Original Article

Noise-induced Hearing Loss: Continuous versus Impact/impulse Noise

Abstract

Background: Impact/impulse and continuous noise are two main causes of noise-induced hearing loss (NIHL) in workplaces. The aim of this study was to compare the effects of impulse/impact noise and continuous noise on hearing status. **Methods:** In this study, 259 workers referred to the occupational medicine clinic of Shahid Rahnemoun hospital, Yazd, Iran, entered the study and were divided into two groups: with exposure to impact/impulse noise and with exposure to continuous noise. Hearing thresholds were measured and compared between the two groups by pure-tone audiometry (PTA). The frequency of hearing loss and audiometric notch according to the results of PTA was compared between the two groups. Data were analyzed by SPSS (ver. 16) using Student's *t*-test, Chi-square test, and Mann–Whitney U test. **Results:** Hearing thresholds were significantly higher at all frequencies in the impact noise group. The hearing threshold at 6000 Hz was higher than other frequencies in both groups. The frequency of hearing loss at high frequencies was higher in the impact group. The frequency of audiometric notch was not significantly different between the two groups. **Conclusions:** The results of this study showed that hearing loss after exposure to impact/impulse noise is probably more frequent and more severe than exposure to continuous noise, but the pattern of hearing loss is similar in both types of noise exposure.

Keywords: *Audiometry, noise-induced hearing loss, occupational noise*

Mohammad Hossein Davari[1], Mohammad Taghi Jalalian[1], Seyyed Jalil Mirmohammadi[1], Ahmad Shojaoddiny-Ardekani[1], Mojgan Piri Ardakani[2], Amir Houshang Mehrparvar[1]

[1]Industrial Diseases Research Center, ShahidSadoughi University of Medical Sciences, Yazd Province, Iran, [2]Department of Occupational Medicine, ShahidSadoughi University of Medical Sciences, Yazd Province, Iran

Introduction

One of the most frequent occupational exposures in different industrial settings is noise.[1,2] Many employees are exposed to occupational noise all over the world.[2] About 28% of the workers in different jobs in the European Union[3] and about 5.7 million workers in manufacturing industries in USA are exposed to hazardous noise.[4] It is estimated that 16% of the disabling hearing losses in adults (over 4 million DALYs) is attributed to occupational noise, ranging from 7% to 21% in the various sub-regions.[5]

Noise-producing equipment or devices may produce two kinds of noise: continuous or impact/impulse, which are different regarding physical characteristics. Most workers are exposed to continuous noise or a combination of continuous and impact/impulse noise, and less workers are exposed only to impact/impulse noise. So, most studies on the effect of noise on health have been performed on continuous noise.[2]

Noise causes a sensori-neural hearing loss (SNHL), that is, noise-induced hearing loss (NIHL), by affecting hair cells in the cochlea.[6] NIHL is the second most common SNHL after presbycusis.[4] Hair cells of the cochlea are the main target of injury due to continuous or impact noise.[7-9] The placement of the hair cells in the organ of Corti follows a frequency-sensitive manner, hence making some parts more sensitive than others to the effects of noise.[10,11]

Impact/impulse noise is a fast increase and decrease in sound pressure lasting no more than 500 ms, and its severity is at least 15 dBA more than background noise.[4] There are various sources of impact/impulse noise in the occupational settings, such as hammering, smithery, automobile body work, military work, and so on. There are considerable amounts of studies on health effects of continuous noise, but we could find only a few studies on health effects of impact/impulse noise. Studies showed that NIHL due to continuous noise has a typical pattern: a symmetric sensori-neural hearing loss mostly affecting 3000 Hz to 6000 Hz frequencies with a better hearing level at 2000 Hz and 8000 Hz frequencies,[12-15] and it may be accompanied by a notch at 3000, 4000, or 6000 Hz,[12-14,16] which is

Address for correspondence:
Prof. Amir Houshang Mehrparvar, Occupational Medicine Clinic, ShahidRahnemoun Hospital, Farrokhiave, Yazd, Iran. E-mail: ah.mehrparvar@gmail.com

Access this article online

Website: www.ijpvmjournal.net/www.ijpm.ir

DOI: 10.4103/ijpvm.ijpvm_368_21

Quick Response Code:

How to cite this article: Davari MH, Jalalian MT, Mirmohammadi SJ, Shojaoddiny-Ardekani A, Ardakani MP, Mehrparvar AH. Noise-induced hearing loss: Continuous versus impact/impulse noise. Int J Prev Med 2024;15:2.

a characteristic pattern in NIHL. This pattern is affected by the frequency spectrum of noise, shape of the ear canal, and probably the type of noise, that is, impact versus continuous. The frequency of hearing loss and its characteristic pattern due to impact/impulse noise can be different from continuous noise, and there are a few studies on this type of noise exposure. So, this study was conducted to assess and compare the frequency and pattern of hearing loss in two groups of workers exposed to impact/impulse and continuous noise.

