

Early Detection of Hearing Impairment Using Dpoae in High Risk Military Personnel

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Abstract

Background: The present study aimed for early detection of hearing impairment in high risk military personnel. **Material and Methods:** A multicentric cross-sectional study was conducted at a tertiary ENT center of a zonal Military Hospital, from Aug 2025 to Aug 2026. The study included 600 male participants, comprising 300 noise-exposed armed forces personnel and 300 civilian controls without occupational noise exposure. All participants underwent Distortion Product Otoacoustic Emissions (DPOAE) and Pure Tone Audiometry (PTA) after providing informed consent and meeting the study's inclusion and exclusion criteria. **Results:** The majority of participants in both groups were 25–30 years of age, with a mean age of 30.81 years among cases and 29.34 years among controls. Among cases, the mean duration of noise exposure was 10.07 years, with 31% exposed for 6–10 years. DPOAE screening showed significantly fewer PASS results in cases than controls in both the left ear (70.66% vs. 91.33%) and right ear (60.33% vs. 91.66%). On pure tone audiometry, 76% of cases had sensorineural hearing loss (SNHL), compared with 23.33% of controls ($p < 0.0001$), with right-sided SNHL being the most common finding among cases. A significant association was observed between DPOAE REFER results and PTA-confirmed SNHL in both ears ($p < 0.005$). Compared with PTA, DPOAE demonstrated a sensitivity of 67.98%, specificity of 77.77%, positive predictive value of 90.64%, negative predictive value of 43.41%, and an overall diagnostic accuracy of 70.33% for detecting noise-induced hearing loss. **Conclusion:** Otoacoustic emissions (OAEs) can detect early outer hair cell damage before changes appear on pure tone audiometry, making them useful for early screening. Hearing loss is most pronounced at 3–6 kHz and usually progresses rapidly during the first 10 years of noise exposure before stabilizing.

Keywords: Hearing Impairment, DPOAE, Early Detection, Military Personnel.

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INTRODUCTION

Excessive noise is one of the most common causes of hearing loss from military, industrial and recreational sources. According to the World Health Organization (WHO), about 16% of hearing loss worldwide is attributable to occupational noise exposure. Military personnel, especially those in combat arms are particularly vulnerable to noise induced hearing loss (NIHL), as a result of routine exposure to firearms and heavy machinery noise (e.g tanks, heavy vehicles, aircraft etc).^[1,2]

WHO recommends that impulse noise must not exceed 140 dB. An automatic gun produces noise levels of 174 dB, 105-mm howitzers produce 194 dB, field cannons produce 188 dB, antitank guns produce 185 dB and small arms produce more than 150dB sound. Hearing Protection Devices (HPDs) attenuate localization cues and provide a sound attenuation of only about 50 dB and make the commands and instructions inaudible.^[3,4]

Noise-induced hearing loss is a major preventable disease. It can be caused by an acute exposure to an intense impulse of sound or by a continuous steady-state long term exposure with sound pressure levels higher than 75–85 dB. It ranks 13th in order, globally as the cause of years lived with disability (YLD). The prevalence of hearing loss and tinnitus in military population are greater than in the general

public. Almost every soldier, sailor, airman will be exposed to hazardous noise levels at some point in their career.^[5,6]

Hearing acuity is a key component of a soldier's effectiveness in the battlefield. The presence of tinnitus and hearing loss can significantly impair a soldier's ability to hear important acoustic cues or communication signals from the unit or the enemy.^[7]

Pure tone audiometry can detect hearing loss only after it has occurred. Otoacoustic emissions (OAE) testing is an important tool for an early identification of noise induced hearing loss (NIHL). Outer hair cells in the inner ear are vulnerable to external effects such as noise; the first signs of cochlear abnormalities may be identified in OAE testing.^[8] Otoacoustic emissions (OAEs) are an attractive tool for use as a screening procedure because they are objective, can be carried out in a few minutes and the results are reproducible.^[9]

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Distortion product otoacoustic emissions (DPOAEs) can measure cochlear function at higher frequencies than transient evoked otoacoustic emission (TEOAEs).^[10] Several studies have assessed the efficacy of this test in military personnel exposed to noise. OAE testing is sensitive and objective and therefore provides valuable information for the diagnosis of NIHL and for supporting audiometry in the diagnosis and monitoring of cochlear function when exposed to noise.^[11]

An appropriate alternative or complementary approach to the behavioural pure-tone audiogram for detecting NIHL may be otoacoustic emissions (OAEs) testing. These low-level signals can be recorded by a sensitive microphone placed in the external ear canal. The emitted response is closely related to the integrity of the cochlear structures, mainly the outer hair cells. Furthermore, the test is short, need not be performed in a sound attenuated room, and requires only minimum patient cooperation. Most importantly, the results are frequency-specific, objective, and relatively consistent and stable. This study aimed for early detection of hearing impairment in high risk military personnel and to analyse the utility of DPOAEs to detect cochlear damage due to chronic exposure to firearm noise in Indian military personnel at a preclinical stage and hence warn about an impending hearing handicap, in a vulnerable population.

