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An Evaluation of Maximum Safe Practice Time of Iranian Musical Instruments to Protect Noise-Induced Hearing Loss in Professionals

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Abstract

Background: Noise-induced hearing loss (NIHL) is one of the most common causes of sensorineural hearing loss. The prevention of NIHL in musicians requires a better understanding of its contributing exposure factors. We aimed to determine typical sound exposure levels received by professional musicians during solitary practice and calculate the maximum safe practice time (MSPT) for the main Iranian musical instruments.

Methods: We conducted a cross-sectional study on 185 professional musicians (147 men and 38 women) between April 2018 and April 2019. The MSPT was calculated for each instrument if the mean sound level was below 85 dB in all musicians, and the music was considered a safe instrument; if it was >85 dB, it was considered a high-risk instruments and some other instruments had different mean sound level (in some participants <85 dB and some other players >85 dB), so these instruments were considered as borderline instruments.

Results: The mean age of the participants was 36.66 ± 0.85 years and their mean daily practice time was 2.89 ± 0.13 hours. The daily practice was significantly higher in plucked string instruments as compared to other instruments (p<0.001). The mean sound level of every instrument varied from 67.77 to 100.77 dB in the right ear and 67.20 to 100.12 dB in the left ear. The highest sound level was in sorna and the lowest one in zanburak.

Conclusion: It seems musicians observe the MSPT of each instrument as much as possible. It is recommended to determine the comprehensive protocol for each instrument to prevent hearing loss in musicians.

Keywords: Hearing Loss, Noise-Induced, Music Instrument, Iranian Musical Instruments

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Introduction

Noise-induced hearing loss (NIHL) is one of the most prevalent causes of sensorineural hearing loss. This kind of hearing damage is permanent, irreversible, but preventable (1). The overall frequency of NIHL in musicians is higher than in the general population, ranging from 33% to 50% (2-4). Most musicians show a hearing loss >20 dB (decibel) and up to 40 to 60 dB at high frequencies between 3 and 4 kHz (5-7). The NIHL in musicians can occur after a single traumatic impulse sound but by repeated exposures

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↑What is "already known" in this topic:
Loud noise causes hearing loss, particularly in people who live a long life and rely on a time weighted averages. Noise-induced hearing loss in musicians needs a deeper understanding of the underlying exposure elements to calculate the typical sound exposure for professional musicians using Iranian musical instruments.

→What this article adds:
The first maximum safe practice time on the issue for the Iranian professional musicians to protect against noise-induced hearing loss was determined. Noise-induced hearing loss was reduced, and a protocol for the health care system which saves the quality of life was presented.

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to high-intensity sound. Although the hearing loss in musicians is often mild, it worsens with continuous exposure (1). On the other hand, long-term hearing problems are usually more challenging to treat. Many factors can contribute to hearing damage, including sound intensity level (measured in decibel), time-frequency of sound exposure, genetics, and age of the individuals (8, 9, 10). According to the NIOSH (National Institute for Occupational Safety and Health) recommendations, high-intensity sound exposure involves a time-intensity trade-off that begins with an allowable 8-hour exposure at 85 dB, decreasing the time exposed by half for every 3 dB increase in intensity. Evidence showed that sound exposure level in music students and teachers was over 85 dB most of the time, so an emphasis on regulating a proper playing time is essential (2, 3). The types of instruments used for playing in each country vary widely. The native instruments used in Iran might have different effects on the hearing system of the musicians (4, 5). For example, in studies, the prevalence of hearing loss was from 7.3% to 20% based on the type of musical instruments (6-10). Since the prevention of NIHL would require a better understanding of its contributing exposure factors and previous studies in Iran focused on the relationship between playing and hearing, we aimed to determine the typical sound exposure levels received by professional musicians during solitary practice and calculate the MSPT for main Iranian musical instruments to provide useful information to develop exposure control measures and educational materials for the Iranian musicians.

