RESEARCH ARTICLE

Exposure to noise and its physiological effects on steel mill workers: A case study

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Abstract:

Noise is a well-known occupational hazard worldwide and hypertension a recognized risk factor for cardiovascular disease. This study investigated the immediate effects of noise exposure on blood pressure in an occupational setting. Systolic and diastolic blood pressure was measured before and after an 8-hour work period and continuous 8-hour personal noise exposure for 19 steel industry workers. Sixty-three percent of the workers were exposed to noise ranging between 75-85 dB(A) while 37% of the workers were exposed to noise above 85 db(A) which is above the Permissible Exposure Limit (PEL) as stated in the First Schedule of the Factories and Machinery (Noise Exposure) Regulations Act 1989. There was a significant difference in both systolic and diastolic blood pressure after an eight-hour work period ($p < 0.05$). We were able to demonstrate that noise exposure is independently associated to hypertension. These results are consistent with other studies to verify the occurrence of non-auditory effects in workers exposed to noise. Therefore, it is important that noise exposure limits are established aiming at preventing both hearing and non-hearing health effects.

Keywords: Blood pressure, Noise exposure

1. INTRODUCTION

Steel manufacturing is an industry where safe working procedures are really important as the workers in this industry are vulnerable towards occupational hazards due to exposure to noise and heat. There are approximately more than 2 million people directly employed by the steel industry worldwide, with a further 2 million contractors and additional 4 million people involved in supporting industries (Agarwal et al., 2016). Noise is one of the physical factors in industries, and, today, more attention is being paid to its harmful effects. Noise is considered a common occupational hazard in various workplaces such as the iron and steel industry, foundries, saw mills, textile mills, airports and aircraft maintenance shops, crushing mills and many other noise-producing activities (Lie, 2016). The main source of noise in a steel plant includes pneumatic tools & equipment for operations such as crushing, grinding, arcing and rolling, in addition to compressors, conveyors, blowers and induced draught fans. Noise levels during various operations in steel plants are high and generally fall within the range of 84 to 120 dBA (Parameswarappa & Narayana, 2015).

Noise induced hearing loss is the most commonly observed condition in workers of the iron and steel industry (Narlawar et al., 2006). In addition to causing damage to the hearing system, noise induced health effects on the human body also include interference in conversation, effects on balance system, effects on the organs of vision, psychological as well as nervous effects, physiological effects, social deterioration and mental effects (Nasiri et al., 2009; Rubio-Romero et al., 2018). Exposure to prolonged high level of noise have shown a significant role in arterial hypertension, blood pressure and cardiovascular diseases (Assunta et al., 2015; Rubio-Romero et al., 2018; Bolm-Audorff et al., 2020).

Noise exposure has been shown to have transient and sustained effects of increasing ambulatory systolic and diastolic blood pressure. Thus, repetition of such stimuli could be attributed to a persistent elevation of blood pressure. Hence, the aim of the study was to investigate the effect of noise exposure on blood pressure of steel industry workers.

2. MATERIALS AND METHODS

The sample size of the study was 19 participants selected through simple random sampling. The inclusion criteria of the study includes; being physically and psychologically healthy, not smoking, not using alcohol, not taking hypnotic drugs, and not working in shifts. The participants' demographic information was gathered through a questionnaire, and their systolic and diastolic blood pressure was measured using BP Digital monitor HEM-7113 (Omron) as per manufacturers' guidelines. Personal noise exposure was measured using a noise dosimeter EG5-D-AC3 (TSI

Quest) clipped onto the worker's collar near his ear for an 8-hour work day. The noise dose is calculated from the following equation:

$$\text{Dose \%} = 100 \times (C1/T1 + C2/T2 + C3/T3 + ... + Cn/Tn)$$

Where, Cn = time spent at each noise level and Tn = 8 / 2(L-90)/5 (L is the measured sound level).

Once the Dose is calculated, the Time Weighted Average of noise exposure is calculated using the following equation:

$$\text{TWA} = 16.61 \text{ Log10 } (D/100) + 90$$

Where, TWA is the 8-hour Time Weighted Average Sound Level; D is the Dose %; and Log10 is the Logarithm to base 10.

Data were entered into the SPSS statistical software, and paired t-test was used to compare the means of the variables before and after noise exposure. Written permission was obtained from the competent authority of the factory and the institutional Research Ethics Committee of University Teknologi MARA, Shah Alam Malaysia cleared the study protocol.

3. RESULTS AND DISCUSSION

The total number of workers at the study site was 50, however only data for 19 workers were collected after meeting the criteria and accounting for withdrawal. The demographic data of all participants is presented in Table 1. Majority of the participants were aged 25–29 years (57.9 %) followed by the age group 21-24 (31.6 %) and all were male. The average age and standard deviation of the workers was 26.53 ± 3.24 years. The participants were gathered from six different workstations in the company.

