6] as an

indicator of NIHL. In our study among the high frequencies, 6 kHz (75.1%) was maximally involved in the various exposure groups followed by 4 kHz (61.13%) and 8 kHz (20.96%). These findings show that a statistically significant number of IAF personnel with NIHL had involvement of 6kHz and it also suggests that there is an initial involvement of 6 kHz in these personnel followed by spread of loss to 4 kHz and lower frequencies. Pelauso et al also reported, in a large study of Canadian military personnel the higher involvement of 6 kHz as compared to 4 kHz [7].

On analysis of audiometric notch, we found significantly higher dip at 6 kHz (57.3%) as compared to 4 kHz (34.3%). Various studies on NIHL have demonstrated similar findings and importance of dip at 6 kHz [19,20]. Raynal et al in their study of pilots of fighter aircraft, transport aircraft and helicopters demonstrated a marked notch at 6 kHz. [21]. Chamyal et al [22] in a study in personnel working in an Indian ammunition proof range and Kessar [23] in Indian artillery personnel have also described a higher dip at 6 kHz when exposed to high intensity impulse noise.

The shift in the audiometric notch from the classical 4 kHz to 6 kHz found in our study can be explained by the fact that the dip at 4 kHz (Aviators Notch) observed in 1930's, was applicable to the piston engine aircraft and the propeller aircraft of the thirties which produced maximum sound energy at lower frequencies. Modern day aircraft and machinery have much greater noise potential especially with the jet efflux and sonic booms, which results in increase in sound energy at higher frequencies with subsequent higher involvement of 6 kHz. The distribution of sound energy in various frequencies in our study revealed a definite increase in intensity at 3 kHz and 4 kHz especially in the operational areas of the IAF base. As the frequencies that are maximally involved in NIHL

are usually ½ to 1 octave higher than the frequency at which there is maximum intensity of incident sound [24], thus the higher involvement of 6 kHz, as seen in our study.

Conclusion

The speech frequency involvement and symptoms of hearing loss are minimal in the earlier periods of NIHL and increases exponentially with duration of exposure. The personnel with NIHL are unaware of their handicap and seldom report to the medical attendant with complaints. Hence periodic indoctrination of all personnel on the effects of noise should be done to make them aware of the problem. Early detection of the personnel with hearing loss by periodic and dramatic assessment mandatory to protect them from its aggravation.

The results of this study show a significant involvement of high frequency especially 6 kHz in IAF personnel with NIHL. With the modernization of the IAF, the sound energy produced by the aircraft and heavy machinery has also increased. The audiometric finding of dip at 6 kHz as diagnostic for NIHL appears to be more appropriate as compared to 4 kHz in the present day noise environment.

Conflict of interest: None

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