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Research Article

EFFECT OF NOISE INDUCED HEARING LOSS ON VESTIBULAR FUNCTION IN MUMBAI TRAFFIC POLICE – A PILOT STUDY

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A B S T R A C T

Background: Noise-induced hearing loss [NIHL] has been defined as a creeping hearing impairment resulting from long-term exposure to loud sound. Traffic policemen deployed at heavy traffic junctions, working for more than 10-12 hours a day, are at a risk of developing NIHL. Evidence suggests factory workers exposed to long-term noise might suffer from vestibular dysfunctions like dizziness, increased sway, disequilibrium and even nystagmus affecting their quality of life; hence this study was undertaken to find and correlate vestibular dysfunctions in traffic police with NIHL to prevent and address these problems at the earliest.

Methodology: A pilot study including 15 trafficpersonnels having 2-10 years of experience in the field were selected out of which pure tone audiometry was conducted for 8 participants based on a prior objective examination in order to ascertain those having noise induced hearing loss (NIHL). Then, vestibular function tests were performed to assess if any vestibular dysfunction occurred post NIHL. Vertigo symptom scale (VSS-SF) was used as an outcome measure for the same.

Result: Strong positive correlation was observed between long standing experience in the field and audiometry values. VSS-SF proved to be a useful tool to assess early vestibular symptoms following NIHL as strong positive correlation coefficients were recorded.

Conclusion: The study concludes that there is a significant correlation between NIHL (noise induced hearing loss) and vestibular dysfunction when assessed for long-term exposure to noise among traffic personnels.

INTRODUCTION

Noise pollution is defined as unwanted sound above 55 dB.[1]The major cause of noise pollution is the road traffic which has rapidly spiked within the previous couple of yearsdue to the rise in the number of vehicles.[2] 'Long or repeated exposure to sounds above 85dB can cause hearing loss' in line with a report by the National Institute on Deafness and Other Communication Disorders. This could be prevented by avoiding exposure to loud noises; per Daniel.[3]

Noise-induced hearing loss [NIHL] has been defined as hearing impairment resulting from exposure to loud sound. This may range from a loss/impaired perception of a narrow range of frequencies of sound waves and can go up to the extent of sensitivity to sound or ringing in the ears. NIHL usually takes an extended time to be noticeable but rarely it can happen immediately. It can last for a brief term i.e. temporary NIHL or may affect the ears permanently. Can be unilateral or bilateral. One-time exposure to an intense loud sound may result in NIHL, such as an explosion, or may occur following continuous exposure to loud sounds over an extended period of time, such as noise generated in a welding shop.

Traffic policemen are constantly exposed to this occupational hazard due to the nature of their job. Working for more than 10-12 hours a day, traffic police deployed at heavy traffic junctions are at a high risk of developing NIHL. Due to the lack of awareness and because of the insidious onset of NIHL, majority of these people are unalarmed about what awaits them after 5-10 years of experience in the field. This problem is sort of a slow poison infiltrating into the life of these community workers that takes a long time to become evident.

Evidence suggests vestibular problems are seen in factory workers exposed to noise for a long term (10 years) or more. Those with NIHL may suffer from vestibular dysfunctions like dizziness, increased sway, disequilibrium and even nystagmus. All these alarming signs can be potentially dangerous and can create a menace in the professional as well as personal life of these community workers. Hence this study was undertaken to find and correlate vestibular dysfunctions in traffic police with NIHL to prevent and address these problems at the earliest.

In Mumbai, the working hours of traffic police are 9am to 9pm. That means 12 hours of duty for a minimum span of 5 - 10 years with no support and availability of any personal

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protective devices/ equipments could potentially harm the cochlea resulting in auditory and vestibular dysfunction.