Methods

This cross-sectional study was conducted on 185 professional musicians (aged 20-77 years) consisting of 147 men and 38 women between April 2018 and April 2019. This research was performed in compliance with the Helsinki Declaration and was approved by the local ethics committee (IR.IUMS.FMD.REC.1397.023). All the participants gave informed consent. Inclusion criteria were at least 10 years of experience in playing Iranian professional instruments. The snowball sampling method was applied to selecting musicians living in different cities in Iran. About 3 to 7 musicians were selected from each of the Iranian musical instruments. These instruments are as follows: (1) Zithers string instruments (*Santur, Tar, Setar, Dutar* [origin: east of Khorasan], *Dutar* [north of Khorasan], *Tar-Azeri, Tanbur, Tanburak, Oud* [Lute], *Divan* [Baglama], *Shurangiz, Qanun, Ghopoz, Tar-bass, Rubab*); (2) plucked string instruments (*GhaychakSuprano, Ghaychak Alto, Ghaychak Bass, Kamanche*); (3) wind instruments (*Nay, Doneli, Ghushme, Karna, Laleva, Sorna, Neylabak* [Reed flute], *Dozaleh, Duduk, Shemshal* (Shimshal), *SutakGeli* [Mud whistle], *Ney-Anban*); and (4) percussion instruments (*Daf, Tonbak, Desarkoten, Dohol, Chubak* [Claves], *ZarbZurkhane, Senj* [Cymbal], *Kuze* [Odo dram], *Dayereh*, *DayerehZangi* [Tambourine], *Dammam* [with hand], *Dammam* [with stick], *Zanburak* [mouth harp]. Average sound levels were measured over the 20 minutes of a practice session in an acoustic room of the audiology department of Firoozgar hospital using a digital dosimeter, Extech 407727 digital sound level meter. Type A dosimeters were set to calculate the sound dose based on the ISO/NIOSH recommendations. The dosimeter was calibrated before each use with the provided compatible acoustical calibrator and care was taken to position the measurement instruments such that normal posture and musical instrument position were not compromised. For measuring the intensity of sound received by the right ear, the microphone part of the dosimeter was placed next to the right ear, while it was spaced 10 centimeters with the musician's ear in time of his/her solitary practice; then, this was repeated for his left ear for playing the same repertoire. The dangerous level for hearing damage was considered at ≥ 85 dB. If the mean of the sound level was lower than 85 dB, the musician could practice without any ear protection and time limitation, but if this was equal to 85 dB, he/she should practice only 8 hours a day. For sound levels >85 dB, the MSPT was calculated according to the following equation instrument. $F(X) = \frac{8}{2^{(X-85)/3}}$. The total mean was calculated in both ears in musicians of each instrument (3 to 7 people in each instrument group), then the higher number of mean was placed in the equation. In our study, most of the Iranian local instruments (different special rural or urban instruments) were examined. Since the playing way of each instrument is unique and the type of music applicable to each instrument is not the same, it is not possible to use a single piece with a single note for all instruments, thus, musicians were asked to perform their routine pieces of music.

Statistical Analysis

All the statistical analyses were performed using SPSS Version 24.0 (IBM). P value < 0.05 was considered statistically significant. Numerical variables are presented as mean ± SD, while categorized variables are summarized by absolute frequencies and percentages. Continuous variables were compared using the Student t test or the nonparametric Mann–Whitney U test whenever the data did not appear to have normal distributions, and categorical variables were compared using the $\chi 2$ or the Fisher exact test, as required.

Results

The mean age of players was 36.66 ± 0.85 years, and 147 (79.4%) were men. The mean duration of playing was 18.29 ± 0.72 years, and the mean daily practice time was 2.89 ± 0.13 hours. The daily practice was significantly higher in plucked string instrument players in comparison with other instrument players (5.92 ± 2.30 hours/day vs 3.53 ± 1.66 hours/day in zithers string instruments, 2.34 ± 1.38 hours/day in wind instruments and 1.88 ± 1.31 hours/day in percussion instruments, p<0.001). The most commonly played instrument type was zithers string instrument (35.1% (65)) followed by percussion, wind and plucked string instruments, with 29.7% (55), 27.6% (51), and 7.6% (17) of participants, respectively. This distribution was significantly (p=0.002) different between the 2 genders. the zithers string and percussion instruments were the most common in men and women, respectively (Table 1).

The average sound level of every instrument in the right and left ears was obtained. This range varied from 67.77 to 100.77 dB in the right ear and 67.20 to 100.12 dB in the left

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Table 1. The frequency of different instruments according to gender

Instruments	Gender, n (%)		*P* Value
	Men (n = 147)	Women (n = 38)	
Zithers string	54 (36.7)	11 (28.9)	0.002
Plucked string	6 (4)	8 (21)	
Wind	45 (30.6)	6 (15.7)	
Percussion	42 (28.5)	13 (34.2)	

Table 2. The maximum, minimum, and mean sound level of each instrument in the musician's right and left ears

