A Review of Ergonomic Aspects of Hearing Impairment of Humans in Different Environments

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Abstract– Noisemay be defined as undesired sound continuous exposure to such sound has severe effect on hearing ability of individuals. It also affects the work ability and posture of individuals. Noise is measured in decibels (db). Generally, a person having hearing threshold level 25 is termed as normal and a person having hearing threshold level more than 85db is considered as permanently hearing impaired. This paper reviews the ongoing development in the field of ergonomic aspects of hearing impairment in human in different environment. The study indicates that hearing conservation programs are requireprotectingindividual's safety and health.

Keywords: Hearing threshold level, Audiometry, Excess risk, Sound pressure level (SPL)

1 INTRODUCTION

Noise may be defined as undesired sound continuous exposure to such sound has severe effect on hearing ability of individuals. It results noise induced hearing impairment in individuals due to repeated exposure of loud sound. It also affects the work ability and posture of individuals.Generally, a person having hearing threshold level 25 is termed as normal and a person having hearing threshold level more than 85db is considered as permanently hearing impaired. The mechanism of noise-induced hearing loss involves the destruction of hair cells in the Organ of Corti within the cochlea of the inner ear.

Hearing ability may decrease gradually due to repeated noise exposure like hearing of loud music and background noise.

2 LITERATURE REVIEW

J. Majumder et al [1] estimate an excess risk of hearing impairment of professional driver in Kolkata city. Sub samples of 30 for drivers having experience less than 10 year and more than 10-year experience and office workers were taken from population. Audiometric testing of both ear at frequencies 0.125, 0.25, 0.5, 1, 1.5, 2, 3, 4, 6, 8 and 10 KHz. Hearing loss is estimated from audiometric data by using 5 standard model equations AAO (1979), AAOO (1959), NIOSH (1972), NIOSH (1998), BSA (2004). The above equation determines average hearing loss for range of frequencies 0.5 KHz-4 KHZ for low and high frequencies 25db to 92 db. Kavanagh calculator is used to calculate excess risk. Hearing threshold level greater than 25db denoted as hearing handicap 85-90db hearing loss considered as functionally deaf. Normal working hours of drivers are 10-12 h/day seven day a week. Office worker work for 7hr per day, six day a week. Generally subjected to noise level $L_{A,eq(8h)}$ = 60-65 db. The samples were recorder as per height, weight and age. Audiometric test conducted at lower frequency 0.125 KHz and at higher frequency 8 and 10 KHz in addition to ISO-1999 (1950) and NIOSH (1998) to arise effect of year of noise exposure on hearing handicap of professional drivers. Audiometric test consists of air conduction, pure tone, hearing threshold measurement of left and right ear alternatively at different frequencies. Device used is a portable audiometer series-500 (Arphi-bombay) Data obtained is analyzed using one tailed –t test to find whether the mean value of three group differ significantly.

Mean hearing threshold levels were lowest for office workers and highest for professional drivers. Average hearing threshold level for driver having experience more than 10 years exceeded more than 25db for both ear for audiometric test frequencies 0.5, 1, 2 and 3KHz. Average threshold level for driver less than ten-year experience exceeded more than 25db for left year for audiometric test frequencies 0.5, 1, 2 and 3KHz. T tailed test indicate that there is a significant difference in auditory threshold levels of office workers and drivers Experience level less than 10 years of noise exposure at 1, 1.5, 3, 4 and 6 KHz for left ear. T tailed test indicate that there is a significant difference in auditory threshold levels of office workers and drivers having experience more than 10 years of noise exposure at 1, 4 KHz for right ear. T tailed test indicate that there is a significant difference in auditory threshold levels of office workers and drivers having

experience more than 10 years of noise exposure for most of tested audiometric frequencies including 4KHZ for both ear. Mean hearing threshold level at different audiometric frequencies for left ear was higher as compared to right ear for all three groups of selected subjects Mean hearing threshold levels for both ears of professional drivers having experience more than ten years are higher as compared to drivers having experience less than ten years. Average estimated excess risk of hearing impairment are 1.33%, 4.25% and 19.00% for office workers, drivers with less than 10 year of noise exposure and drivers with more than 10 year of noise exposure. The average estimated risk of hearing impairment with different models ranged 14.90-19.00% for different models.

