

## Original Research Article

# Army recruits of Indian origin: early detection and further prevention of noise induced hearing loss by otoacoustic emission

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### ABSTRACT

**Background:** There has been no study on Indian population which has tested ears prone for “noise induced hearing loss”. Also, no study on recruits of Indian origin could be found in the literature, so an attempt has been made to screen the individuals to prevent noise induced hearing loss.

**Methods:** Otoacoustic emission (OAE) screening is done over recruits before and after first exposure to loud noise of rifle firing in our study. Recruits were followed up at 04 hours, 24 hours, 01 month and 06 months after exposure. Individuals showing variation in OAE at 24 hours were also subjected to pure tone audiometry (PTA) at 01 month and 06 months.

**Results:** 98 recruits developed ‘refer’ in OAE at initial 4 hours out of which 67 recruits recovered in 24 hours. Remaining 31 recruits (45 ears) when followed up and screened at 01 month shows ‘refer’ in OAE in 22 recruits (37 ears) and high frequency loss on PTA in 17 recruits (31 ears). At 06 months 16 recruits (28 ears) shows ‘refer’ in OAE and 12 recruits (22 ears) shows dip in high frequency in PTA.

**Conclusions:** OAE is more sensitive tool for early detection of noise induced hearing loss. This study also correlates time and frequency involved in OAE in detecting early hearing loss as the individuals who show refer in OAE at both 04 hours and 24 hours with both 3 kHz and 4 kHz involved are more prone for noise induced hearing loss in future.

**Keywords:** NIHL, Indian origin, Screening, Otoacoustic emission

### INTRODUCTION

Loud noise exposure is one of the most common cause of hearing loss especially in armed force personnel as they are exposed to loud noise more often than their civil counterparts in the form of firing, tank movement, grenades, rocket launchers etc. In one study, 55.8% of Belgian military personnel were reported to have suffered from hearing impairment attributable to firearm noise exposure.<sup>1</sup> Also, the US national institute for occupational safety and health criteria document states that exposure to impulse noise should not exceed 140 dB.<sup>2</sup> As in a 2006 study, hearing loss was the most

prevalent disability due to military service in USA resulting in a striking \$1.6 billion cost for rehabilitation the same year.<sup>3</sup> A screening right in the beginning of their military career in their recruiting days can be useful to identify individuals prone for developing noise induced hearing loss in future. As no Indian study till date has been done to find out ill effect of noise exposure and prevention of the same by early screening. In this study an attempt has been made to screen the recruits before and after firing exposure by otoacoustic emission followed by pure tone audiometry (PTA) at regular intervals after exposure. This finding can be used to enforce avoidance, intervention to avoid loss of hearing

in an individual and in turn manage efficient manpower to organization and nation.

**Aims and objectives**

Aims and objectives of the study were to correlate the initial screening by otoacoustic emission (OAE) after firing for the first time and hearing loss in future in recruits of Indian origin, to confirm the hearing loss by augmenting PTA finding in addition to OAE during follow up at 01 and 06 months and to provide better assessment of initial OAE screening in terms of frequency involved and time frame of screening so as to prevent further exposure and hearing loss (if any).

**METHODS**

**Study**

This study was carried out at department of ENT at zonal hospital from October 2018 to March 2019. 360 recruits of army training centre at major city of a state of India were included into the study. An informed consent was taken from all individuals and permission from training centre was also taken prior to study. Procedure along with pre and post firing timing of procedure explained to Individuals. After thorough history taking to rule out previous ear illness, clinical examination of tympanic membrane was done. A prospective study was carried out on the recruits.

A study group of 360 recruits assessed prior to firing by OAE and again were assessed after 4 hours of firing by OAE. Same recruits assessed at 24 hours after firing by OAE. OAE finding were recorded on 2, 3, 4 kHz bilaterally. Recruits who were showing “pass” before firing and showing “refer” after firing were included for OAE and PTA examination after 30 days and 06 months of firing. All recruits fired 20 rounds of 5.56 mm INSAS rifle while lying down in prone position.

**Inclusion criteria**

Recruits who underwent ENT examination during selection procedure and found out to be fit without any abnormalities/disease and recruits without any symptoms, signs of ears and intervention from ENT side were included.

**Exclusion criteria**

Acute rhinitis with retracted tympanic membrane, dull TM with fluid behind tympanic membrane, otitis externa and OAE finding of “refer” before firing exposure were excluded.