Instruments		N	Maximum		Minimum		Mean	
			Right	Left	Right	Left	Right	Left
Zithers string	*Santur*	5	88.72	94.5	69.3	70.44	81.6	82.22
	Tar	6	95.12	89.77	69.93	70.85	84.25	81.17
	Setar	5	82.56	78.28	62.34	55.64	72.42	70.74
	Dutar (East of Khorasan)	6	83.87	81.12	70.67	71.18	78.87	76.05
	Dutar (North of Khorasan)	2	81	79.25	70.7	68.45	76.85	75.3
	Tar-Azeri	4	100.95	92.48	67.63	66.9	88.53	81.53
	Tanbur	5	80.14	80.06	69.88	70.58	75.72	75.14
	Tanburak	3	81.07	80.53	70.63	69.07	76.57	76.37
	Oud (Lute)	5	84.4	82.16	67.28	60.38	77.3	73.06
	Divan (Baglama)	5	81.76	80.78	67.36	66.48	75.4	74.06
	Shurangiz	3	85.23	83.03	69.2	69	80.47	78.77
	Qanun	5	98.14	97.72	61.34	63.08	82.74	82.4
	Ghopoz	3	81.27	80.5	64.23	59.57	73.13	70.23
	Tar-bass	3	86.73	82.77	65.43	66.67	79.17	76.43
	Rubab	5	85.08	83.8	66.9	61.94	78.78	76.74
Wind	*Nay*	6	97.03	94.53	52.17	48.25	80.7	77.09
	Doneli	3	98.13	100.9	71.47	77.77	83.27	83
	Ghoshme	3	99.4	102.5	66.97	77.93	94.1	94.93
	karna	3	99.77	99.3	90.33	93.3	95.2	95.5
	Laleva	3	99.63	98.77	78.93	76.57	87.7	86.87
	Sorna	6	106.42	106.57	90.83	85.72	100.77	100.12
	Neylabak (Reed flute)	6	98.92	93.68	61.17	60.1	83.58	84.03
	Dozaleh	5	98.24	94.36	73.56	76	90.88	90.48
	Duduk	6	91.38	90.32	54.72	60.08	82.47	81.99
	Shemshal (Shimshal)	2	95.75	97.4	42.95	56	83.78	85
	SutakGeli (Mud whistle)	4	110.48	112.55	57.58	49.35	99.8	99.25
	Ney-Anban	4	94.58	96.25	84.68	83.03	89.24	89.55
Plucked string	*Ghaychak Alto*	3	98.13	100.7	68.57	68.13	83.13	83.61
	GhaychakSuprano	3	98.47	99.57	72.93	73.4	82.93	84.77
	Ghaychak Bass	3	95.2	96	62.47	69.93	80.05	79.85
	Kamanche	5	91.76	93.56	61.26	70.42	79.72	80.14
Percussion	*Daf*	6	98.88	103.2	80.53	84.25	90.68	97.38
	Tonbak	5	93.94	89.76	74.22	73.32	84.78	83.32
	Desarkoten	3	95.97	98.77	85.6	88.87	91.53	93.63
	Dohol	7	101.04	100.69	85.33	88.6	93.13	94.93
	Chubak (Claves)	3	82.07	84.33	55.73	51.97	71.8	72.1
	ZarbZurkhane	3	103.77	102.1	89.37	85.63	98.37	97.57
	Senj (Cymbal)	5	99.76	101.66	74.08	62.3	88.94	84.91
	Kuze (Odo dram)	4	78.93	79.53	56.2	53.08	68.83	68.5
	Dayereh	6	91.8	100.02	79.63	83.92	86.03	90.97
	DayerehZangi (Tambourine)	3	88.17	100.97	76	74.07	81.43	91.07
	Dammam (with hand)	5	89.6	89.44	68.26	67.68	80.78	81.3
	Dammam (with stick)	2	95	97	74.5	78.5	84.6	87.3
	Zanburak (mouth harp)	3	74	80.6	61.1	49.33	67.77	67.2
Total		185	92.66	92.62	69.85	69.55	83.66	83.33

Maximum: The average of the highest intensity of sound input to the musician's ears; A, Minimum: The average of the lowest frequency of sound input to the musician's ears; B, Mean: The average of the mean frequency of sound input to the musician's ears; C

ear. The highest sound level was for *Sorna* and the lowest one was for Zanburak (Table 2).

The mean sound level of some instruments including *Santur*, *Setar*, *Dutar*, *Tanbur*, *Tanburak*, *Oud* (Lute), *Divan* (Baglama), *Shurangiz*, *Ghopoz*, *Tar-bass*, *Rubab*, *Doneli*, *Duduk*, *Ghaychak bass*, *Chubak* (Claves), *Kuze* (Odo dram) and *Zanburak* (Mouth harp) was below 85 dB in all musicians, therefore, they were considered as safe instruments. Some other instruments (*Tar*, *Qanun*, *Nay*, *Neylabak* [Reed flute], *Ghaychak Alto*, *GhaychakSuprano*, *Kamanche*, *Tonbak*, *Senj* (Cymbal), and *Dammam* with hand, although had mean sound levels < 85 dB, in some musicians, according to their playing style, this sound intensity could be above 85 dB or below 85 dB. Hence, the instrument may be considered a safe one, while it may be harmful to musicians, so these instruments are in the border category (borderline instruments). Also, the mean sound level was more than 85

