Original Article

Noise Induced Hearing Loss - A Comparison Between Speech Frequency And 4000Hz Frequency.

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ABSTRACT

Objective: To compare the prevalence and degree of noise induced hearing loss at speech frequency and at 4000Hz among textile workers of Surat city and also to compare the effect of duration of exposure to noise on them.

Material and Methods: 50 male Hindu workers of the textile mill of Surat city between 20-50 years of age were examined by audiometry. Controls were selected from Surat city between the age group of 20-50 years. All were male and Hindu by religion with no history of any kind of exposure to noise

Results: Among 50 workers exposed to high level of sound, at speech frequency 80% workers had some degree of hearing loss and 20% were normal whereas at 4000Hz 90% workers had hearing loss and 10% were normal. At speech frequency 62% workers had mild degree hearing loss and 18% had moderate degree of hearing loss whereas at 4000Hz 4% worker had mild degree, 36% had moderate degree, 38% had moderately severe degree and 12% had severe degree of hearing loss. When the duration of exposure to noise is considered—workers with <10 years of exposure (n=15), at speech frequency 53.33% had normal hearing and 46.66% had mild degree of hearing loss. At 4000Hz, 20% had normal hearing and 80% had hearing loss---13.33% had mild, 40% had moderate and 26.66% had moderately severe. With duration of exposure between 10-20 years, at speech frequency 13.33% had normal hearing and 86.66% had hearing loss—80% had mild and 6.66% had moderate. At 4000Hz 13.33% had normal hearing and 86.66% had hearing loss--- 53.33% had moderate and 33.33% had moderately severe.With duration of exposure >20 years, at speech frequency all workers were suffering from hearing loss---60% had mild and 40% had moderate. At 4000Hz again all workers were suffering from hearing loss--- 20% had moderate, 50% had moderately severe and 30% had severe degree of hearing loss. When the prevalence of hearing loss was compared between speech frequency and 4000Hz no significant difference was observed but highly significant difference was observed when degree of hearing loss was calculated. Similarly, duration of exposure does not have any significant difference between speech frequency and 4000Hz as far as prevalence is concerned. But degree of hearing loss is significantly higher at 4000Hz than at speech frequency.

Conclusion: From this study it can be concluded that the degree of hearing loss was very high at 4000Hz than speech frequency, although the difference in prevalence could not be established statistically.

KEY WORDS: audiometry, hearing threshold, temporary threshold shift

Introduction

The occupations have developed in relation with the needs of the human beings and also according to the geographical surroundings. Occupational hazards i.e. adverse effect of different occupations on health is known since times. During the 4th century BC, HIPPOCRATES was probably the first person to recognise the toxic properties of lead and to describe the attacks of lead colic. He wrote the first book 'Air, Water & Places' where he explained the effect of environment on the development of disease.[1]The industrial revolution of the 18th century had brought in new problems of society like creation of slums and accumulation of refuse and sewage, overcrowding, problems of hygiene and industrial diseases etc.

Introduction of louder machines with industrialization makes the noise perhaps the most common occupational and environmental hazard. After presbyacusis noise induced hearing loss is the second most common cause of nerve deafness.[2]

Hearing is the subjective experience of exposure to sound. Sound consists of waves of alternating condensation and rarefaction in an elastic medium.[3] Noise can be defined as' wrong sound in the wrong place at the wrong time.'[4]

Occupational noise induced hearing loss was recognized as early as the publication of Bernardo Ramazini's text on diseases of occupation in the 18th century. [5] During the 1830s, boilermaker's ear, weavers deafness were used to identify and explain hearing impairment due to occupational noise exposure .Our first practical programme of hearing conservation seemed to begin around the early 1950s.[6]

A study by UK Factory Inspectorate in 1971, estimated that 5,90,000 0f the 6.4 billion workers in manufacturing industries were exposed to noise level of 90 dB or more for at least 6 hours per day. A further 5,70,000 were exposed to such level of noise at least for the part of the time.[7,] The highest incidence appear to be in German Democratic Republic. The number of finally recognized cases of ONIHL in that country rose from 15 in 1956 to7069 in 1968 when the population was about 16 million.[8] The relationship between various parameters of occupational noise exposure and the resulting hearing loss was extensively investigated by Burns and Robinson in the 1960s. [9] About pathophysiology, Habermann and Igarshi [10,11,12,13,] reported that it was spiral organ which was involved markedly.