Methods

This was a cross-sectional study on two groups of workers referred to the occupational medicine clinic of Shahid Rahnemoun hospital, Yazd, Iran, to perform periodic occupational health evaluations. The first group (impact) included workers exposed to impact/impulse noise from different industries who were selected by consecutive sampling. The second group included workers from a tile industry exposed to continuous noise who were selected by random sampling from different parts of the factory.

Inclusion criteria were the following: working at least 1 year in an industry with impact/impulse noise as their main noise exposure (for impact noise group) and working at least 1 year in a tile industry (for continuous noise group). Individuals older than 50 years and those with a history of acoustic trauma, conductive or mixed hearing loss in audiometry, and ototoxic substance exposure were excluded from the study. In each group, exposure to recreational or non-occupational noise (such as gun shooting, using musical instruments, using portable music devices, etc.) was considered as the exclusion criterion.

In total, 72 individuals were selected in the impact noise group. Their jobs included blacksmithery (n = 31), metal cabinet manufacturing (n = 24), and automobile body working (n = 17). We did not have access to noise measurements in this group. They were exposed to noise for about 8 hours in a day according to their self-report. In the continuous noise group, 187 workers were selected from different parts of the tile industry, including mixing and grinding, ball mill, spray drying, forming, and glazing. All participants were exposed to a noise level higher than 85 dBA (range: 85.2–89.7 dBA, time-weighted average for an 8-hour work shift). Data about noise exposure were extracted from the information which was present in the factory.

An audiometric test (PTA) was performed for the individuals in both groups. All individuals were asked not to get exposed to high levels of noise (occupational or non-occupational) for at least 16 hours before the test, and the test was done after this period of abstinence from noise by an expert audiologist blinded to the study. The test device was a diagnostic audiometer (AC40, Interacoustic, Denmark, head-phone: TDH 39) in an acoustic chamber meeting ANSI 2010 criteria.[17] Hearing thresholds were recorded at 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz for left and right ears for air and bone conduction using a standard method. The hearing threshold at each frequency was recorded and compared between two groups.

Hearing loss at each frequency was defined as a hearing threshold higher than15 dB-HL. Total hearing loss was considered as average hearing thresholds at 3000, 4000, and 6000 Hz higher than 15 dB-HL. Audiometric notch was defined as at least 10 dB difference between the hearing threshold in the observed frequency (3000, 4000, or 6000 Hz) and the hearing threshold at its previous and next frequencies.[18]

Statistical analysis

Data were analyzed by SPSS (ver. 16) using Student’s *t*-test, Chi-square test, and Mann–Whitney U test. The level of significance was set at $P < 0.05$. Odds ratios were calculated for comparison of the frequency of audiometric notch.

An informed consent was obtained from each participant. The protocol of the study was approved by the ethics committee of the university (ethic code: IR.SSU.SPH.REC.1398.125).

Results

After considering the inclusion and exclusion criteria, 259 individuals entered the study. The mean age of the participants was 32.46 ± 9.65 years and 31.73 ± 8.23 years in impact and continuous groups, respectively. There was no statistically significant difference between groups regarding age and work history ($P = 0.21$ and $P = 0.09$ for age and work history, respectively). All individuals were males.

The hearing threshold at all frequencies was significantly higher in the impact group compared to the continuous group. Table 1 compares the mean hearing thresholds at each frequency between the two groups, which shows a significantly higher hearing threshold in the workers exposed to impact noise.

Table 2 compares the frequency of audiometric notch at 3000, 4000, and 6000 Hz in each ear between the two groups.

The frequency of unilateral and bilateral hearing loss (averaged at 3000, 4000, and 6000 Hz) was significantly higher in the impact noise group. Figure 1 shows the frequency of hearing loss in each group.

