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Noise-Induced hearing loss among professional musicians

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Abstract: Objectives: After presbycusis, noise exposure is considered the second cause of sensorineural hearing loss. Due to exposure to high-intensity sounds, musicians may be at risk of noise-induced hearing loss (NIHL). Given the importance of good hearing in music career, this study aimed to investigate the frequency of hearing loss and use of protective measures among Iranian musicians. **Methods:** In this cross-sectional study, 125 musicians, including 21 women (16.8%) and 104 men (83.2%), with at least five years of work experience were recruited. All participants underwent clinical and audiometric examinations. Demographic data, complaints about hearing loss, and information about the use of protective devices were collected through interviews. **Results:** Audiometric notch in either one or both ears and bilateral hearing loss were present in respectively 42.4% and 19.2% of the participants. The history of tinnitus after performance and ear pain during performance was reported by 64 (51%) and 35 (28%) individuals, respectively. Less than 2% of the participants used hearing protection devices. **Conclusions:** Long-term exposure to loud sounds puts musicians at risk of hearing loss. However, due to their inadequate knowledge, most musicians never use protective devices to prevent damage to their auditory system.
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Introduction

Noise-induced hearing loss (NIHL) is the second cause of hearing loss after presbycusis[1]. NIHL is a sensorineural hearing impairment generally manifesting as a bilateral, symmetrical, and irreversible disorder. People with hearing loss often have a prolonged exposure (5-20 years) to loud sounds (over 85 dBA) for several hours a day. Various levels of hearing loss can be measured through audiometric tests[2,3]. Exposure to noise is responsible for most cases of disability due to hearing loss[4]. Music, even when used as an entertainment, can cause hearing damage[5,6]. Professional musicians whose job exposes them to excessively loud sounds may also develop noise-induced complications[7]. Fortunately, protective measures can prevent NIHL in many jobs[8]. As with other occupations, while hearing loss is a disability among all people, the dependence of musicians' success on their full hearing ability multiplies the significance of such disorders. Therefore, it is critical to determine the prevalence and levels of hearing loss in this group of professionals.

Despite the growing number of live concerts and the professional and unprofessional use of musical instruments in recent years, no previous studies have evaluated NIHL among Iranian musicians. Considering the necessity of research in this field, the present study sought to examine hearing status, noise exposure levels, awareness about acoustic trauma and hearing protection devices, and frequency of using such devices among Iranian musicians.

Materials and Methods

This cross-sectional study was conducted on traditional and/or pop musicians with at least five years of professional work experience in Tehran, Iran. In order to select the participants, the researchers visited music academies in Tehran and invited qualified teachers to participate in the study. The only inclusion criterion was having at least five years of experience as a professional musician. Individuals diagnosed with a ruptured eardrum (in one or both ears) or any hearing impairment (hereditary, acquired, or disease-related) confirmed through history taking or clinical examination were excluded. Musicians with a history

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Table 1. The frequency of complaints about possible complications of noise exposure

Complaints	Frequency
I feel I cannot hear well.	9 (7.2%)
Recently, I cannot hear some words well.	5 (4%)
Recently, I cannot hear some music notes well.	2 (1.6%)
Recently, hearing loss prevents me from tuning a musical instrument.	9 (7.2%)
I feel that my hearing loss has negatively affected the quality of my performance.	4 (3.2%)
I have experienced tinnitus after music performance.	64 (51.2%)
I have experienced ear pain due to the high volume of music during the performance.	35 (28%)

of skull base fractures, exposure to loud sounds other than music, long-term use of ototoxic medications were also excluded. Finally, 125 musicians were recruited and asked to provide informed consent.

Data were collected using a 28-item questionnaire containing general information (e.g., age, gender, auditory complaints, thinking about using personal protective devices, and frequency of using personal protective devices) as well as occupational exposures and experiences (e.g., the duration of playing musical instruments, the number of hours of playing music per week, history of exposure to other risk factors for hearing loss, such as taking ototoxic medications, exposure to loud and sudden sounds including explosions, and history of severe head trauma). After completing the questionnaire and clinical examination, the hearing threshold level of the participants was determined in both ears at frequencies of 250, 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz in the audiometry clinic of a teaching hospital. Each individual's cumulative occupational noise exposure was calculated by multiplying the number of their years of exposure by the number of hours of exposure per week. The definition presented by Coles, which has been used in most similar studies[9,10], was adopted to determine the presence or absence of NIHL based on subjects' audiograms. Coles defined a notch if the hearing threshold at 3,000 and/or 4,000 and/or 6,000 Hz was at least 10 dB greater than the threshold(s) at 1,000 or 2,000 Hz, and at 6,000 and/or 8,000 Hz, respectively[11].

All statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA). Frequency and ratio values were used to analyze qualitative variables. Mean and standard deviation values were also used for the analysis of quantitative variables. Chi-square and t-tests were applied to compare ratios and means, respectively. P values less than 0.05 were considered significant.