How noise actually damages hearing has been the subject of a variety of research effort. Most of the studies were conducted on animals. In some studies it was suggested that it is due to decreased blood supply to the basilar membrane which is responsible for damage. [14,15,16,17,] Apoptosis was also observed in noise exposed cochlea by Hu in 2000.[18] Continuous sound pressure level is more damaging than intermittent sound.[19] when the impact noise is superimposed on continuous noise, the injurious potential is synergistically enhanced.[20]

The major risk factor for suffering from ONIHL is prolonged exposure to unprotected level of noise usually beyond 85dB. Cigarette smoking is said to be strongly associated with increased risk of developing ONIHL.[21,22,23,24] In some studies association between blood sugar level[25], lipid profile[26,27] and body melanin level[28,29] is also demonstrated.

A noise level of 90 dB(A) SPL, 8 hours a day for 5 days per week is the maximum safe limit as recommended by Ministry of Labour, Govt. Of India- Model rules under Factories Act. No exposure in excess of 115 dB (A) is to be permitted. No impulse noise of intensity greater than 140 dB(A) is permitted.[30]

There are many industries where the risk of development occupational noise induced hearing loss is very high e.g. oxygen torch industry, diesel engine room, electric furnace, newspaper press etc. Textile industry is one of such industry where the risk of development of hearing loss is very high as the average sound level is about 106 dB(A).

Because the hearing ability of a person is mainly dependent on the hearing threshold level below 3000 Hz, so the prevalence and degree of hearing loss is determined by calculating average hearing threshold level at 500Hz, 1000 Hz and 2000 Hz (as per WHO criteria), which is known as speech frequency. Again ONIHL is most prominent at 4000 Hz, so prevalence and degree of hearing loss is also calculated at 4000 Hz and then both are compared.

Materials and Methods

After exclusion criteria a sample size of 50 male workers were taken who were working in different textile mills of Surat city (study group). Controls were taken from different part of Surat city that were male and had no history of exposure to any kind of high level of sound. Age group of all the workers in study group and all the persons included in control was between 20-50 years and all were Hindu by religion.

Data were collected through interviews, physical and local examinations and by audiometry. Study was conducted with the help of pre-tested questionnaire. The questionnaire includes a detail and relevant history related to hearing, duration of exposure to noise, history of auditory problem, any difficulty in speech and use of personal protective devices if any

All audiometric tests were carried out in a quiet room outside the factory before the workers entered their work shift to avoid the effect of temporary threshold shift due to recent noise exposure inside the factory. Testing frequency was from 250 Hz to 8000 Hz

Audiometry:

Measurement of hearing using electro acoustic devices, in contrast to the non-electro acoustic devices (human voice, tuning fork) is termed audiometry. It is an electronic device in which an earphone is connected to an electronic oscillator capable of emitting pure tones ranging from low frequency to high frequency. The instrument is so calibrated that the zero intensity of sound at each frequency is the loudness that can barely be heard by the normal person. A calibrated volume control can increase or decrease the loudness at each frequency below or above the zero level.

In this study the model used was 'ELCON MILLI'. The instrument consists of an audio-oscillator capable of generating pure tone sounds of various frequencies usually at regular steps of 125, 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. Each tone can be separately amplified to a maximum of 100 or 110 dB in most frequencies. The audiometer was connected to a standard and specified earphone through which the sound can be presented to the subject's ear. The audiometer is operated by means of a noiseless switch called interrupter which can introduce or interrupt a tone.

Hearing threshold is the minimum sound that a subject may hear for a given tone or frequency. The International Standards Organization has defined hearing threshold as *"the lowest sound pressure level at which under specified conditions, a person gives a predetermined percentage of correct response on repeated trials,"* for our clinical use this 'predetermined percentage' was 50% of the number times the tone is introduced into the ear. That is, the sound at threshold should be so faint that if the sound is presented to the test ear 6 times, the subject will hear it only thrice and miss it for the other three times.

Procedure for pure tone audiometry- The method used for audiometry was that recommended by ASHA i.e. American Speech And Hearing Association. In this the test is started with 1000 Hz and the threshold is obtained for various frequencies in the order 1000-2000-4000-8000 and then 250 & 500 Hz.