Discussion

Noise, a physical agent, is frequently observed as an important occupational exposure in different workplaces. It may cause some health problems, among which NIHL is the most frequent one. The type of noise (i.e., continuous

Table 1: Comparison of mean hearing threshold between two groups

Ear	Audiometric frequency (Hz)	Continuous				Impact				*P*
		Mean	SD	Min	Max	Mean	SD	Min	Max	
Right	250	9.43	2.60	5	20	10.41	1.81	10	20	0.004
	500	9.73	3.05	0	25	10.41	1.81	10	20	0.022
	1000	9.97	4.84	5	50	11.36	2.53	10	20	0.001
	2000	11.09	7.89	5	60	11.98	4.06	10	30	<0.001
	3000	13.50	10.44	5	60	17.13	12.56	10	65	0.002
	4000	15.61	11.99	5	75	23.15	17.52	5	85	<0.001
	6000	18.76	13.87	5	95	27.53	17.40	10	85	<0.001
	8000	15.82	13.17	0	80	21.43	15.71	10	80	<0.001
Left	250	9.73	3.31	5	35	10.20	0.99	10	15	0.037
	500	9.97	4.51	5	35	10.34	1.52	10	20	0.050
	1000	9.97	4.51	5	35	11.57	4.47	10	40	<0.001
	2000	10.64	7.02	5	50	13.57	9.08	10	60	<0.001
	3000	14.62	10.62	5	65	20.34	15.48	5	70	0.002
	4000	17.82	13.26	5	85	26.23	18	5	80	<0.001
	6000	17.43	12.71	5	85	27.26	16.99	10	75	<0.001
	8000	16.1	13.51	5	85	24.38	16.43	10	75	<0.001

Table 2: Frequency of audiometric notch in two groups

Ear	Frequency (Hz)	Number (%)		OR	95% CI
		Continuous (*n*=187)	Impact (*n*=72)		
Right	3000	3 (1.60)	1 (1.38)	1.17	0.12-11.47
	4000	6 (3.21)	9 (12.50)	0.23	0.08-0.69
	6000	23 (13.37)	18 (25.00)	0.43	0.21-0.85
Left	3000	3 (1.60)	4 (5.55)	0.28	0.06-1.29
	4000	21 (12.20)	2 (2.77)	4.51	1.03-19.78
	6000	12 (6.97)	9 (12.50)	0.49	0.19-1.21
Bilateral	3000	0 (0)	0 (0)	-	-
	4000	1 (0.06)	0 (0)	-	-
	6000	4 (2.32)	4 (5.55)	0.37	0.09-1.55

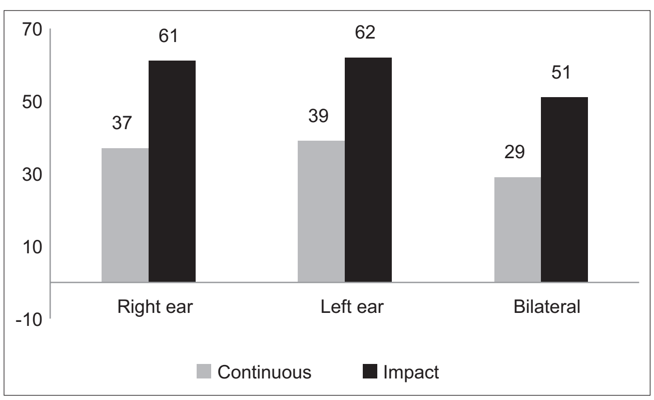

Figure 1: Comparison of the frequency of hearing loss in continuous and impact noise groups

vs. impact/impulse) may differently affect hearing of the exposed individuals. In this study, the effect of continuous and impact/impulse noise on hearing was compared.

This study showed that both the frequency and severity of hearing loss (especially at 3000, 4000, and 6000 Hz) due to impact/impulse noise were significantly higher than those due to continuous noise. This difference was seen in a Russian study in which impulse noise created a more severe hearing loss than was expected from the estimated A-weighted noise dose.[19] Some other studies have found as well a significant hearing loss after exposure to impulse noise.[20,21] Clifford and Rogers in a review article found that hearing damage due to impulse noise is higher than the calculated level of energy would indicate, compared to continuous noise.[22] This result was in agreement with the results of the current study.

The most frequent pattern of NIHL is a sensorineural hearing loss mostly observed at high frequencies, that is, 3000–8000 Hz in both types of noise,[16,23,24] and audiometric notch is a characteristic feature in NIHL,[13] although NIHL may occur without an audiometric notch.[15] These findings have been derived mostly from the studies on the effect of continuous noise on hearing.