Results

A total of 125 musicians, including 21 women (16.8%) and 104 men (83.2%), were studied. The mean age and work experience of the participants were 35.9 ± 9.1 and 12.4 ± 6.9 years, respectively. The subjects were exposed to noise for a mean duration of 15.8 ± 4.4 hours a week (range: 7-30 hours). Electronic, percussion, stringed, and wind instruments were the main instruments played by 21 (16.8%), 12 (9.6%), 87 (69.6%), and 5 (4%) participants, respectively.

Only four subjects (3.2%) had positive response to the question "Have you ever thought about using hearing personal protector?," and one of them never used it. Other three subjects (2.4%) used personal protective devices to prevent NIHL. The devices were occasionally used by one of these three individuals and rarely used by the other two. The participants were asked about their probable acute and chronic complaints about noise exposure and their responses are summarized in Table 1.

Overall, 14 participants (11.2%) complained of at least one chronic complication of exposure to loud noise. Moreover, 70 participants (56%) complained of at least one acute complication of noise exposure, e.g., ear pain and tinnitus, during or after the performance.

According to audiometry results and Coles' definition, the presence of a notch was used as an indicator of NIHL in either ear. Based on the obtained audiograms, 42.4% of the subjects had notches in either one or both ears. Notches were more frequent in musicians with more work experience than in those with less experience. Chi-square tests were used to compare the frequency of notches in the right and left ears of musicians with work experience ≥10 years and <10 years (Table 2).

The frequency of notch in either one or both ears was 50% in participants with at least one acute complication of noise exposure and 32.7% in those without such complications ($P = 0.05$). The frequency of bilateral notch was higher in musicians with acute complications of exposure than in those without such complications (21.4% vs. 16.4%; $P > 0.05$).

The frequency of notch in either one or both ears was 46.25% in men and 23.8% in women. According to chi-square test results, the frequency of notches in either one or both ears in the two genders was not significantly different ($P = 0.089$). Table 3 shows the frequency of audiometric notches in players of different types of musical instruments. As seen, no significant difference in the frequency of hearing loss was detected between these

Table 2. The frequency of audiometric notch in the right and left ears of the studied musicians

Presence of notch	All subjects (n=125)	Work experience		P value
		≥10 years (n=65)	<10 years (n=60)	
Right ear	43 (34.4%)	28 (43.1%)	15 (25%)	0.034
Left ear	34 (27.2%)	20 (30.7%)	14 (23.3%)	0.35
Bilateral	24 (19.2%)	17 (26.2%)	7 (11.7%)	0.040
Either one or both ears	53 (42.4%)	31 (47.7%)	22 (36.7%)	0.21

Table 3. The frequency of hearing loss among musicians playing different instruments

Hearing loss	Electronic instruments	Percussion instruments	Stringed instruments	Wind instruments	P value
Notch in the right ear	6 (28.6%)	3 (25%)	32 (36.8%)	2 (40%)	0.78
Notch in the left ear	8 (38.1%)	2 (16.7%)	23 (26.4%)	1 (20%)	0.55
Notch in either one or both ears	9 (42.9%)	3 (25%)	39 (44.8%)	2 (40%)	0.63
Bilateral notch	5 (23.8%)	2 (16.7%)	16 (18.4%)	1 (20%)	0.95

Table 4. Comparison of the mean cumulative exposure in groups with different levels of hearing loss

Hearing loss	Cumulative exposure		P value
	Musicians with notch (SD)	Musicians without notch (SD)	
Notch in the right ear	244.4 (189.1)	183.7 (127.8)	0.035
Notch in the left ear	252.5 (221.1)	186.6 (115.8)	0.032
Bilateral notch	263.8 (218.5)	190.5 (131.3)	0.035
Notch in either one or both ears	240.8 (196.5)	177.9 (106)	0.023

groups. The frequency of hearing loss in the left ear of violin players (41.7%) was higher than expected (27.5%) but no significant difference was detected between violin and other instruments.

The mean age of participants with notch in either one or both ears and without notch was 37.2 ± 9.7 and 34.9 ± 8.5 years, respectively (P = 0.17 according to t-test results). In order to estimate the amount of exposure to loud noise, the participants were asked about their work experience (in years) and the number of normal working hours per week. These two values were multiplied and used as an indicator of cumulative exposure. T-tests were then applied to compare the mean cumulative exposure between subjects with and without hearing loss (Table 4). As seen, in all classifications of audiogram results, the mean cumulative exposure was significantly higher in people with notches than in those without notches. To evaluate the absolute effect of age on hearing loss independent of exposure duration, we used logistic regression analysis. We did not find any relation between age of subjects and notch in audiogram after adjustment for exposure duration.

