Research Square

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Epidemiological Investigation on Symptoms and Influencing Factors of Noise-Induced Deafness in Officers and Soldiers After Live Firing Training

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Research

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Abstract

Objective To study the symptom and influencing factors of acute acoustic injury in soldiers after shooting training.

Methods A questionnaire survey was conducted among 571 soldiers who participated in live firing training. The necessary information of soldiers, the history of noise exposure before enlistment, and acute acoustic injury symptoms after shooting practice were collected and analyzed statistically.

Result The soldiers seldom contact with impulse noise before enlistment. Another environmental noise intensity is medium, and contact time is short; after enlistment, most of them have received shooting training. The most common symptom of acute acoustic injury is tinnitus. The low-frequency tinnitus is more common, and the degree of discomfort is low; A few soldiers wear protective equipment. Statistics found that military age, whether to wear protective equipment, blood type, is related to acute acoustic injury.

Conclusion Acute acoustic injury is more likely to occur after exposure to impulse sound in shooting training, and tinnitus is the most common symptom. With the increase of military age, it is more likely to have acoustic injury symptoms. Wearing personal protective equipment can effectively reduce acoustic damage and the susceptibility to the noise of type A blood is low.

1 Background

Military noise is a particular type of noise in a special environment, mainly including high-intensity impulse noise. The level of noise generated by military guns can be as high as 150–180 dB SPL, far exceeding the safe limits —85 dB SPL. Such high-intensity noise will seriously damage the hearing of unprotected people[1]. Acute acoustic trauma symptoms can range from mild reversible hearing loss and tinnitus to severe hearing loss with long-term tinnitus[2]. In foreign military combat training, the utilization rate of personal hearing protection devices (HPD) has reached more than 90%, effectively reducing the occurrence of various acoustic traumas. However, hearing protection is still low in the training of our army's basic units, mainly because of restricted equipment conditions poor protection awareness, and other aspects. Our study conducted a field survey on soldiers after shooting training to investigate the current status and the influencing factors of noise-induced hearing loss in our army officers and soldiers.

2 Material And Methods

2.1 Research object

571 officers and soldiers were involved in this study after shooting training. There were 553 men in the sample, accounting for 96.8%. The longest service period of soldiers is 34 years, the shortest is one year, the average military age is 5.81 ± 7.03, and the median military age is two years. Among these soldiers, soldiers who have type O blood accounted for 35.9%, type A blood 24.9%, type B blood 26.5%, and type

AB 14%; 7.8% of the participating officers and soldiers had otitis media in the past, and 2.3% had a history of ear trauma, but no symptoms left by these diseases. Standard 5.8 mm caliber 95 type automatic rifles are used in the shooting training.

2.2 Research methods

After the shooting training, the "Noise-induced Hearing loss Questionnaire" was designed and distributed to soldiers for the surveys to obtain basic information, the history of noise exposure before enlistment, and symptoms of noise-induced hearing loss after shooting training. After the questionnaire recovered, the relevant information was analyzed statistically.

2.3 Statistical methods

This study's data were statistically analyzed using SPSS 20 statistical software, and $\chi 2$ tested the incidence between symptoms and various related factors of noise-induced hearing loss. $P < 0.05$ indicates that the difference is statistically significant.

3 Results

3.1 High level noise exposure and symptoms before joining the army

Before joining the army, only 14.3% of soldiers had been exposed to high level noise environments, and the main noise was daily life noise. Only about 2% of soldiers had experienced strong impulse noises such as explosions in industrial and mining operations (Fig. 1). In the independent rating of the noise intensity, 45.9% of the officers and soldiers believed that the noise intensity before joining the army was moderate (Fig. 2A). The cumulative exposure time of high level noise was relatively short, and 63.3% of the officers and soldiers claimed that the cumulative exposure time was less than one year (Fig. 2B).

Figure 1 Types of high level noise exposure history of soldiers before enlistment

Fig.2 Specific characters of high level noise. **A** The intensity of high level noise exposure of officers and soldiers before joining the army. **B** The cumulative exposure time of officers and soldiers to high level noise before joining the army.