The Function of vestibular system is to stabilize visual images on the retina to allow clear vision and maintaining postural stability during head movements. It also acts to provide information for spatial orientation.[4]

As per study conducted by Kryter in 1970,vestibular injury in acoustic trauma occurs due to the close proximity of the vestibular and cochlear systems, explained further by the fluid connection between the two systems. Experiments conducted on laboratory animals exposed to noise showed physiological and pathological evidence of damage in the saccule, the utricle and the semicircular canals.[5]The cochlea and semicircular canals share a common embryonic origin (oticvesicle). Hence, they utilize the same basic principle of mechano-electric transduction with the help of the sensory hair cells.[6]The studies on vestibular evoked myogenic potential have shown that saccule can be stimulated with sound levels at or above 100 dB SPL.[7][8]In accordance to this report the noise levels that can cause damage to the cochlea could possibly also stimulate the balance system.[9]When the vestibular noise stimulation threshold gets lowered it implies that oversensitivity to vertigo can occur even at everyday noise levels.[10]Evidence suggests vestibular problems are seen in factory workers exposed to noise for a long term. Those with NIHL are reported to have significantly increased body sway,[11][12]higher incidence of nystagmus[13], reduced vestibular evoked potential,[14]lower vestibule ocular reflex gain and decreased caloric responses as compared to those without occupational noise exposure.[9]

Our Major concern is that such people will become patients for vestibular rehabilitation in the future. It also emphasizes on the need for ear protective devices and hearing aids for traffic police. Most of the study subjects are in the economically productive age groups and if they suffer from hearing disability at this age, they would have to live with that disability throughout their life and if effective measures are taken at this stage, health hazards could well be prevented. Hence, our suggestionis that PPEs should be made available and workshops should be conducted periodically to motivate the subjects for their correct and regular usage.

METHODOLOGY

The study is a pilot study conducted in Mumbai at the Kashimira Vahatuk Vibhaag where a sample size of 15 traffic personnels with an experience of minimum 2 and maximum 10 years and a daily exposure of more than 8 hours were selected using a convenient sampling method. The study utilized a 256 Hz tuning fork, a chair and a plinth.

Inclusion criteria*:* 1. Willing to participate in the study. 3.On duty for 2-10 yrs. 4. Duration of exposure for minimum 8hours/day. 5.Male and female police. 6.Traffic police appointed at major highways and junctions of heavy traffic.7. Subjects who do or do not drink/smoke.

Exclusion criteria*:* 1. Traffic police with pre-existing ear problems or balance issues. 2. Unwilling to participate. 3.Subjects with cervical conditions or vision problems. 4.On duty for less than 2 yrs or more than 10 yrs.

Procedure

An informed consent was obtained. The ethical clearance was obtained from institutional research ethics committee prior to the study. Permission from the traffic police head department was obtained. All demographic data was taken before the initiation of the study. 8 participants underwent pure tone audiometry following an objective examination of their presenting symptoms. Rinne's and Weber's test were done to look for NIHL and if present, then its type. Gaze stability including saccadic eye movements, smooth pursuit, nystagmus and convergence movements were checked. Then vestibular function tests were performed including dix-hallpike test, horizontal roll test and the head impulse test.[4]

1. **Dix-hallpike test**: The patient is moved from a long sitting position with the head rotated to 45 degrees to one side, to a supine position with the head extended 30 degrees beyond the horizontal with head still rotated 45 degrees. The maneuver places each of the SCCs in a gravity dependent position and the physical therapist should observe the eyes for nystagmus and ask for vertigo. The patient is then brought back to the starting position and the other side is tested. The direction of nystagmus is unique to the involved SCC. Used for testing posterior canal.
2. **Roll test for horizontal canal**: The patient is positioned in supine. Initially the patients head should be placed in 20º of cervical flexion. Next, the head is quickly turned 90 degrees to the left side. The therapist then checks for nystagmus and vertigo. Then the other side is tested. The head is then returned to the neutral starting position.
3. **Head Impulse test**: The test is performed by having the patient first fixate on a near target (ex: clinician's nose). When testing the horizontal semi-circular canal, the head is flexed 30 degrees. Patients are asked to keep their eyes focused on the target while their head is manually rotated in an unpredictable direction using a small amplitude (5-15 degrees). When the VOR (vestibulo-ocular reflex) is functioning normally, the eyes move in the direction opposite to the head movement and gaze will remain on the target. In a patient with loss of vestibular function, the VOR will not move the eyes as quickly as the head rotation and eyes move off the target. The patient then makes a corrective saccade to reposition the eyes on the target.
4. Lastly, answers to Vertigo symptom scale – Short form questionnaire were recorded and scoring was done for the same.