MATERIALS AND METHODS

After obtaining clearance from institutional ethical committee, a cross sectional study was conducted as multi-centric study at Unit Medical Inspection Room & Department of ENT & HNS at Command Hospital (EC) Kolkata from January 2018 to June 2019.

The study included 600 male participants, comprising 300 asymptomatic armed forces personnel exposed to high-intensity noise and 300 civilian controls with no history of such exposure. Noise-exposed participants included combat/exercise personnel, engine room sailors of ships/submarines, and aircrew. All participants underwent Distortion Product Otoacoustic Emissions (DPOAE) and Pure Tone Audiometry (PTA) after obtaining informed consent and confirming eligibility based on the study's inclusion and exclusion criteria.

Inclusion criteria

- Serving military personnel in 20-40 years age group with history of regular exposure to loud noise.
- General population in 20-40 years age group without history of exposure to loud noise.

Exclusion criteria

- Personnel with otological abnormalities.
- Personnel with chronic conditions associated with hearing loss.
- Personnel with ear infections.

Materials Used: Hearing assessment was performed using the Grason-Stadler (GSI) Audio Screener with AUDIOscreener+ AUDIotrac™ software. It is a portable, handheld, battery-operated device that combines Distortion Product Otoacoustic Emissions (DPOAE) and Auditory

Brainstem Response (ABR) for hearing screening and diagnosis. The device operates within a frequency range of 2,000–4,000 Hz ($\pm 2\%$), with a frequency resolution of 50 Hz, measurement accuracy of ± 1 dB SPL, and a dynamic range of 96 dB. It delivers 100- μ s click stimuli and Blackman window tone pips (2,000 and 4,000 Hz) at a stimulus rate of 32–62 stimuli/second, with intensity adjustable from 0–100 dB in 5-dB steps.

Methodology: After obtaining informed written consent, all participants (male, 20–40 years) underwent detailed history taking and ENT examination according to the study proforma. Individuals with otological abnormalities were excluded.

Hearing assessment was performed using Distortion Product Otoacoustic Emissions (DPOAE) in a sound-attenuated room after ensuring the external auditory canal was free of wax or debris and the tympanic membrane was intact. Appropriate probe tips were used to obtain an adequate seal, and strict hygiene protocols were followed. DPOAEs were recorded at 1, 2, 3, 4, and 6 kHz using primary tones ($f_1:f_2$ ratio 1:1.22) at 70 dB SPL, and results were reported as PASS or REFER.

Participants with a REFER result underwent Pure Tone Audiometry (PTA) in a sound-treated audiology room at frequencies of 0.25, 0.5, 1, 2, 3, 4, and 6 kHz. Individuals with bone conduction thresholds >20 dB at any tested frequency were classified as having sensorineural hearing loss (SNHL). Participants with conductive or mixed hearing loss, acute acoustic trauma, or hearing loss attributable to causes other than noise exposure were excluded. The remaining military personnel with noise-induced SNHL were included as cases.

Data analysis: Data was collected as per Data Collection Protocol. Analysis of variance and correlation coefficient with significance levels is calculated on the data collected using an appropriate statistical test. The data for all groups was compiled on Microsoft Excel software and was analyzed using SPSS STATISTICAL PACKAGE VERSION 21 association between categorical variables was analyzed using Chi Square tests. P value less than 0.05 was considered significant. The results of study group were compared with those of the control groups to analyze for significant differences.

RESULTS

In the present study, we assessed the age distribution of the study subjects. We observed that in both cases and controls, majority of the study subjects belonged to the age group of 25–30 years (31.66% years each in both cases and controls), followed by 31–35 years age group, in cases (27.66%), and 21–25 years (24.66%). The mean age of the study subjects was 30.81 years among cases and 29.34 years in controls.

In our study, majority of the cases had exposure duration between 6–10 years (31%), followed by less than 5 years among 25.66% cases, 11–15 years of exposure among 24% cases and more than 15 years of exposure was observed among 19.33% of the cases. The mean exposure observed among the cases was of 10.07 years [Table 1].