Only 13.4% of the officers and soldiers participating in the investigation developed ear symptoms after being exposed to high level noise before enlisting(Fig. 3A), and 21.1% of them had tinnitus (Fig. 3B).

Figure 3 The status of symptoms due to acute acoustic injury after high level noise exposure before enlistment. **A** The proportion of people with acute acoustic injury symptoms after high level noise exposure. **B** The proportion of tinnitus due to acute acoustic injury before enlistment.

3.2 High level noise exposure and symptoms after enlistment

88.8% of Officers and soldiers have had a history of exposure to strong impulse noise such as weapon explosion or shooting. 38% of officers and soldiers have symptoms such as tinnitus, ear fullness, and hearing loss after training(Fig. 4A), of which tinnitus is the most common (56%). Hearing loss accounted for 14%, ear swelling, and fullness 20% (Fig. 4B).

Figure 4 The status of symptoms due to acute acoustic injury after enlistment. **A** The proportion of people with acute acoustic injury symptoms after high level noise exposure among all solders. **B** The proportion of specific symptoms among solders who have acute acoustic injury after shooting training.

In tinnitus rate classification, High-frequency tinnitus accounted for 41%, low-frequency tinnitus accounted for 49%(Fig. 5A); in the independent rating of discomfort, mild discomfort accounted for 44%, extreme discomfort accounted for only 5%, and the average discomfort was level 2 (Fig. 5B).

Figure 5 Characteristics of tinnitus after shooting training. **A** Tonal characteristics of tinnitus after shooting training; **B** The evaluation of tinnitus discomfort after acute acoustic injury due to shooting training.

3.3 HPD wearing situation when exposed to strong impulse noise

During shooting training, only 20% of officers and soldiers actively wear HPD, and they have various styles and non-standard equipment(Fig. 6A). Among them, earplugs account for up to 41%, earmuffs account for 28%, cotton balls account for 15%, and bullet shells account for 11% (Fig. 6B).

Figure 6 Current status of wearing HPD in officers and soldiers in shooting training. **A** Proportion of HPD wearers in officers and soldiers. **B** Specific types of HPD worn by officers and soldiers.

3.4 The relationship between military age, HPD wearing, blood type, and hearing loss symptoms after noise

221 people filled the form about military age and symptoms after shooting. The average military age is 5.81 ± 7.03, and the median military age is two years. Because the standard deviation of military age is large, it is believed that the median is more representative of the military age distribution of the people participating in this research. Therefore, chi-square statistics were conducted on the relationship between military age and hearing loss symptoms after noise by taking two years as the limit. The probability of noise damage symptoms after serving more than two years was 45.1%, and the probability of occurrence of noise damage symptoms less than two years was 31.1%. The difference between them was statistically significant (chi-square value = 4.594, $P = 0.032 < 0.05$); 215 people filled the form about the symptoms after shooting and HPD wearing status, 65.8% of those who wore HPD were asymptomatic, those who did not wear HPD and with symptoms accounted for 51.9%. The difference was statistically significant (chi-square value = 4.255; $P = 0.039 < 0.05$); Among the people with acute noise injure after shooting, the proportion of blood type O appears the highest and rising, reaching 39%, which is compared with the proportion of blood type O (35.6%) in the total population participating in shooting training. The

proportion of blood type A with symptoms after the shooting is 18%, which was lower than the proportion of the total population (24%) (Fig. 7). Statistics found no statistical difference between the proportion of blood type O with symptoms and other blood types (chi-square value = 0.073, P = 0.787 > 0.05. There is a statistical difference in the proportion of blood type A without symptoms and other blood types (chi-square value = 4.138, P = 0.042 < 0.05).

Figure 7 Blood group distribution of the general population participating in shooting training and blood group distribution of solders with acute acoustic injury symptoms after shooting training.