The pattern of hearing loss and the frequencies affected by each type of noise was similar in this study. The hearing frequency with the most severe loss in both continuous and impact/impulse noise-exposed groups was 6000 Hz, which was consistent with some other previous studies,[16,25,26] although many studies have found 4000 Hz as the frequency most frequently affected by noise; hence, the noise was continuous in most studies.[27,28] Audiometric notch was not so common in both groups, and the difference was significant only at 4000 Hz in the right ear. So, the findings of this study did not show a different frequency of notch between the two groups exposed to impact/impulse and continuous noise.

This study showed that hearing loss due to both impact/impulse and continuous noise was more frequent in the left ear than the right ear, which was consistent with most of the previous studies.[11,29]

Most guidelines of hearing preservation programs are focused on the exposure to continuous noise. Some studies have proposed to calculate the A-weighted noise level for impact/impulse noise as an equivalent-continuous noise level.[30] But, due to the more damaging effect of impact/impulse noise on hearing, some studies proposed to add a safety margin to the calculated noise from impact/impulse noise.[31]

The mechanism and severity of the damage in the internal ear due to impact/impulse noise may be different in some aspects from continuous noise. Hamernik *et al*.[32] showed that spectrum ciliary changes in inner and outer hair cells after acoustic trauma are different from changes after exposure to continuous noise. The internal ear is somehow preserved from the effects of continuous noise by acoustic reflex, but due to the time delay of this reflex, it is not probably activated when an individual is exposed to impact/impulse noise.[33] Besides, proper and timely use of hearing protection devices when the individual is exposed to impact/impulse noise is more problematic than exposure to continuous noise, although the results should be interpreted cautiously due to some confounders which could not be controlled.

According to our findings, the hearing protection program (HPP) is more important in impact/impulse noise-exposed workers. Future longitudinal studies are recommended to demonstrate the trend of hearing loss in this type of noise exposure.

This study had some limitations: we did not have the noise measurements of different workplaces in the impact/impulse group, so we cannot conclude with certainty that the difference between the two groups is only due to the type of noise; there was no information about the use of hearing protection devices and some other confounding factors in both groups, which is probably a confounding factor. This study was cross-sectional with its intrinsic limitations; so, the findings of this study should be proved in future studies with more detailed information about the exposure to noise.

Conclusions

The results of this study showed that hearing loss after exposure to impact/impulse noise is probably more frequent and more severe than exposure to continuous noise, but the pattern of hearing loss is similar in both types of noise exposure.

Acknowledgments

The authors are grateful to SommayeShirmohammadi for herkind collaboration in this project

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Received: 16 Aug 21 **Accepted:** 30 Aug 23
Published: 31 Jan 24