**Statistical analysis**

Statistical analysis was performed by using descriptive and inferential statistics with chi square test/fisher exact

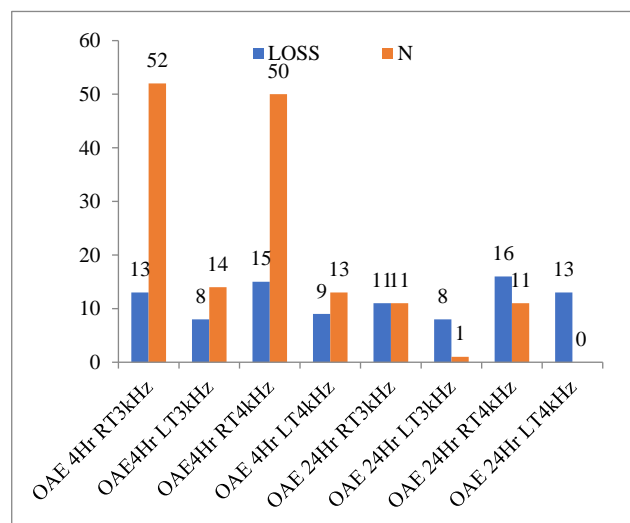
test for categorical data. Frequency and percentage were also presented. P value less than 0.05 considered as significant at 95% confidence level. The statistical software SPSS version 24.0 was used in the analysis.

**Observations**

Out of 360 recruits, 43 were lost in follow up or further exposed to firearms during observation period and remaining 317 shows following pattern of observations 98 recruits (total 116 ears) developed “refer” in OAE. It included involvement of both 3 kHz and 4 kHz in 42 recruits (total 57 ears), only 3 kHz involved in 29 recruits (total 30 ears), and 4kHz in remaining 27 (total 29 ears) at initial 4 hours of exposure after firing for the 1<sup>st</sup> time. Out of 98 recruits, 67 recovered at OAE screening after 24 hours of firing by showing “pass”. Remaining 31 recruits (total 45 ears) who still showed “refer” at OAE screening after 24 hours of firing underwent OAE and PTA at 30 days after firing and shows refer in 22 recruits (37 ears) in OAE and dip in high frequency hearing thresholds in PTA in 17 recruits (total 31 ears). Out of these affected 31 ears, 17 had shown “refer” for both 3 kHz and 4 kHz. 02 affected ears had shown “refer” at 3 kHz and 12 ears had shown “refer” at 4 kHz during OAE screening at 24 hours after firing. After 06 months of firing these 31 recruits again underwent OAE showing refer in 16 recruits (28 ears) and dip in audiogram in 12 recruits (22 ears).

**RESULTS**

This analysis shows that after firing for the first time OAE screening of the recruits shown “refer” at 3 kHz, 4 kHz and at both 3 and 4 kHz in some individuals. This screening when repeated after 24 hours after firing, some recruits recovered from “refer” to “pass”. Remaining recruits when underwent OAE and pure tone audiogram at 30 days and 06 months after firing shows refer in OAE and dip in high frequency hearing thresholds.



**Figure 1: "Refer" on OAE at 4 and 24 hrs.**

These recruits shows co relation with the OAE screening as maximum 17 ears showing hearing threshold shift after 30 days of firing and 14 ears at 06 months after firing were “refer” ears at previous screening by OAE at both 4 hours and 24 hours after firing for the first time and more so common when both 3 kHz and 4 kHz frequencies are involved.

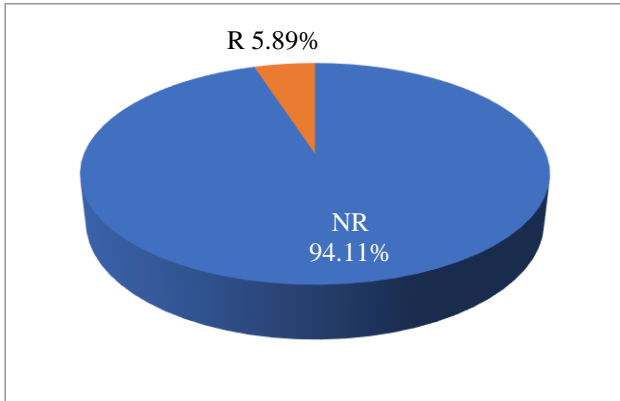


Figure 2: OAE at 30 days.

AT 30 days 31 recruits (total 45 ears) (who still showed “refer” at OAE screening after 24 hours of firing)

underwent OAE and PTA at 30 days after firing and shows refer in 22 recruits (37 ears) in OAE and dip in high frequency hearing thresholds in PTA in 17 recruits (total 31 ears).