After determining hearing threshold at different frequencies, prevalence of hearing loss was calculated at speech frequency i.e. average of 500 Hz, 1000 Hz and 2000 Hz and then at 4000 Hz. Then depending upon hearing threshold level workers were classified into six grades—no hearing loss, mild hearing loss, moderate hearing loss, moderately severe hearing loss, severe hearing loss and total hearing loss (WHO classification).

Hearing loss (in dB)	**Degree of hearing loss**
0-25	Not Significant
26-40	Mild
41-55	Moderate
56-7	Moderately severe
71-91	Severe
Above 91	Total

Results

First we have calculated the prevalence of hearing loss at speech frequency and at 4000 Hz frequency.

Hearing loss	**Frequency**	
	Speech	**4000 Hz**
Present	**40**	**45**
Absent	**10**	**5**
Total	**50**	**50**

p>0.05

Table 1: Comparison of prevalence of hearing loss at speech frequency and at 4000 Hz

At speech frequency 40 out of 50 workers (80%) were suffering from hearing loss whereas at 4000 Hz 45 out of 50 (90%) workers were suffering from hearing loss. This difference was statistically not significant as p>0.05. (**Table 1, Figure 1**)

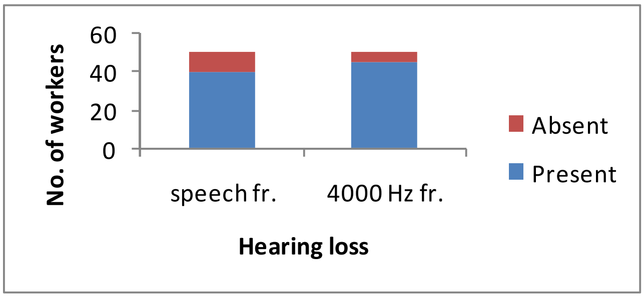

Figure 1: Comparison of prevalence of H.loss at speech fr. & at 4000 HZ

Then the degree of hearing loss was compared at speech frequency and at 4000 Hz. At speech frequency 40 workers were suffering from hearing loss among which 31 had mild degree of hearing loss and 9 had moderate degree of hearing loss. It means there was no one with hearing loss more than 55 dB. At 4000 Hz 45 workers were suffering from hearing loss among which 2had mild degree of hearing loss, 18 had moderate degree loss, 19 had moderately severe degree hearing loss and 6 had severe degree of hearing loss .

Table 2: Comparison of degree of hearing loss at speech frequency and at 4000 Hz

Frequency			Hearing loss		
	Normal	Mild	moderate	Mod. severe	severe
Speech	10	31	9	0	0
4000 Hz	5	2	18	19	6

P<0.05

This means that there were 20 workers with hearing loss less than 55 dB whereas 25 workers had hearing loss more than 55 dB. Among these 25, 6 workers had hearing loss between 71-91 dB. This difference was statistically highly significant as p<.05. this signifies that hearing loss is more severe at 4000 Hz than at speech frequency**. (Table 2, Figure2)**

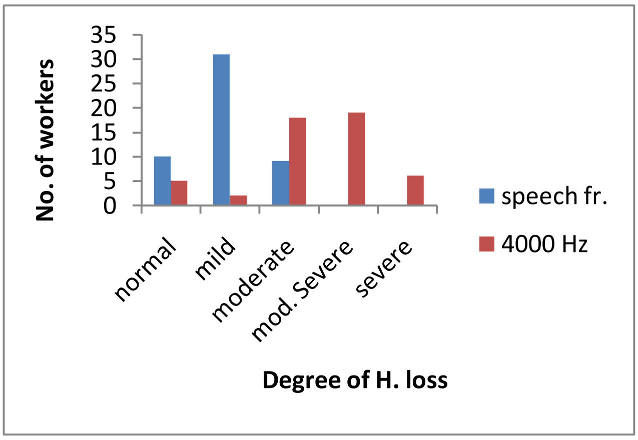

Figure 2 : Comparison of degree of H.loss at speech frequency & at 4000 Hz

After this, effect of duration of exposure was calculated on prevalence and degree of hearing loss at speech frequency as well as on 4000 Hz frequency. For this, workers were divided into three groups- <10 years of exposure (n=15), 10-20 years of exposure (n=15) and >20 years of exposure (n=20). At speech frequency with <10 years of exposure, 7out of 15 workers had hearing loss. With duration of exposure 10-20 years, 13out of 15 workers were affected and with duration of exposure >20 years, all 20 workers were suffering from hearing loss. This increase in prevalence was statistically highly significant as p< 0.05 (**Table 3, Figure 3**).