Data analysis and interpretation

A total of 15 subjects were enrolled in the study. Data was collected on a data sheet and encoded for computerized analysis using SPSS 28 software (United States). Shapiro- wilk test was used to find out the normality distribution. Descriptive statistics were mentioned in terms of mean and standard deviation. Correlation of pure tone audiometry for both right and left ear was done with experience(in years) and working hours and later with the vestibular function tests using Spearmann's correlation test. A p value of $<0.05$was considered statistically significant. The correlation coefficient values were defined as follows: very strong correlation (≥ 0.8); moderately strong correlation (0.6-0.8); fair correlation (0.3-0.5), and poor correlation (≤ 0.3).

RESULT

Out of the 15 participants included in the study, 14 were males and one was a female. Pure tone audiometry test was done for only 8 of them due to the covid pandemicrestrictions, hence the subjects who had more years of experience and a strong history indicative of NIHL were sent for audiometry. Age range was 30-53 years. 8 subjects had 2-4 years of experience and the remaining had 5-10 years of experience in the traffic department. Working hours each day varied between 12-24.Table 1 shows mean and standard deviation for Demographic variables such as age, height, weight, bmi, working Hours, experience (in years), Pure tone audiometry test findings for the right and left ear, and VSS results for both the ears.

Table 1 Demographic data of participants recruited

Demographic characteristics	N	Minimum	Maximum	Mean	Standard deviation
AGE	15	30	58	43.13	6.74
HEIGHT	15	161	192	83.47	13.22
WEIGHT	15	58	115	176.2	8.6
Working Hours	15	12	24	12.93	3.1
Experience (in years)	15	2	10	4.47	2
PTA RIGHT	08	18.00	31.66	23.7	4.3
PTA LEFT	08	17.00	31.66	23	4.9
VSS	15	0	11	4.13	3.50

The Shapiro-Wilk test was done to assess whether the data is normally distributed. The test showed that the data was not normally distributed.

Table 2

Tests of Normality			
	Shapiro-Wilk		
	Statistic	df	Sig.
Age	.960	15	.684
Height in cm	.946	15	.461
Weight in kg	.880	15	.048
Workinghrs	.347	15	<.001
experience in yrs	.871	15	.035

Correlations

Correlation between various components was done using Spearman's correlation test.

Table 3

Table 3 shows correlation (*r* value) between working hours and audiometry for the right ear (PTAR) which is found to be 0.581 indicating a moderately strong positive correlation. *r* value between working hours and audiometry results of the left ear (PTAL) was 0.595, again a moderately strong positive correlation.

			Working HRS	PTAR	PTAL
Spearman's rho	Working hrs	Correlation Coefficient	1.000	.581	.595
		Sig. (2-tailed)	.	.131	.119
		N	15	8	8
	PTAR	Correlation Coefficient	.581	1.000	.883**
		Sig. (2-tailed)	.131	.	.004
		N	8	8	8
	PTAL	Correlation Coefficient	.595	.883**	1.000
		Sig. (2-tailed)	.119	.004	.
		N	8	8	8

Table 4

Table 4 shows negligible correlation between working hours with rinne's and weber's test indicative of the fact that these tests are not very reliable when it comes to assessment of any person for NIHL. Rinne's and weber's test were also correlated with the audiometric findings and the correlation was found to be negligible.

			working HRS	rinne	webers
Spearman's rho	Working hrs	Correlation Coefficient	1.000	.120	.093
		Sig. (2-tailed)	.	.669	.741
		N	15	15	15

Table 5 (a)

Table 5(a) shows strong positive correlation between years of experience in the field of traffic department and audiometry findings of the right ear shown to be 0.721 indicating that there is a directly proportional relationship between these two variables, so as experience and time in the field increases, possibility of NIHL also increases.