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Table 3. Risky Instruments and Their MSPT

Instrument		N (Total = 62)	MSPT, min
Zithers string	*Tar-Azeri*	4	3:34
Wind	*Ghoshme*	3	0:49
	Karna	3	0:42
	Laleva	3	4:17
	Sorna	6	0:13
	Dozaleh	5	2:09
	Shemshal (Shimshal)	2	8:00
	SutakGeli (Mud whistle)	4	0:16
	Ney-Anban	4	2:49
Percussion	*Daf*	6	0:28
	Desarkoten	3	1:05
	Dohol	7	0:49
	ZarbZurkhane	3	0:26
	Senj (Cymbal)	5	3:13
	Dayere	6	2:28
	DayereZangi (Tambourine)	3	2:00
	Dammam (with stick)	2	4:42

dB in some instruments, including *Ghoshme*, *Karna*, *Laleva*, *Sorna*, *Dozaleh*, *Shemshal* (Shimshal), *SutakGeli* (mud whistle), *Ney-Anban*, *Daf*, *Desarkoten*, *Dohol*, *Zarb zurkhaneh*, *Senj* (Cymbal), *Dayere*, *DayereZangi* (Tambourine), and *Dammam* (with stick); therefore, they were considered as high-risk instruments. The range of MSPT expanded from 13 minutes to 8 hours, which significantly varied between different instruments (P = .003). Results showed that Sorna had the lowest MSPT (13 minutes) and Shemsha l (Shimshal) had the highest MSPT (8 hours). In many of the studied instruments, the participant's mean daily practice time was more than its MSPT (Table 3).

Discussion

This study showed that the mean sound level for the instruments was 78-89 dB in total, which suggests more attention to hearing health in musicians. In terms of the 4 main types of instruments, the highest sound intensity in both ears was for the wind instruments. Although this study was done for the Iranian instruments, the results of our study are comparable to the mean sound levels found by previous studies, which ranged across instruments from 88 to 98 dB (7, 8). Hence, due to high sound level exposure, musicians are at a high risk of permanent hearing loss (10). A musician is affected by sound exposure differently, considering intervening factors, such as the type of instrument, age, seat position in the orchestra, the played rhythm, and the overall duration of playing (7). Note that the MSPT calculated in this study is only for daily solo practice, regardless of group practice time, attending a concert, or listening to music. Therefore, the time should be adjusted in case of any of these situations. In addition to the sound level, the duration of playing at a particular sound intensity is an important factor in hearing damage. The musicians in our study spent an average of 2.89 (0.5-8) hours per day in their practice. Although this range was in accordance with the previous studies (11), our concern is that musicians practice throughout the day with short breaks. Therefore, this lifestyle does not allow for the 12 hours of rest from noise exposure required to reduce the temporary threshold shift (12. 13). Moreover, our study suggests that some instrumentalists should not play for a long time during the day. The total MSPT values for the *sorna*, *daf*, *sutakGeli* (Mud whistle), *zarbzurkhane*, *karna*, and *dohol* were less than 1 hour, while often musicians do not follow this and practice 8 hours or more a day, especially in the days of nearness the performance day (5, 14). Also, due to the proximity of borderline instruments, such as *tar* and *qanun,* and *tonbak*, it is recommended that musicians of these instruments should follow a playing time limit of approximately 8 hours. It seems that many musicians who participated in this study, regardless of the type of instruments, are at risk for hearing loss because they practiced more than the recommended time allowed by the NIOSH. However, our study showed that, unlike urban instruments, most loud instruments are rural and played in large spaces which may decrease the harm. The next important point is that the hearing loss usually does not develop abruptly, but it progresses slowly over time, and the individual is usually unaware of this impairment until the advanced stages (15). Hence, routine periodic audiometry is recommended for all musicians. In addition to annual audiometric testing, some other components recommended by the NIOSH as the hearing conservation program include environmental noise measurements of all practice and performance spaces, introduction to and instruction in the use of hearing protectors, education, and training. Also, a silencer (a muzzle device that reduces acoustic intensity) is recommended to be used for high-risk instruments (16). The strength of our study was calculating the MSPT of Iranian musical instruments for the first time and it was also the first article to provide information about the maximum amount of noise exposure time compared to previous articles. However, this study had some limitations; we only measured a short single practice session that could not be representative of all practice sessions.

Conclusion

It seems that musicians observed the MSPT time of each instrument as much as possible. It is recommended to determine the comprehensive protocol for each instrument according to this research to prevent hearing loss in musicians, although conducting more comprehensive studies is needed.

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Ethics Approval

This work was done with ethical approval and consent to participate.

Conflict of Interests

The authors declare that they have no competing interests.

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