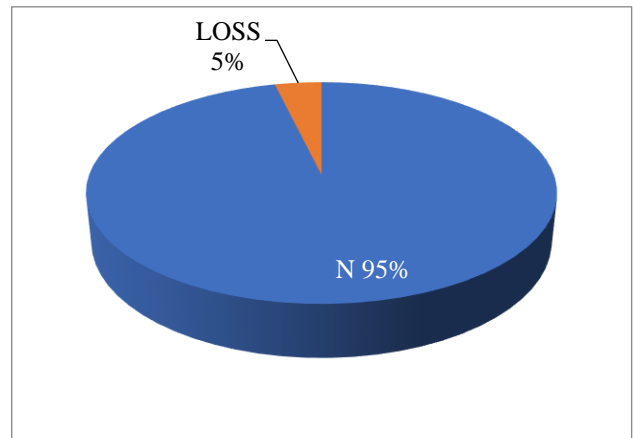


Figure 3: PTA at 30 days.

Out of these affected 31 ears, 17 had shown “refer” for both 3 kHz and 4 kHz. 02 affected ears had shown “refer” at 3 kHz and 12 ears had shown “refer” at 4 kHz during OAE screening at 24 hours after firing.

Table 1: Initial screening at 04 and 24 hours (after firing) by OAE.

Variables	4 hours		24 hours		P value
	N	%	N	%	
<b>OAE RT 3 kHz</b>	<b>N</b>	<b>%</b>	<b>N</b>	<b>%</b>	<0.001
R	65	20.5	22	6.9	
NR	252	79.5	295	93.1	
Total	317	100	317	100	
<b>OAE LT 3 kHz</b>					0.0167
R	22	6.9	9	2.8	
NR	295	93.1	308	97.2	
Total	317	100	317	100	
<b>OAE RT 4 kHz</b>					<0.001
R	65	20.5	27	8.5	
NR	252	79.5	290	91.5	
Total	317	100	317	100	
<b>OAE LT 4 kHz</b>					0.117
R	22	6.9	13	4.1	
NR	295	93.1	304	95.9	
Total	317	100	317	100	

Table 2: Correlation of OAE with PTA done at 30 days after firing.

Variables	PTA at 30 days		Total	Pearson Chi-square	P value
	Loss	NL			
<b>OAE at 4 hours</b>	R	17	81	40.143	<0.001
	NR	0	219		
<b>OAE at 24 hours</b>	R	17	14	165.7	<0.001
	NR	0	286		
<b>Both 4 and 24 R</b>	Both R	17	11	185.4	<0.001
	Other	0	289		
<b>Total</b>		17	300		

**Table 3: Correlation of time and frequency involved in OAE with PTA done at 30 days.**

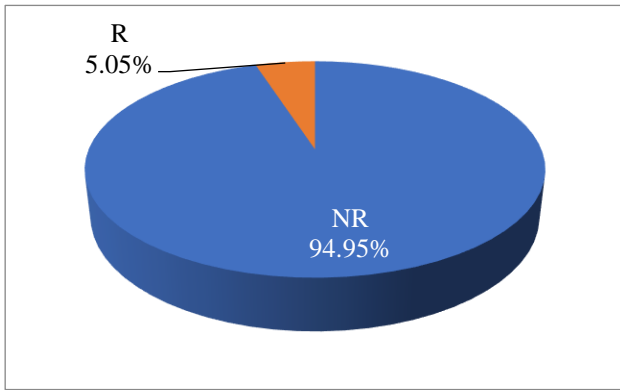
Variables		PTA at 30 days		Total	Pearson Chi-square	P value
		Loss	N			
OAE 4 hours RT 3 kHz	R	13	52	65	34.517	<0.001
	NR	4	248	252		
OAE 4 hours LT 3 kHz	R	8	14	22	44.767	<0.001
	NR	9	286	295		
OAE 4 hours RT 4 kHz	R	15	50	65	50.55	<0.001
	NR	2	250	252		
OAE 4 hours LT 4 kHz	R	9	13	22	58.857	<0.001
	NR	8	287	295		
OAE 24 hours RT 3 kHz	R	11	11	22	92.812	<0.001
	NR	6	289	295		
OAE 24 hours LT 3 kHz	R	8	1	9	127.3	<0.001
	NR	9	299	308		
OAE 24 hours RT 4 kHz	R	16	11	27	168.9	<0.001
	NR	1	289	290		
OAE 24 hours LT 4 kHz	R	13	0	13	239.2	<0.001
	NR	4	300	304		
<b>Total</b>		17	300	317		