Table 1. Demographic data of workers

Variables	Frequency (Percentage)
Gender	
Male	19 (100)
Age	
21 - 24	6 (31.6)
25 - 29	11 (57.9)
30 <	2 (10.5)
Workstation	
Continuous pickling line	3 (16.0)
High cold reduction mill	3 (16.0)
Electrolytic cleaning line	5 (26.0)
Batch annealing furnace	4 (21.0)
Tension levelling line	2 (10.5)
Recoiling line	2 (10.5)

N=19

3.1. Personal noise exposure

Workers exposure to noise varied depending on the activities performed at each manufacturing line. Figure 1 shows the distribution of mean personal noise exposure (LAeq dB(A)) for six working sections in the steel mill. Workers at the Continuous Pickling Line section had the lowest mean noise exposure at 78.5 dB(A) whereas the highest mean was recorded for workers from the Batch Annealing Furnace at 89.4 dB(A). The peak noise exposure recorded was a minimum of 127.3 dB(C) and a maximum of 150.3 dB(C) with a mean value of 140.4 dB(C). This might also be due to the process of batch annealing which requires usage of heavy machinery with loud noises compared to the continuous pickling line section with lower noise exposure. Engineering controls had been implemented to reduce the noise exposure towards the workers but the noise coming from numerous machines and work process becomes the limiting factor to reduce noise exposure to a lower range. Noise from the equipment and machines that are being used in the steel factory such as furnace, boiler, and cooling tower system can produce noise levels ranging from 83 to 98 dB(A) (Golmohammadi et al., 2014).

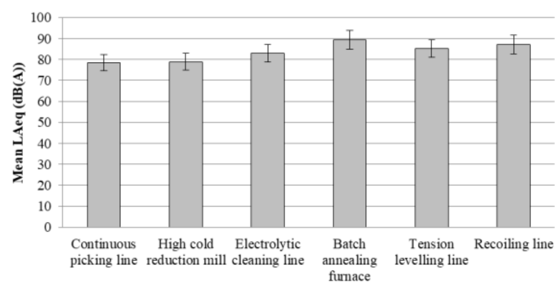

Figure 1. Mean personal noise exposure in different working sections

Based on Figure 2, 63 % of the workers were exposed to noise ranging between 75-85 dB(A) while 37% of the workers were exposed to noise above 85 db(A), which is above the Permissible Exposure Limit (PEL) as stated in the First Schedule of the Factories and Machinery (Noise Exposure) Regulations Act 1989. Approximately, 63 % of production and manufacturing workers are exposed to moderate noise levels within the range of LAeq.d between 80 and 85 dB(A) with peak noise levels of between 135 - 137 dB(A) (Barrero et al., 2018). The findings in this study show a similar pattern. In a separate study, it was concluded that over the last ten years, mean values of noise exposure to workers had been increasing to 94.2 dB(A) with a mean peak of 114.7 dB(C) (Rubio-Romero et al., 2018). The usage of personal protective equipment or hearing protective devices can reduce noise exposure to the workers working in noisy work stations. The use of the personal hearing protectors was not examined as all of the workers were obliged to use hearing protectors in their daily work period, and it is believed the noise exposure of workers was probably lower than indicated by the measured noise levels.

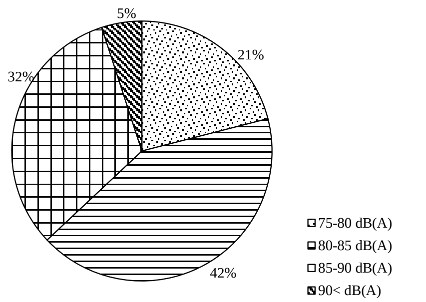

Figure 2. Percentage of worker's exposure to different noise range

3.2. Blood pressure

Participants' blood pressure was taken twice before they commenced work and after 8 hours of working (Figure 3). The mean systolic and diastolic blood pressure at baseline prior to the start of the work day was 114.21 mmHg and 77.84 mmHg respectively. After an eight hour normal work period, mean systolic and diastolic blood pressure was measured at 120.52 and 79.60 mmHg, respectively. The results indicate that significant rises in average systolic and diastolic blood pressure were found in the workers after exposure to noise ($p < 0.05$). Thus, these findings support the theory that exposure to high level of noise may influence the level of blood pressure of exposed workers. A high decibel noise can trigger the stimulation of sympathetic nerves causing the adrenaline secretion to be elevated which consequently cause the blood pressure to rise (Lai & Huang, 2019).

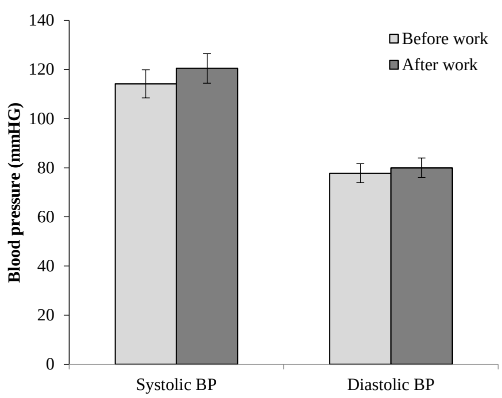

Figure 3. Mean systolic and diastolic blood pressure (mmHg)

These results are consistent with those of other studies and suggest that occupational exposure to noise may lead to increases in blood pressure and heart rate of workers (Li et al., 2019). Studies have also shown that occupational exposure to noise may increase the risk of hypertension in exposed groups (Neghab et al., 2009). Although, the results of this study showed a significant effect of exposure to high levels of noise on increases in blood pressure of workers, in all studied workers systolic and diastolic blood pressure were within the normal range of blood pressure criteria. The absence of adequate limits for non-hearing effects of noise exposure may result in the occurrence of health effects possibly associated to harmful exposures, but not identified.

4. CONCLUSION

Occupational noise exposure had transient effects on workers' blood pressure. The results showed a statistically significant increase of systolic and diastolic blood pressure in workers after exposure to industrial noise. Worksite health programs including monitoring hypertension and other cardiovascular diseases should also focus on noise-exposed workers. Further experimental investigations are needed to determine the relationships between these variables.

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