References

1. LaDou J, Harrison R. Current Occupational and Environmental Medicine. New York: McGraw-Hill; 2007.
2. McBride DI, Williams S. Audiometric notch as a sign of noise induced hearing loss. Occup Enviro Med 2001;58:46-51.
3. European Agency for Safety and Health sat Work (EASHW). Monitoring the state of occupational safety and health in the European Union pilot study, 2000.
4. Tak S, Davis RR, Calvert GM. Exposure to hazardous workplace noise and use of hearing protection devices among US workers: NHANES, 1999–2004. Am J Ind Med 2009;52:358–71.
5. Nelson DI, Nelson RY, Concha-Barrientos M, Fingerhut M. The global burden of occupational noise-induced hearing loss. Am J Ind Med 2005;48:446–58.
6. Dunn DE, Rabinowitz PM. Noise. Textbook of Clinical Occupational and Environmental Medicine. Elsevier Inc.; 2005.
7. Samant Y, Parker D, Wergeland E, Wannag A. The Norwegian labour inspectorate's registry for work-related diseases: Data from 2006. Int J Occup Environ Health 2008;14:272–9.
8. Kirchner DB, Evenson E, Dobie RA, Rabinowitz P, Crawford J, Kopke R, *et al*. Occupational noise-induced hearing loss: ACOEM Task Force on Occupational Hearing Loss. J Occup Environ Med 2011;54:106–8.
9. Henderson D, Bielefeld EC, Harris KC, Hu BH. The role of oxidative stress in noise-induced hearing loss. Ear Hear 2006;7:1-19.
10. World Health Organization (WHO). Prevention of noise induced hearing loss, Report of a WHOPDH informal consultation, No 3 in the series, Strategies for prevention of deafness and hearing impairment, WHO—PDH—98.5, 1997.
11. Hong O, Kerr MJ, Poling GL, Dhar S. Understanding and preventing noise-induced hearing loss. Dis Mon 2013;59:110-8.
12. R¨osler G. Progression of hearing loss caused by occupational noise. Scand Audiol 1994;23:13–37.
13. Leensen MCJ, Van Duivenbooden JC, Dreschler WA. A retrospective analysis of noise-induced hearing loss in the Dutch construction industry. Int Arch Occup Environ Health 2011;84:577–90.
14. Hétu R, Getty L, Quoc HT. Impact of occupational hearing loss on the lives of workers. Occup Med 1995;10:495-512.
15. American College of Occupational and Environmental Medicine (ACOEM). Occupational noise-induced hearing loss: ACOEM task force on occupational hearing loss. J Occup Environ Med 2012;54:106–8.
16. Mehrparvar AH, Heidari F, Mostaghaci M, SoltaniSharifabadi M, ZareSakhvidi MJ. Prevalence and pattern of noise-induced hearing loss in tile and ceramic industry. International journal of occupational hygiene 2017;2:67-72.
17. ANSI/ASA S3. 6, 2010. Specification for audiometers. American National Standards Institute.
18. Rabinowitz PM, Galusha D, Slade MD, DixonErnst C, Sircar KD, Dobie RA. Audiogram notches in noise-exposed workers. Ear Hear 2006;27:742–50.
19. Suvorov G, Denisov E, Antipin V, Kharitonov V, Starck J, Pyykko I, *et al*. Effects of peak levels and number of impulses to hearing among forge hammering workers. Appl Occup Environ Hyg 2001;16:816–22.
20. Christiansson BAC, Wintzell KA. An audiological survey of officers at an infantry regiment. Scand Audiol 1993;22:147–52.

21. McBride DI, Williams S. Air blast circuit breaker noise and hearing loss: A multifactorial model for risk assessment Occup Med 2000;50:173–81.
22. Clifford RE, Rogers RA. Impulse noise: Theoretical solutions to the quandary of cochlear protection. Ann Otol Rhinol Laryngol 2009;118:417–27.
23. Mostaghaci M, Mirmohammadi SJ, Mehrparvar AH, Bahaloo M, Mollasadeghi A, Davari MH. Effect of workplace noise on hearing ability in tile and ceramic industry workers in Iran: A 2-year follow-up study. ScientificWorldJournal 2013;2013:923731.
24. Tambs K, Hoffman HJ, Borchgrevink HM, Holmen J, Engdahl B. Hearing loss induced by occupational and impulse noise: Results on threshold shifts by frequencies, age and gender from the Nord-Trondelag hearing loss study. Int J Audiol 2006;45:309–17.
25. Mehrparvar AH, Mirmohammadi SJ, Ghoreyshi A, Mollasadeghi A, Loukzadeh Z. High-frequency audiometry: A means for early diagnosis of noise-induced hearing loss. Noise Health 2011;13:55:402-6.
26. Philips SL, Henrich VC, Macs ST. Prevalence of noise-induced hearing loss in student musicians, Int J Audiol 2010;49:309-16.
27. Rachiotis G, Alexopoulos C, Drivas S. Occupational exposure to noise, and hearing function among electro production workers. AurisNasusLarynx 2006;33:381-5.
28. Mirzakhani A, Monazzam MR, Monazzam M. Noise exposure and hearing status among the registered locksmiths in Tehran, Iran. Int J Occup Med Environ Health 2014;6:56-60.
29. Berg RL, Pickett W, Linneman JG, Wood DJ, Marlenga B. Asymmetry in noise-induced hearing loss: Evaluation of two competing theories. Noise Health 2014;16:102-7.
30. Atherley GRC, Martin AM. Equivalent-continuous noise level as a measure of injury from impact and impulse noise. Ann Occup Hyg 1972;14:11-23.
31. Thorne P. Noise induced hearing loss. Final report. Auckland UNI Services Ltd. 2006.
32. Hamernik RP, Turrentine G, Roberto M, Salvi R, Henderson D. Anatomical correlates of impulse noise-induced mechanical damage in the cochlea. Hear Res 1984;13:229-47.
33. Zera J. Impulse noise in industrial plants: Statistical distribution of levels. Int J Occup Med Environ Health 2001;14:127-33.