**Table 4: Correlation of OAE with PTA done at 06 months after firing.**

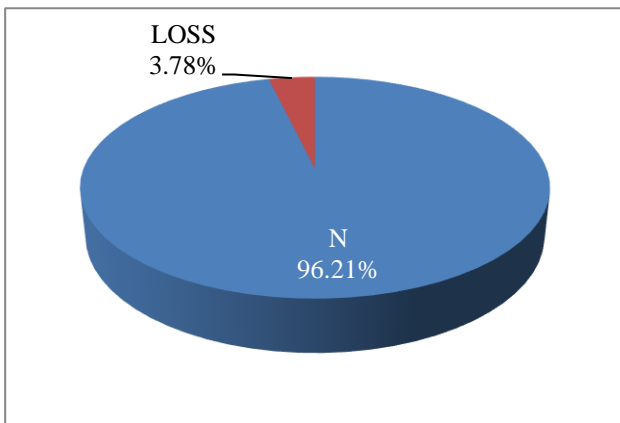
Variables		PTA at 06 months		Total	Pearson Chi-square	P value
		Loss	NL			
OAE at 4 hours	R	12	86	98	25.41	<0.001
	NR	0	219	219		
OAE at 24 hours	R	12	19	31	109.3	<0.001
	NR	0	286	286		
Both 4 and 24 R	Both R	12	16	28	117.3	<0.001
	Other	0	289	289		
<b>Total</b>		12	305	317		

**Table 5: Correlation of time and frequency involved in OAE with PTA done at 6 months.**

Variables		PTA at 6 months		Total	Pearson Chi-square	P value
		Loss	N			
OAE 4 hours RT3 kHz	R	11	54	65	38.74	<0.001
	NR	1	251	251		
OAE 4 hours LT3 kHz	R	7	15	22	51.006	<0.001
	NR	5	290	295		
OAE 4 hours RT 4 kHz	R	11	54	65	38.74	<0.001
	NR	1	251	252		
OAE 4 hours LT 4 kHz	R	7	15	22	38.59	<0.001
	NR	5	290	295		
OAE 24 hours RT 3 kHz	R	10	12	22	112.7002	<0.001
	NR	2	293	295		
OAE 24 hours LT 3 kHz	R	8	1	9	184.196	<0.001
	NR	4	304	308		
OAE 24 hours RT 4 kHz	R	11	16	27	110.666	<0.001
	NR	1	289	290		
OAE 24 hours LT 4 kHz	R	9	4	13	159.412	<0.001
	NR	3	301	304		
<b>Total</b>		12	305	317		



**Figure 4: OAE at 06 months.**



**Figure 5: PTA at 06 months.**

## DISCUSSION

Firearms produce impulses noises characterized by peak pressure level and frequency. It is more commonly seen in military personnel. Adverse effects on hearing have been reported even after a single gunshot fire. In spite of using hearing protectors, loud noise exposure can lead to TTS and PTS.

In fact, not a single volunteer was recorded to have an audiometric threshold >25 dB HL in any of the measured frequencies after noise exposure. Our results are also in accordance with multiple studies that suggest that military personnel are vulnerable to cochlear damage during training.<sup>1,3-5</sup>

Because such audiometric threshold shifts are a common finding and specific treatment plan of noise-induced hearing loss still remains ambiguous, prevention remains the cornerstone of proper management when dealing with these acute and first exposures to noise.

Marshall et al suggested that low-level OAEs indicate an increased risk of future hearing loss by as much as 9 times.<sup>6</sup> Lapsley Miller et al further reported that the PTS in military personnel was predicted by baseline low-level or absent OAEs.<sup>7</sup> Additionally, 317 US marine corps

recruits were studied before and after exposure to impulse-noise sources from the firing of weapons, where audiometric thresholds and otoacoustic emissions measurement before and after 6 months of noise exposure on an aircraft carrier are done. A Bayesian analysis indicated that permanent threshold shift status following a deployment was predicted by baseline low-level or absent otoacoustic emissions. The best predictor was transient-evoked otoacoustic emission amplitude in the 4 kHz half-octave frequency band, with risk increasing more than six folds from approximately 3% to 20% as the emission amplitude decreased. As It is also possible that the otoacoustic emissions indicated noise-induced changes in the inner ear, undetected by audiometric tests so otoacoustic emissions may therefore be a diagnostic predictor for noise-induced-hearing-loss risk.