Adarsh Kumar et al. [2] evaluate the noise transmitted by tractor and other machines to the driver in different operations; to compare the observed noise levels with international criteria for safe exposure for noise; to examine whether tractor driving farmers (TDFs) are at a greater risk of hearing impairment than non-tractor driving farmers (NTDFs). Noise measurements were performed on tractors and other machines to observe the magnitude of noise levels. The measurements were carried out on the farms and households of the farmers of both the groups. The measurements were taken on all the equipment owned by exposed and control group farmers and were done with handheld battery operated noise meter. The measured values were compared with international norms (OSHA and NIOSH) of noise level.
The measurement of sound levels on different tractor models indicated that the noise level exceeds 100-dB. Other commonly used equipment like electric pump sets, diesel pump sets, fodder cutter machines, flourmill and agricultural machines like thresher and sugar cane crusher also exceed 90 dB noise levels
Madbuli H. Noweir et al.[3] asses the noise exposure and hearing threshold level of aircraft worker at workshop of international airport in Saudi Arabia. Noise in Aircraft maintenance work is considered as too much high and most of the workers are subjected to noise level ≥ 85db. A sample of 200 maintenance workers was subjected to pure tone audiometry. Octave band 1, 2 and 4 kHz contribution is high in overall noise level that is revealed in frequency analysis of sound pressure level. Sound pressure level is measure B&K sound level meter type 2236.sound measurement is made by using B&K 1800 audiometer. The pure tone audiometric test was conducted for each ear at frequencies 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The 2 sample T-test is used as statistical tool to compare the hearing threshold level of non-exposed individuals and sample workers. Result indicate that the Leq,8h level is more than 85db as recommended by SASO. Also, data obtain from audiogram indicate that sample workers are having significant hearing impairment as compared to non-noise exposed individuals at all frequencies except 2kHz.

A.Pazzona *et al* [4]estimate risk of hearing impairment of worker engage in sheep husbandry. The amount of sound energy absorbed by the workers annually is found to be 89.8db of Leqover 2020hr/year. B&K-2218 precision integrated sound level meter is used for noise measurement. In milking worker exposed to an average of 86.5 dB Leq and peak value is 106dB. In ploughing it is 99.3 dB and in forage baling it is 98.1dB. ISO/DIS 1999 model is used to calculate mean exposure level

L_{eq} dB = 10 log(1/T) $\sum_{k=1}^{n} T_i * 10^{0.1Li}$

Where T is total time measured in hours,Ti is the times of different operation and Li is the sound energy measured in L_{eq}. Also, hearing threshold shift is determined by formula

H = A + N – (A * N/120)

Where A is age related threshold shift and N is the noise induced threshold shift

Hearing threshold shift is calculated at frequency range 1 kHz to 4kHz. Study reveals that workers are exposed to 89.9 dB for L_{eq} for 2020 h/yr which exceed 80 kHz L_{eq} for 2000 h/yr.

Mohamed A. Zytoon et al [5]estimate the noise exposure of small and medium scale fishing vessels worker by measurement and questionnaire approach.24 fishing vessels were selected for calculating sound pressure level and data regarding sound pressure level is collected all working or resting locations and during speeding and slow-down moods of the engine. The average existence times of the crew at such locations were collected using a questionnaire. Study reveal that average daily noise exposure levels ($L_{EP,d}$,8h) for engine mechanics in all vessel types (91.2-94.3dBA) and the tiller operators in gill/trammel and purse seining vessels (84.7-88.4dBA) exceeded the NIOSH recommended exposure limit of 85dBA. Noise assessment is done by using TBM strategy according to ISO 9612. Maximum duration of noise exposure is calculated by