In the left ear, 91.33% of controls showed a PASS result compared with 70.66% of cases, while REFER results were more frequent among cases (29.33% vs. 8.66%). Similarly, in the right ear, 91.66% of controls passed the DPOAE test

compared with 60.33% of cases, and the proportion of REFER results was markedly higher in cases (39.66% vs. 8.33%) [Table 2].

In the current study, we observed the pure tone audiometry finding of the study subjects. We observed that among cases majority of the cases had right sided SNHL (35.33%), followed by bilateral SNHL (28.33%) and left sided SNHL (12.33%). Whereas among controls only 4.66% cases had bilateral SNHL. The difference between the observations was evaluated using Chi-square test, and it was found statistically strongly significant, Chi-square value: 78.39, p-value: <0.0001 [Table 3].

A Statistically significant association was observed between DPOAE findings and PTA-confirmed sensorineural hearing loss (SNHL) in both ears. In the right ear, participants with a REFER result on DPOAE were more likely to have SNHL than those with a PASS result ($\chi^2 = 33.91$, $p < 0.005$).

Similarly, in the left ear, a significant association was observed between REFER DPOAE findings and the presence of SNHL ($\chi^2 = 89.82$, $p < 0.005$). These findings indicate that DPOAE is an effective screening method for detecting cochlear dysfunction and identifying individuals with noise-induced sensorineural hearing loss [Table 4].

The present study observed that the sensitivity of the DPOAE to measure SNHL with respect to PTA observations is 67.98%, while the specificity was 77.77%, positive predictive value was 90.64% and negative predictive value was 43.41%. The overall diagnostic accuracy of the DPOAE test to measure the right sided SNHL was observed to be 70.33% [Table 5].

In the present study, we observed that 76% cases had hearing loss (228 positive cases for hearing loss in PTA out of 300 study sample), while in control group, among general population, we observed that 23.33% controls had hearing loss (70 controls out of total 300 controls).

Table 1: Distribution of cases according to their duration of exposure

Duration of Exposure (Years)	Cases (n)	Percentage (%)
< 5 years	77	25.66
6–10 years	93	31.00
11–15 years	72	24.00
> 15 years	58	19.33
Total	300	100.00
Mean Duration of Exposure	10.07 years	

Table 2: Distribution of cases and controls according to their Left sided and Right sided DPOAE findings

Ear	DPOAE Finding	Cases (n = 300)	%	Controls (n = 300)	%
Left Ear	P	212	70.66	275	91.33
	R	88	29.33	26	8.66
Right Ear	P	181	60.33	275	91.66
	R	119	39.66	25	8.33

Table 3: Distribution of cases and controls according to their PTA findings

PTA Findings	Cases (n = 300)	%	Controls (n = 300)	%
Within Normal Limits (WNL)	72	24.00	280	93.33
Left Ear SNHL	37	12.33	2	0.66
Right Ear SNHL	106	35.33	4	1.33
Bilateral SNHL	85	28.33	14	4.66
Total	300	100.00	300	100.00
significance	Chi-square value: 78.39, p-value: <0.0001			

Table 4: Comparison between right sided and left sided DPOAE findings and PTA results

Ear	DPOAE Finding	SNHL Present	SNHL Absent	Total	Chi-square	P-value
Right Ear	REFER	100	19	119	33.91	<0.005*
	PASS	91	90	181		
	Total	191	109	300		
Left Ear	REFER	73	15	88	89.82	<0.005*
	PASS	49	163	212		
	Total	122	178	300		

Table 5: Diagnostic accuracy of the DPOAE in cases (Combined)

Combined DPOAE Findings	SNHL Present	SNHL Absent	Total
REFER	155	16	171
PASS	73	56	129
Total	228	72	300
Diagnostic Parameter	Value		
Sensitivity	67.98%		
Specificity	77.77%		
Positive Predictive Value (PPV)	90.64%		
Negative Predictive Value (NPV)	43.41%		

DISCUSSION

The primary intent of this study was to find out the benefit of using Distortion Product Otoacoustic Emission as a screening tool for detecting noise induced hearing loss in asymptomatic military personnel. The study subjects contained of 600 male adults (300 cases and 300 controls).