4 Discussion

Noise is a very special item in a severe military operating environment. In addition to direct damage to the hearing system, it can also cause serious damage to multiple systems throughout the body. In recent years, with the rapid development of army's new equipment and weapons, officers' and soldiers' ratio to military noise has increased significantly. As an example, the percent of US Marines with NIHL increased by almost 68% in recent years. The Department of Veteran Affairs states that hearing loss and tinnitus are the third most common form of disability within the military, representing approximately 680, 000 individual cases. Hazardous noise exposure in the US military is greater than it has been in more than 30 years, with 30% of all post-deploying soldiers reporting noise exposure and 28% reporting corresponding hearing loss and/or tinnitus. While noise exposure is a staggering problem for deployed soldiers, it is also a problem for non-deployed soldiers. Recently, it was reported that 11% of Marines sustain hearing loss during basic training, despite the use of hearing protection[3]. As all known, high level noise is the direct cause of acute acoustic injury. When officers and soldiers operate live ammunition, they produce high-intensity impulse sound. The blast wave generated by it can directly act on the human body and cause damage. The alternating overpressure and negative pressure in the blast wave are the main factors leading to hearing organs' damage. The instantaneous overpressure blast wave moves in the air at supersonic speeds, causing violent fluctuations in the lymph fluid in the labyrinth of the inner ear, which leads to mechanical damage and metabolic disorders such as basement membrane, vestibular membrane, and stria vascularis, and finally leads to hearing impairment[4]

Research by the U.S. military has shown that some veterans can tolerate hearing loss to a certain extent but can hardly tolerate long-term tinnitus. Not only does it sound like sleep, but it can also even cause hallucinations and depression, which seriously affects the quality of life. According to the statistics of officers and soldiers' symptoms after shooting training, tinnitus has the highest incidence, accounting for 56%, which is consistent with other literature reports. However, the degree of self-rating discomfort is lower, which may be related to most officers' and soldiers' shorter military age. In the classification of tinnitus sounds, low-frequency sounds are the most common, which may be related to conductive damage caused by strong impulse sounds.

This study shows that the probability of noise damage symptoms in service for more than two years is much higher than that of less than or equal to 2 years. Past studies have shown that the severity of noise-

induced hearing loss increases with exposure time[5], which is consistent with this study's results. It is suggested that the noise exposure time should be reduced as much as possible during officers' and soldiers' training, and the prevention work should be focused on those who have served longer. Data shows that 18% of the U.S. military has significant noise-induced hearing loss[6]. According to our survey, 38% of the officers and soldiers participating in shooting training have different noise-induced hearing loss degrees. This significant difference may be related to the lack of protective measures in our army. This survey shows that only 20% of the officers and soldiers wear HPD, which is much lower than that of foreign soldiers. In the foreign army,90% of the military wear HPD. Whether or not to wear HPD is highly correlated with the appearance of symptoms. This study shows that wearing HPD and asymptomatic accounted for 13.9% higher than those without HPD and asymptomatic. The difference is statistically significant, suggesting that wearing HPD is very important for preventing noise-induced hearing loss.

This study shows that blood type has a certain correlation with the population's susceptibility to noise. Among people with noise-induced hearing impairment after shooting, the proportion of blood type O appears the highest, which is higher than the proportion of blood type O (35.6%) compared to the total population participating in shooting training. The proportion of people who appear symptoms after shooting with type A blood is 24%, lower than that of the general population. Previous studies have shown that blood type, and noise susceptibility of people are related. Several previous studies have shown that blood type is highly correlated with people’s noise susceptibility. Blood type O is more susceptible to noise[7, 8]. However, in this study, there was no statistical difference in the proportion of people appear symptoms with type O blood and other blood types, which may be related to the particularity of the population under investigation. Simultaneously, the ratio of no symptoms with type A blood and no symptoms with other blood types appeared statistically significant differences. The difference suggests that type A blood may be more able to tolerate high-intensity noise.

5 Conclusion

In this study, a large sample epidemiological survey was conducted among the officers and soldiers who participated in the firing training to understand the influencing factors and related symptoms of acute acoustic injury, We found that military noise is more likely to cause noise induced hearing loss, among which tinnitus is the most common symptoms. Military age is one of the susceptible factors of noise induced hearing loss. The blood group is related to the susceptibility of noise induced hearing loss, and the blood type A is relatively low.