Discussion

This study was conducted on 125 professional musicians with at least five years of work experience. The mean professional work experience of the participants was over 12 years. Unfortunately, only three participants used protective devices to prevent NIHL. This finding suggested musicians' lack of awareness about the adverse effects of exposure to loud noise on their hearing. O'Brien et al. (2014) evaluated 367 orchestra musicians and found that only 64% of the participants occasionally (not regularly) used protective devices during their performance[12]. Pawlaczyk-Luszczynska et al. (2010) reported that 14% of the 65 studied musicians had experienced using personal protective devices when exposed to loud noise. Moreover, about 30% were aware of the potential risks and intended to use personal protective devices in the future[13].

About half of our participants had experienced tinnitus after a performance and 28% had ear pain during the performance. In total, 56% of the subjects had experienced one of these symptoms during or after the performance.

However, despite these experiences, they were still unaware of the risk of hearing loss and had not taken control measures. A comparison with the findings of Pawlaczyk-Luszczynska et al. and O'Brien et al. indicates that the musicians in our study had poor knowledge of the risks associated with exposure to loud music.

An important finding of the present study was the difference between the frequency of subjective complaints and objective symptoms (audiometry results). In fact, although the obtained audiograms showed notch in either one or both ears and bilateral notches in respectively 42% and about 20% of our participants, only about 7% of the subjects complained of their hearing impairment. It can thus be concluded that musicians' lack of attention to preventive measures and screening programs, along with their mere attention to subjective symptoms and complaints, contributed to not only the development, but also the delayed diagnosis of many cases of hearing loss among this group of professionals.

In the present study, a higher risk of NIHL was observed in musicians who had experienced acute symptoms of exposure to loud noise (tinnitus or ear pain). This finding highlights the importance of preventive measures in individuals with similar experiences.

Notch in either one or both ears and bilateral notch were present in the audiograms of 42% and about 20% of our participants, respectively. Similar to our findings, Phillips et al. (2009) estimated the prevalence of notch in music learners as 45%[14]. However, they reported the prevalence of bilateral notches as 11.5%. This inconsistency between the two studies could be due to differences in the duration and intensity of exposure to music among music learners and professional musicians[14]. Kaharit et al. (2003) concluded that 74% of musicians developed a type of hearing impairment, i.e., hearing loss, tinnitus, hyperacusis, or diplacusis, due to exposure to music[15]. This rate was much higher than that obtained in our study. In fact, except for hearing loss, which was measured objectively, other hearing problems had lower frequency in the current study. This may indicate that musicians tend to hide their hearing problems to prevent any potential damage to their professional position.

In a study on an audience of 204 individuals in a concert, almost 38% of the participants complained of hearing impairment[16]. According to a four-year cohort study conducted by Schink et al., the risk of NIHL among musicians was 3.6 times higher than that among the general population[17]. The results of our study were in line with all the above-mentioned studies and it can be concluded that professional musicians are at risk of NIHL.

NIHL is bilateral in most cases. However, in the case of asymmetric exposure to noise, unilateral or asymmetric loss may be observed[1,2]. In the present study, 22% of the subjects had unilateral hearing loss (about 8% in the left ear and about 14% in the right ear). This is probably due to asymmetric exposure to sound sources and loudspeakers or musicians' positions during performances. We did not find any statistically significant relation between the type of instrument and side of hearing loss. The frequency of hearing loss in the left ear of violinists was higher than expected. We did not detect significant difference between violin and other instruments. This may be because of few numbers of violinists and low power of our study. A larger sample size might have led to significant differences.

In the current study, the prevalence of hearing loss was higher in people with ≥10 years of work experience. This finding was consistent with previous studies and indicated the dose-response effect[18]. Moreover, hearing loss was more frequent in men than in women. Although this difference was not statistically significant, a larger sample size might have led to significant differences. Hu examined 172 singers and introduced male gender as a risk factor for hearing loss[19]. As Warner-Czyz (2016) reported, boys tended to do noisy activities more than girls[20]. The higher frequency of hearing loss among our male participants might have been caused by men's tendency to play louder music.

We did not find a significant relationship between the type of musical instrument and the level of hearing loss (probably due to the low number of participants who played each type of instruments). In contrast, in a study on about 3,000 musicians Chesky et al. reported a significant relationship between the type of instrument and hearing loss[21].

Our findings highlighted the considerable prevalence of NIHL among professional musicians. However, our participants were selected from music academies in Tehran and may not be the representative of all people working professionally in this field across the country. Therefore, our findings cannot be generalized to the whole country. However, since Iranians' favorite genre of music and culture are relatively similar throughout the country, future studies on musicians in other parts of the country are not expected to yield significantly different results. Despite the essential role of good hearing in music career, the prevalence of hearing loss was high among our participants. This reflects musicians' neglect of using protective measures. Therefore, development of hearing loss prevention programs for people involved in the music industry seems necessary. The most important part of these prevention programs may be designing and implementation of training programs to raise awareness of the risks of noise exposure.

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