In present study, the subjects ranged from 20 to 40 years. Majority of them belonged to the age group of 25-30 years (31.66% years each in both cases and controls). The mean age of the study subjects was 30.81 years among cases and 29.34 years in controls. The current study aims to analyse the utility of DPOAEs to detect cochlear damage due to chronic exposure to firearm noise in Indian military personnel at a preclinical stage and hence warn about an impending hearing handicap in a vulnerable population. Incidence and severity of hearing loss has been shown to increase with age and number of years of military service and hence, noise exposure. A study on Brazilian military personnel reported poorer TEOAE parameters in noise exposed normal hearing subjects vis-à-vis non exposed normal hearing subjects. However, the study was silent on the impact on DPOAEs.^[12]

Audrey Collee et al conducted a cross sectional study over 2055 subjects aged 18-55 years in Belgian military population. The prevalence of slight, moderate and severe HL increased significantly with age and was higher for subjects from para-commando and infantry units. Fighting in Built-Up Area (FIBUA) training, shooting with large calibre weapons, and participation in military exercises were the best determinants of HL in this population. These results suggest that subjects from infantry and para commando units run the highest risk of Hearing loss. The difference in findings of this study as compared to our study can be attributed to the characteristics of study subjects as in our study all the subjects were from the branches with high intensity noise exposure and the age bracket was also kept < 40yrs to filter out the cases of age related hearing loss.

A study was conducted by Dr Abhijeet Bhatia et al on role of OAE in detection of noise induced cochlear damage in AHRR, New Delhi.^[13] They observed that TEOAE amplitudes of the study group varied significantly from those of both the control groups at almost all frequencies. However, DPOAE amplitude of the study group was less than that of control group 1, the difference was not significant. The DPOAE amplitude of study group varied significantly from control group 2. DPOAEs proved to be useful in distinguishing between normal hearings from hearing loss ears.

In our study, all military personnels including Army, Navy and Airforce are included in study group, we took age cut off of 40 years of only two groups, those who were exposed to high intensity sounds and were not having hearing loss was our study group and DPOAE is performed prior to PTA. SNHL cut off is taken as > 20 dB. Aman Pankaj et al performed a case control study in artillery unit of Indian army. The cut off for age was 35 yrs with mean age of 28.52 yrs.^[14] They found 89% of control group having SNHL at 4000 Hz while 67% of study group had SNHL at

4000 Hz. In our study 76% of study group having SNHL while 23.33% of control group had SNHL.

Nair S et al conducted a study in Indian Air Force personnel involving 1000 personnels with an age group of 18-58 yrs.^[15] The prevalence of NIHL was found to be 22.9% taking a cut off of 25dB for hearing loss. The prevalence significantly increases with increase in duration of exposure as 50.8% of personnel having > 30 yrs of exposure to loud noise had NIHL. In our study 31% of personnel having atleast 10 yrs of exposure, found to have NIHL.

Timothy S Wells et al had evaluated hearing loss in US military associated with combat deployment.^[16] They used data from the Millennium Cohort Study and found that combat experience was associated with a 63% increased risk for hearing loss which further correlates with our results too.

Moon IS studied hearing loss in South Korean military personnel after regular periodic gunfire exercise.^[17] The average outcome of post exposure air conduction thresholds was 6.5 dB in the right ear and 33.1 dB in the left ear. In the next periodic gunfire exercise, the result of a supplement of unilateral earplug protection proved its effectiveness on acoustic trauma caused by gunfire noise.

Joseph Attias et al studied the application of the click-evoked and distortion products otoacoustic emissions (CEOAEs and DPOAEs, respectively) in the diagnosis and detection of noise-induced hearing loss (NIHL).¹⁰ A clear association between the OAEs and the severity of the NIHL was noted. Furthermore, OAE testing between ears with and without NIHL revealed a high sensitivity (79 - 95%) and specificity (84 - 87%). This study shows that OAEs provide objectivity and greater accuracy, complementing the behavioural audiogram in the diagnosis and monitoring of the cochlear status following noise exposure.

In the present study, we measured the diagnostic accuracy of the DPOAE findings (combined) with PTA findings. We observed that the sensitivity of the DPOAE to measure SNHL with respect to PTA observations is 67.98%, while the specificity was 77.77%. The positive predictive value was 90.64% and negative predictive value was 43.41%. The overall diagnostic accuracy of the DPOAE test to measure the SNHL was observed to be 70.33%. According to the results of our study the increase in hearing loss with age may reflect the number of years of military noise exposure at work, associated with the number of years of service. Unilateral hearing loss may be due to their habit of practicing firearms with the same hand every time.

The development of NIHL is affected by many factors, such as individual sensitivity, noise level, noise characteristics, duration of exposure and the effectiveness of noise protection.