Table 3: Effect of duration of exposure on prevalence of H. loss at speech fr. & at 4000 Hz

Duration of Exposure	Prevalance of hearing loss	
	Speech frequency*	4000Hz **
> 20 Years (n =20)	20	
10 – 20 years (n=15) 86.66%	13 (86.66 %)	13
< 10 years (n=15)	7 (46.66%)	12 (80%)

*P<0.05 **p >0.05

At 4000 Hz 12, 13 and 20 workers were effected respectively with duration of exposure <10 years, 10-20 years and >20 years. Here p>0.05, so it was statistically not significant.

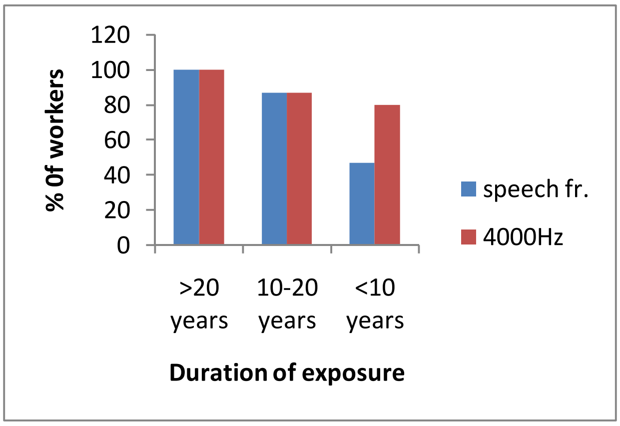

Figure 3: Effect of duration of exposure on prevalence of hearing loss

This may be due to the fact that at 4000 Hz except 5 workers all other were affected irrespective of duration of exposure.**(Table 4, Figure 4)**

Table 4: Effect of duration of exposure on degree of hearing loss at speech frequency

Duration of exposure	Degree of hearing loss				
	Normal	mild	moderate	Mod. severe	Severe
>20 Yrs (n=20)	0	12 (60%)	8 (40%)	0	0
10-20 yrs (n=15)	2	12 (80%)	1 (6.66)	0	0
<10 Yrs (n=15)	8	7 (46.6%)	0	0	0

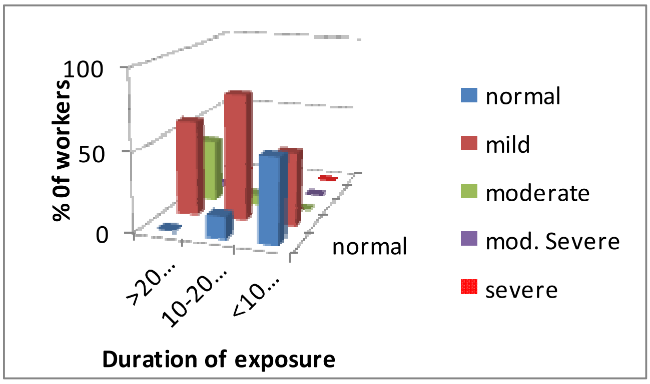

Figure 4: effect of duration of exposure on degree of H. loss at speech frequency

Then it was tried to find out the effect of duration of exposure on severity of hearing loss at speech frequency and at 4000 Hz. With duration of exposure <10 years, at speech frequency 7 workers were effected and all of them were suffering from mild degree of hearing loss whereas at 4000 Hz 12 workers were effected among which 2 had mild, 6 had moderate and 4 had moderately severe degree of hearing loss. With duration of exposure between 10-20 years, at speech frequency 12 workers were suffering from mild and only 1 had moderate degree of hearing loss. No one had moderately severe or severe degree of hearing loss. At4000 Hz, no one had mild degree of hearing loss, 8 workers had moderate and 5 had moderately severe degree of hearing loss. With duration of exposure >20 years, at speech frequency 12 workers had mild and 8 had moderate degree hearing loss again no one had moderately severe or severe degree of hearing loss. At 4000 Hz frequency, 4 had moderate, 10 had moderately severe and 6 had severe degree of hearing loss. Here also no one was suffering from mild degree of hearing loss. (Table 4, Figure 4) & **(Table 5, Figure 5)**