Our results seem to further validate the above findings. In our study, evidence suggests that indeed baseline OAEs recorded prior and after to exposure to gunfire noise could effectively identify participants that may suffer from a future noise induced hearing loss in the form of TTS/PTS. In addition, because cadets had no prior exposure to significant occupational-related impulse noises, it appears that such a prediction applies not only to previously “damaged” ears, as shown by previous work, but to the general population as well.<sup>8</sup> If further studies confirm our suggestions, serious consideration should be given for the inclusion of OAEs as prerequisite for all military and nonmilitary hearing conservation programs. All recruits were of the same age and with no previous active duty or exposure to firearms of any kind. In both of the previous studies mentioned the authors used active duty personnel of various ages and experience therefore, with undefined previous exposure to noise and possibly different amounts of preexisting cochlear damage.<sup>7,8</sup>

Study done by Shupak et al where PTA thresholds, TEOAE and DPOAE amplitudes and contra lateral medial olivocochlear reflex were repeatedly evaluated during 02 years and compared between cohort of 135 ship engine room recruits and a control group with no noise exposure gram is not significantly co relates with PTA and cannot be used as an objective measures of PTA in early NIHL.<sup>9</sup> TEOAE changes after 01 year showed high sensitivity but this study was done for 2 years and changes in investigatory finding were detected over 02 years with individual being exposed to loud noise for the said period.

In another study done by Attias et al a clear association between the OAEs and the severity of NIHL was noted.<sup>10</sup> OAEs were found to be more sensitive to noise damage than behavioral audiometry. Noise induced emission loss (NIEL) was found in subjects with normal audiogram but with history of noise exposure thus bringing out disadvantage of pure tone behavioral audiometry is its insensitivity to subtle noise induced cochlear changes. This study shows that OAEs provide objectivity and

greater accuracy complementing the behavioral audiogram in the diagnosis and monitoring of cochlea status following noise exposure.

Several studies had taken individual characteristics into consideration and proposed as indicators of susceptibility to noise induced damages like sex, age, smoking, race, genetic predisposition, genes, and medical conditions, among others.<sup>11-20</sup> A vast number of clinical tests had been proposed to forecast such damages, yet none of the studies proved specific or sensitive enough to achieve satisfactory results in a clinical setting.<sup>21-23</sup> Currently, no audiometric test is available to evaluate oversensitive participants to impulse noise. On the other hand, OAEs have repeatedly shown high sensitivity and specificity in assessing cochlear damage after short exposure to noise.<sup>24,25</sup>

The same ambiguity applied to other similar efforts with populations exposed to harmful environments or activities.<sup>26-28</sup> Clearly, in such obscure conditions, real exposure may have been highly diversified between participants, thus inserting bias. In our case, all participants fired 20 single rounds using the same 5.56 mm INSAS assault rifle while lying down in the same prone position and for the first time thus eliminating any prior exposure among study population.

We should also stress that in our study, both TTS and PTS predictions were attempted. Although TTS is by definition only temporary, but it is now understood that a TTS that does not produce a PTS as measured by pure-tone thresholds does not mean that no long-term damage was done. In many circumstances, significant TTS will produce long-term degeneration of auditory nerve fibers which degrades hearing ability (e.g., hearing speech in noisy environments) without producing a significant change in thresholds (termed “hidden hearing loss”).<sup>29</sup>

Sarantis et al in their study suggested that OAEs amplitude is both sensitive and specific enough to efficiently identify participants who are particularly susceptible to hearing loss caused by impulse noise generated by firearms. Hearing conservation programs may therefore want to consider including such tests in their routine.<sup>30</sup>

## CONCLUSION

Although hearing loss due to exposure to loud noise in the form of firearms remains a significant risk among military personnel, there is no clinical method that can effectively identify individuals more prone for noise induced hearing loss to implement precautionary measures to avoid the same.

The data analysis yielded substantial evidence to suggest that OAE screening is sensitive and specific enough to be used as predictor for leading us to efficiently identify

individuals who are particularly prone for developing noise induced hearing loss.

This particular study over Indian population of recruits with respect to time and frequency shows ears/recruits showing “refer” at both 3 kHz and 4 kHz at OAE screening at 4 hours and 24 hours after firing for the first time are more prone to have noise induced high frequency hearing thresholds shift. Also, this study concurs with the study done by Attias et al showing that OAE is more sensitive tool than PTA to determine any shift in hearing thresholds due to noise exposure as evident by more % of sensitive cases picked up by OAE than PTA at both after 30 days and 06 months of firing.

However, in this study we didn’t carry out follow up of all study groups (recruits) at 06 months, but we know TTS that does not produce a PTS as measured by pure-tone thresholds does not mean that no long-term damage was done. So, this study needs further research before proceeding with the implementation of suppression of OAEs in hearing conservation program.

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