			Ptar	Experience
Spearman's rho	Ptar	Correlation Coefficient	1.000	.721*
		Sig. (2-tailed)	.	.044
		N	8	8
	Experience	Correlation Coefficient	.721*	1.000
		Sig. (2-tailed)	.044	.
		N	8	15

Table 5(b)

Table 5(b) shows a moderately positive correlation between years of experience in traffic department and audiometry of the left ear shown to be 0.510 indicating that there is a directly proportional relationship between these two variables.

			Experience	Ptal
Spearman's rho	Experience	Correlation Coefficient	1.000	.510
		Sig. (2-tailed)	.	.197
		N	15	8
	Ptal	Correlation Coefficient	.510	1.000
		Sig. (2-tailed)	.197	.
		N	8	8

Table 6(a)

Vestibular function tests were performed on all the participants of the study.Table6(a) shows weak positive correlation between dix-hallpike test which is a vestibular function test used for assessing BPPV and audiometry findings of the right ear. Since audiometry was done for 8 participants, the vestibular function test is correlated with the same number of subjects.

			PTAR	Dixhallpike test
Spearman's rho	PTAR	Correlation Coefficient	1.000	.373
		Sig. (2-tailed)	.	.362
		N	8	8

Table 6(b)

Table6(b) shows low/weak positive correlation between dix-hallpike test and audiometry findings of the left ear indicating that vestibular system is affected following NIHL.

			PTAL	Dixhallpike test
Spearman's rho	PTAL	Correlation Coefficient	1.000	.333
		Sig. (2-tailed)	.	.420
		N	8	8

Table 7(a)

Table7(a) shows negligible positive correlation between roll test and audiometry findings of the left ear indicating that roll test is not effective to demonstrate if the vestibular system is affected following NIHL. Roll test is suggestive of horizontal semi-circular canal involvement. Left ear more affected than right.

			PTAL	Rolltest
Spearman's rho	PTAL	Correlation Coefficient	1.000	.260
		Sig. (2-tailed)	.	.534
		N	8	8

Table 7(b)

Table7(b) also shows negligible positive correlation between roll test and audiometry findings of the right ear indicating that roll test is not suitable to show whether or not the vestibular system is affected following NIHL.

Correlations				
			PTAR	Rolltest
Spearman's rho	PTAR	Correlation Coefficient	1.000	.253
		Sig. (2-tailed)	.	.545
		N	8	8

Hence, we can conclude that roll test is less sensitive than dix-hallpike test for assessing NIHL as the *r* value is on the low.

Table 8

Table8(a) and 8(b) show negative correlation between head impulse test and audiometry findings of the right ear and the left ear respectively, stating that this test is not suitable and reliable for subjectively assessing subjects with NIHL.

8a Correlations				
			PTAR	Headimpulsetest
Spearman's rho	PTAR	Correlation Coefficient	1.000	-.249
		Sig. (2-tailed)	.	.552
		N	8	8
8b Correlations				
			PTAL	Headimpulsetest
Spearman's rho	PTAL	Correlation Coefficient	1.000	-.255
		Sig. (2-tailed)	.	.542
		N	8	8

Table 9

Table9(a) and 9(b) shows strong positive correlation between vertigo symptom scale short form (VSS-SF) and audiometry findings of the both the ears indicating that VSS-SF can be used as an effective tool to assess vestibular system in those affected with NIHL. Left ear more affected than right.