Table 5: Effect of duration of exposure on degree of hearing loss at 4000 Hz

Duration of exposure	Degree of hearing loss				
	Normal	mild	moderate	Mod. severe	Severe
>20 Yrs (n=20)	0	0	4 (20%)	10 (50%)	6
10-20 yrs (n=15)	2(13.33%)	0	8 (53.33%)	5 (33.33%)	0
<10 Yrs (n=15)	3 (20%)	2 (13.3 %)	6(40%)	4 (26.6%)	0

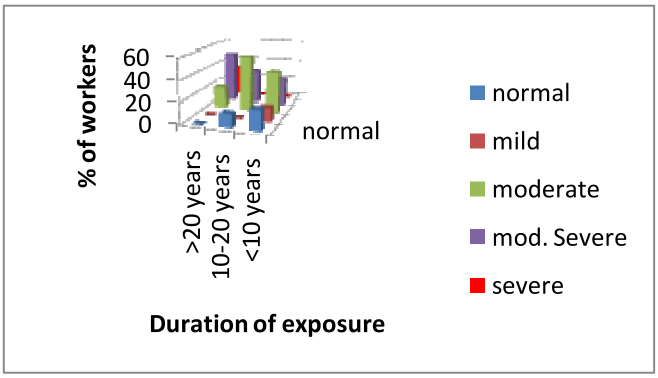

Figure 5: effect of duration of exposure on degree of hearing loss at 4000 Hz

Discussion

In this study we have seen that high level of noise has deleterious effect on hearing threshold level of human being at speech frequency as well as at 4000 Hz frequency. The difference in the prevalence between these two frequencies could not be established significant statistically. This may be due to smaller sample size or may be due to the fact that majority of workers (35 out of 50) had duration of exposure more than 10 years. Among 15 workers with duration of exposure <10 years, only 2 workers had exposure <5 years. This means that among 50 workers, 48 workers had duration of exposure >5 years. This prolong duration of exposure may had involved both speech frequency and 4000 Hz frequency. So the difference in prevalence was not significant.

When we look for the degree of hearing loss i.e. severity of hearing loss at speech and 4000 Hz frequency, we can see that the number of workers having normal or mild degree of hearing loss at 4000 Hz is much less than the number of workers at speech frequency (7 workers at 4000 HZ as compared to 41 at speech frequency) whereas the number of workers suffering from moderate, moderately severe or severe degree of hearing loss at 4000 Hz is much higher than at speech frequency (43 workers at 4000 Hz as compared to only 9 workers at speech frequency. But the hearing loss at 4000 Hz does not affect the hearing ability of a person. So usually the person does not complain about any hearing difficulty, unless gradually lower frequencies also get involved. So serial audiometry can play a crucial role to prevent development of hearing difficulties as the worker can be transferred to a lesser noisy occupation or can be shifted to another job before they develop hearing difficulty.

When we calculate the effect of duration of exposure on prevalence of hearing loss, it shows a positive relationship, i.e. prevalence increases with increase in duration of exposure. Till the duration of exposure is < 10 years, 46% w0rkers get affected. But when the duration is > 20 years, it becomes 100%. This relationship could not be found at 4000 Hz because till the of exposure reaches to 10 years, already 80 % workers become affected.

As far as effect of duration of exposure on degree of hearing loss is concerned, certainly it has more deleterious effect at 4000 Hz. Workers were suffering mainly from moderate, moderately severe or severe degree (86%) hearing loss whereas at speech frequency mainly they had mild (62%) and few (18%) had moderate degree of hearing loss.

All the possible precautions were taken during the course of this study. But certain limitations were there, like the workers were personally interviewed and investigator has to rely on their truthfulness and memory without any documentary proof. The sample size was small, so it was not possible to generalize these observations for all the workers working in textile factories of Surat city.

Conclusion

In the present study we had tried to find out the difference in the prevalence and degree of hearing loss at speech frequency and at 4000 Hz frequency and their relationship with duration of exposure. Certainly the prevalence and degree of hearing loss was found very high. The difference in prevalence between these two frequencies could not be established statistically significant, but the difference in degree of hearing loss is significantly high at 4000 Hz similarly the duration of exposure had more effect on speech frequency as far as prevalence is concerned, but when degree of hearing loss is considered, it is 4000 Hz which is more effected than speech frequency.

Whatever may be the cause, the condition is critical and improvement by means of integral work organization must be considered.

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