T_{max}= 8 * 2 $^{(85\text{-}Leq)/3}$

$$L_{eq,T} = 10 \times \log \frac{1}{T} \sum_{i=1}^{k} \left(t_i \times 10^{\frac{L_i}{10}} \right)$$

Here T is the total time of exposure and L_i is the sound pressure level(dBA) for sub period t_i

Equation used for noise dose (%)

$$L_{EP,d} = L_{eq,T} + 10 \times \log\left(\frac{T}{8}\right)$$

$$\text{Noise dose} = 100 \times 10^{\left(\frac{L_{EP,d} - 85}{10}\right)} \%$$

Paulo Henrique Trombetta Zannin [6] estimates noise level in Brazilian urban bus. For study sample of 20 each for By-articulated, speedy and feeder busses were selected. Noise level measurement is performed according to ISO 1999 (Determination of occupational Noise exposure) and NHO-01 that Brazilian Standard for occupational health and measured noise exposure level $L_{eq,8h}$ were below 82 dB(A) thus quality of workplace is acceptable. If applying NR-17(standard for ergonomics) it indicates that buses are uncomfortable with $L_{ex,8h} \geq 65$ dB(A)

Ali Aybek et al (7) determine sound pressure level, a weighted sound pressure level, permissible exposure time for tractor without cabins, field installed cabins and original cabins. Bruel and Kjaer-2236 C noise meter is used for sound pressure measurement also sound pressure level is measured at one octave band center frequencies i.e. 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000 Hz. Study reveals that type of operation, type of cabins statistically significant for sound pressure level & equivalent sound pressure level.it is found that sound pressure level lies in the range of 65 dB-110 dB in agriculture work and lies below 90 dB for frequencies higher than 1000 Hz also it is found that sound pressure level decreases with increase of center frequency.

SarpKorkut Sumer et al (8) measure and compare the noise exposed on operators of the combines with and without a cab used for wheat harvesting. The sound pressure levels (dB) at one octave band center frequencies (31.5–8000 Hz) and the sound levels (dBA) at the ear level of the operators were measured. Study indicates that sound pressure levels were 75–102 dB and 46–89 dB at low (31.5–500 Hz) and high (500–8000 Hz) frequencies for all combines. Mounting cabs after manufacturing lower sound pressure level up to 6-17 dB at frequency 4000 Hz also in case of original cabs sound pressure level lower up to 9-28 dB in comparison of combines without caps.

RaunoPääkkönen (9) measured noise exposure of spectators at air shows. The measurement contains analysis of maximum sound pressure level, minute to minute total noise description and analysis of noise dose of spectators. MIP 7178P an integrated sound level meter and B&K 2225 and B&K 2209 precision sound level meters were employed for noise level measurement. MIP 6074a dosimeter is employed for noise dose measurement. Study indicate that maximum level near spectators ranged from 110-115 dB and noise dose of spectators lies in between 84-92dB.

Sayed Abas Ai Ali et al (10) investigates effects of noise on student's learning achievement. Subjective evaluation is also carried out by using questionnaire. Measurement of noise indicates that L_{Aeq}ranged between 61.3-73.2dB. Responses from respondent indicate that 57% respondent feel that noise obstructs their learning achievement. for restriction of noise experiment were carried out.

Mario Penzkofer et al (11) measured exposed sound pressure level and potential hearing threshold shift of amateur musician during rehearsals. Audiometric test was conducted to measure potential hearing threshold shifts. Measurement of noise indicates that non-professionally orchestra were subjected to sound pressure level of 117 dB(A) and resulted in sound pressure level 92 dB(A) for average duration of rehearsal of 2 hours.