Limitations: The main limitation of our study is its reliance on self-reported information of exposure to noise in a retrospective way because no objective measures were possible. Another limitation of the present study was related to its cross-sectional design, implying that neither causal inferences nor a temporal relationship between exposure and HL can be drawn from our findings.

Strength: The main strength of the current study is including triservices personnel (Army, Navy, Airforce) and the availability of information on different sources of noise to

which military personnel are exposed.

CONCLUSION

The high prevalence of hearing loss (HL) among military personnel indicates that it is a significant occupational health problem in the Indian Armed Forces. Personnel from infantry, naval ship crews, and airbase units are at greater risk due to prolonged exposure to high-intensity noise from firearms, aircraft engines, and ship engines, leading to acquired cochlear damage and chronic noise-induced hearing loss (NIHL). Otoacoustic emissions (OAEs) are an objective and sensitive method for detecting early outer hair cell dysfunction, often before changes become evident on pure tone audiometry, making them valuable for early screening of NIHL. Hearing loss, particularly at the noise-sensitive frequencies of 3–6 kHz, typically develops rapidly during the first 10 years of noise exposure before gradually reaching a plateau, highlighting the importance of early detection and preventive measures.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Collee A, Legrand C, Govaerts B, Van Der Veken P, De Boedt F, Degraeve E. Occupational exposure to noise and the prevalence of hearing loss in a Belgian military population: a cross-sectional study. *Noise Health*. 2011;13:64–70.
- Fitzpatrick DT. An analysis of noise-induced hearing loss in Army helicopter pilots. *Aviat Space Environ Med*. 1988;59:937–41.
- Task Group HFM-147. Military noise environments. Hearing Protection – Needs, Technologies and Performance. Ch. 3. France: Research and Technology Organization – North Atlantic Treaty Organization; 2010. p. 1–17.
- Yankaskas K. Prelude: noise-induced tinnitus and hearing loss in the military. *Hear Res*. 2013;295:3–8.
- Saunders GH, Griest SE. Hearing loss in veterans and the need for hearing loss prevention programs. *Noise Health*. 2009;11:14–21.
- Ylikoski M. Prolonged exposure to gunfire noise among professional soldiers. *Scand J Work Environ Health*. 1994;20(2):87–92.
- Lang GT, Harrigan MJ. Changes in hearing thresholds as measured by decibels of hearing loss in British Army Air Corps Lynx and Apache pilots. *Mil Med*. 2012;177:1431–7.
- Atcharyasathian V, Chayapham S, Saekhow S. Evaluation of noise-induced hearing loss with audiometer and distortion product otoacoustic emissions. *J Med Assoc Thai*. 2008;91:1066–71.
- Attias J, Furst M, Furman V, Reshef I, Horowitz G, Bresloff I. Noise-induced otoacoustic emission loss with or without hearing loss. *Ear Hear*. 1995;16:612–8.
- Attias J, Horowitz G, El-Hatib N, Nageris B. Detection and clinical diagnosis of noise induced hearing loss by otoacoustic emissions. *Noise Health*. 2001;12(3): 19–31.
- Shera CA. Mechanisms of mammalian otoacoustic emission and their implications for the clinical utility of otoacoustic emissions. *Ear Hear*. 2004 Apr;25(2):86–97. Review. Erratum in: *Ear Hear*. 2004;25:308.
- Kuronen P, Toppila E, Starck J, Paakkonen R, Sorri MJ. Modelling the risk of noise-induced hearing loss among military pilots. *Int J Audiol*. 2004;43:79–84.
- Bhatia A. Otoacoustic emissions in detection of pre-clinical noise induced cochlear damage in military personnel. *Int J Otorhinolaryngol Head Neck Surg*. 2015 Oct;1(2):58–64.
- Aman P., and Bhatia A. (2015). Otoacoustic emissions in noise induced cochlear damage in artillery soldiers. *Indian journal of otology*, 21(2), 98.
- Lt Col S Nair. Prevalence of NIHL in Indian Air Force personnel. *MJAFI* 2009; 65: 247–251.
- Timothy S. Wells, Amber D. Seelig, Margaret A. K. Ryan, Jason M. Jones, Tomoko I. Hooper, Isabel G. Jacobson, and Edward J. Boyko. Hearing loss associated with US military combat deployment. *Noise Health*. 2015 Jan-Feb; 17(74): 34–42.
- Captain InSeok Moon, Noise-Induced Hearing Loss Caused by Gunshot in South Korean Military Service. *Military Medicine*, 172, 4:421, 2007.