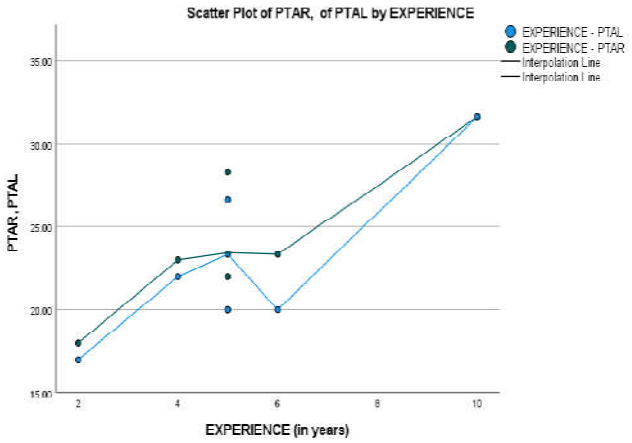
Table 9 (a)

			PTAL	VSS-sf
Spearman's rho	PTAL	Correlation Coefficient	1.000	.730*
		Sig. (2-tailed)	.	.040
		N	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

Table 9 (b)

			PTAR	VSS-sf
Spearman's rho	PTAR	Correlation Coefficient	1.000	.712*
		Sig. (2-tailed)	.	.048
		N	8	8



Graph

Intepretation

The abovescatter block graph displays the correlation plot between work experience in years and audiometry findings of the left and the right ear (PTAR, PTAL). On x-axis work experience in years is noted and on y-axis PTAR and PTAL values are noted. Audiometry values above 23.33 are indicative of ear pathology. A dip at 4kHz indicates NIHL. This graph depicts that, subjects with 5 years of experience or more have higher audiometry values and more chances of suffering from Noise induced hearing loss. So as the no. of years and experience profile in the field increases, chances of NIHL also increase.

DISCUSSION

Noise induced hearing loss is a frequently viewed occupational hazard. Whether or not NIHL occursdepends upon many factors like the susceptibility of the individual, their age, noise amplitude, characteristics of noise including its (pitch, shrill, type), duration of exposure, and use of ear protective devices.[15] Age has anadditive effect on hearing impairment.

In this study, we aimed to correlate NIHL which occurs in the cochlea of the ear with vestibular system affection which occurs at the semi-circular canals. In the present study there were 15 participants, these traffic personnel were medically and audiologically fit before they joined their duty, (due to the pandemic, only this much population was available) among which 14 were male and 1 female, all with no history of alcohol or smoke abuse. Only 8 had undergone audiometry due to ongoing pandemic (covid-19) situation as they were suspected of NIHL during initial history taking and general examination. The subjects were Mumbai traffic police with experience ranging from 2-10 years and objective measures were used to check if vestibular apparatus gets affected post NIHL. Correlation was found out using spearman's rho correlation formula.

Traffic personnels belonging to the mean age group of 43.13 ± 6.74 SD participated in the study. This is the economically productive age group. The mean values and standard deviation for working hours was 12.93 ± 3.1 hours and that for experience was 4.47 ± 2 years. A moderately strong positive correlation with an r value of 0.581 for the right ear and 0.595 for the left, was observed between working hours and audiometry findings signifying that long working hours somewhere adversely affected hearing organs. Similarly, a strong positive correlation was also observed between years of

experience in the traffic department with the audiometry findings with r values of 0.721 in the right ear and 0.510 in the left ear denoting that more the experience years in the field, worse it is for the ear without the use of ear protective devices. The service interimgives acumulative effect to noise in causing NIHL. Frequency range between 4-6 kHz is usually affected firstwith maximum affection occuring at a frequency of 4kHz.[16]In the initial stages of NIHL, the patients have a very few symptoms as the speech (conversation) frequencies are less affected and hence they are usually unmindful of the deleterious effects of sound. [17]

Correlation of working hours with rinne's and weber's test showed poor results stating that these tests aren't helpful during the initial stages as they can't detect minor changes. The specificity and sensitivity of rinnes and webers is low.[18] Also, the test results vary from person to person depending on factors like, how hard is the tuning fork strung (the harder its strung, the longer the duration of vibration). The environmental settings including masking, also significantly affect the results.

Three vestibular function tests were carried out post audiometry to determine whether the vestibular system is affected post NIHL. Out of which, the dix-hallpike test showed the best value of correlation with audiometry results i.e. 0.373 for the right ear and 0.333 for the left ear. Other tests such as roll test had poor correlation with a value of 0.260 for the left and 0.253 for the right ear, whereas head impulse test had negative correlation. Since dix-hallpike test is responsible for assessing the posterior canal we can conclude that the posterior canal gets affected the most; following NIHL.