P.A. Hellström (12) compared the high frequency hearing loss in 238 females and 230 male due to listening portable cassette players (PCP). Study concentrated on three groups of subjects.First group of subjectslisten to music from PCPs several times a week or daily. Second group consist of persons listening to music as often but via loud speaker. Third group consist non-listeners. Sound pressure level measurement and Pure tone audiometry test is conducted on each subject with acceptance level <dBHL on test frequencies 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz. The group of non-listenerscontain highest number of subject with high frequency hearing loss. The group which contain subjects who listen to music from PCPs several times have highest number of best hearing at high frequecie 3, 4 and 6 kHz

Folashade O. Omokhodion (13) measured the noise level and hearing levels of urban community. Noise level was measured by sound level meter CEL 269.Recorded noise level was 95-102dBA at saw mills, 87-101dBA at carpentry tools, 85-88dBA at printing presses, 88-105dBA at grain mills, 89-99dBA at music shop, 86-90dBA at major road side and 61-65dBA on side street. Also, measurement shows rage of noise level in high density area 55-59dBA and 39-41dBA in low density area. Audiometric test measurement reveals that 55% subjects had normal hearing, 33%mild hearing impairment and 17% subjects had moderate hearing impairment.

Antonio Sergio Melo Barbosa (14) asses the hearing status of workers related to coordination of vehicle traffic in Brazil. The result of audiometry was divided in to two categories one is normal and second one is noise induced hearing loss (NIHL). The study indicates that NIHL is higher among those

working in noisier areas compared to those working in lower noise level area.

Pavlina Gidikova et al (15) conducted pure tone audiometry screening and ear examination of workers which are occupationally exposed to intermittent noise level of 85dBA to 105dBA. Study indicate a hearing loss of up to 30 dB in 25 workers and the workers having a service length of over 10 years have sharp increase in frequency can be found. Worker whose having service length below 10 years have frequency 5.45% and 26.5% among those having service length over 10 years. Study indicates a correlation between years of exposure of excessive noise and frequency of hearing impairment.

R.L. Neitzelet al (16) assess potential noise exposure sources and evaluate noise induced hearing loss for firefighters in America and made a comparative study for 8hr and 24hr recommended noise level exposure limit of 85dBA and 80.3dBA. Study indicates that noise levels were found in rage of 82dBA to 109dBA which exceeded from recommended exposure limit.

RafetEmek Kurt et al (17) investigate the sources of noise and their potential impacts on workers of ship recycling yard.investigation was made on an operational ship recycling yard.BruelKjaer Hand Held Analyzer Type 2250 sound level meter was used for sound level measurement. Study indicates that noise exposure exceeded from limit value 87dBA and 140 dBA near torch cutter defined by the European Union's Physical Agents (Noise) Directive (EC 2003b).

R. Nilsson et al (18) evaluate the dose response relationship for effect of noise on hearing in shipbuilding industry. Microphone and tape recorder used for evaluating noise exposure and it is found that about 2500 impulses with peak level ranges from 110-135 dB occur daily. The measured equivalent level near field and reverberant field was 94dBA and 88dBA. Audiometry test indicate that 41.9% employees had normal hearing, 58.1% had some hearing impairment and 20.4% had severe noise induced hearing impairment. It concluded that shipyard noise is more harmful than continuous noise.

Frank A. Russo et al (19) evaluate the noise exposure and hearing loss in different groups of professional ballet orchestra. The groups which were subjected to highest level of exposure had highest pure tone threshold. Test frequencies above 2 kHz had greatest differences in threshold and at 4 kHz had average difference between groups was 15dB. Noise exposure level was below 85dBA (Hazard limit) in orchestra but longer orchestra playing time will be at greater occupational risk.

Michel Picard et al (20) studied noise induced hearing loss and work related accident risk. Study include 52982 male workers who were supposed to be exposed to a minimum noise level of 80dBA on daily basis the bilateral average hearing threshold of participant at frequencies 3, 4 and 6 kHz ranging from normal to hearing loss more than 50 dB due to occupational noise exposure. Study relates accident risk and hearing sensitivity of workers. Also 12.2% of total accidents considered in this study were attributable to a combination of noise exposure in the workplace (≥90dBA) and noise-induced hearing loss.

3 CONCLUSION

This study reviews the ongoing development in the field of ergonomic aspects of hearing impairment in human in different environment. Study reveal that interval of noise exposure, working condition, types of operation and age of individuals have significant effect on individual hearing ability. The study indicates that hearing conservation programs are required to protect individual's safety and health.

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