This study revealed that a robust correlation was seen between audiometry findings and vertigo symptom scale questionnaire hinting that the vestibular system gets affected post prolonged exposure to traffic noise. It also states that VSS-SF is a suitable outcome measure to be used to screen people for early NIHL. This is because VSS-SF has components of symptoms that arise in the early stages of NIHL like headaches, sudden temperature changes, tinnitus, palpitations, dizziness, nausea and unsteadiness so people can relate to it easily if they have been experiencing such symptoms which could be a potential cause of vestibular dysfunction. Dizziness handicap inventory (DHI) failed to be substantial in this study.

The slight variations in the results of present study and the previous ones may be due to the differences in the sample size of the studies, the amount of traffic noises in the area and working hours. Due to the pandemic, only a small population was available and thus this study had to be undertaken with the available resources.

As this study research was started before the covid pandemic, the data collection was done during the lockdown period when the traffic personnels were lined with a lot of work to not allow people to roam outdoors unnecessarily. Hence the availability was less but all the covid precautions and safety was undertaken.

Previous studies conducted in Kanthmandu, Patiala amongst traffic police and other studies done in factory and construction workers have shown that NIHL occurs in these personnels due to long term exposure. One of the studies also suggested that apart from self assessment of hearing abilities[19], audiometry had to be done to diagnose any hearing impairment hence audiometry was carried out in this study. In the previous article a larger population of participants reported having trouble during normal (40%) and telephonic conversation (16.7%). 61% subjects reported having work related tinnitus and ear fullness.[19]

Values of upto 25dB is considered as normal hearing. Graph 1 represents that as the years of experience increase, values of audiometry also increase. A drop in 4kHz was observed in many subjects which is indicative of mild SNHL at high frequency even though they had hearing sensitivity within normal limits. 1 among these 15 subjects who presented with symptoms of reduced hearing capacity, headaches and dizziness; worked at major traffic junctions with an experience of 10 years recorded audiometry values of 31.66 on both the right and the left ear, confirming moderate NIHL bilaterally.

On taking VSS-SF, dizziness was reported to occur ocassionally and lasted for a short period. Therefore, the vestibular deficits were subtle and they did not substantially affect the individual's functional capability. One of the major reason cited by traffic constables for not using personal protective devices was the non -availability of ear plugs/ear muffs which was a common revelation among this study and many previous studies.[19]

CONCLUSION

The study concludes that there is a significant correlation between NIHL and vestibular dysfunction when assessed for long-term exposure among traffic personnels due to the nature of their job indicating that they are at a risk of vestibular problems in the later stages of their life.

Vertigo symptom scale – short form (VSS-SF) scale is and effective and quick tool that can be used to assess traffic personnels for early symptoms of NIHL and vestibular dysfunction.

The need of the hour is to create awareness among the traffic departments and the city dwellers regarding the condition and prevent it as best as possible. Proper road traffic rules need to be laid down by the government and norms must be made to control unnecessary honking. Stringent legislations need to be introduced regarding the usage of horns. Public awareness campaigns using social media platforms, newspapers, rallies and banners need to be undertaken wherein they are explained in detail about the ill effects of noise. Ear protective devices including ear muffs/ ear plugs and ear canal protectors need to provided by the government authorities to the traffic personnels engaged on field. Regular check-up of traffic constables needs to be carried out by trained otologists and rotational duty of all traffic policemen between heavy and light junctions can be helpful methods to deal and prevent NIHL.

Limitations

- The study was performed over a small sample size.
- Only traffic personnels with no history of smoking and alcoholism were taken.
- Traffic personnels with 2-10 years of work experience were taken into consideration.
- Study was conducted during lockdown of covid-19.

Suggestions

Further researches should focus on:

- Using a larger sample size.

- Audiometry can be conducted on all the participants.
- Participants who drink and smokecan also be included in the study.
- Participants with work experience of more than 10 years and under the age of 50 can be included.

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