Declarations

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Authors’ contributions

Shi-Ming Yang and Ning Yu conceived the idea. Lei Shi, Li-Sha Ma, Dong-Yan Li and Guo-Wei Qi designed the experiments, interpreted the data and performed the experiments. Lei Shi wrote the manuscript. All authors read and approved the final manuscript. Shi-Ming Yang and Ning Yu are the Co-corresponding author.

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Availability of data and materials

The data and materials used in the current study are all available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

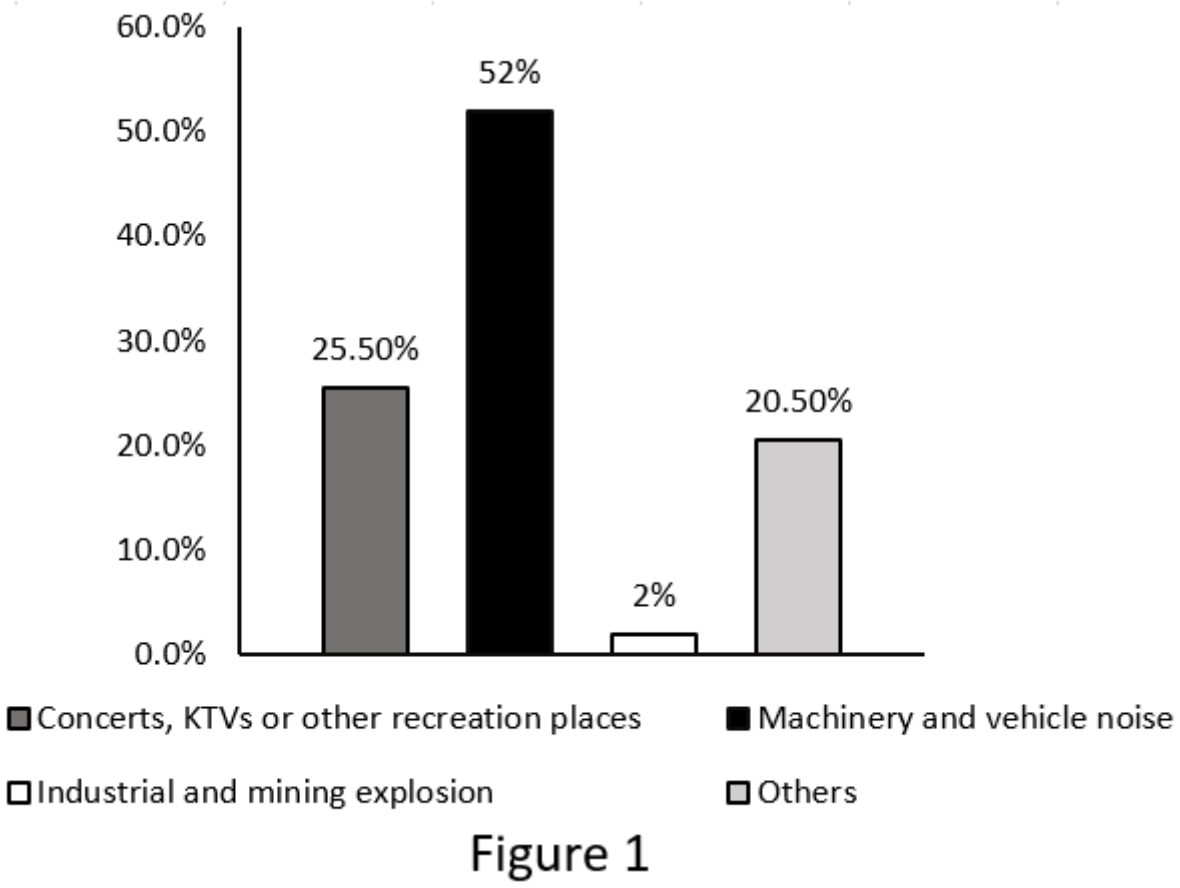
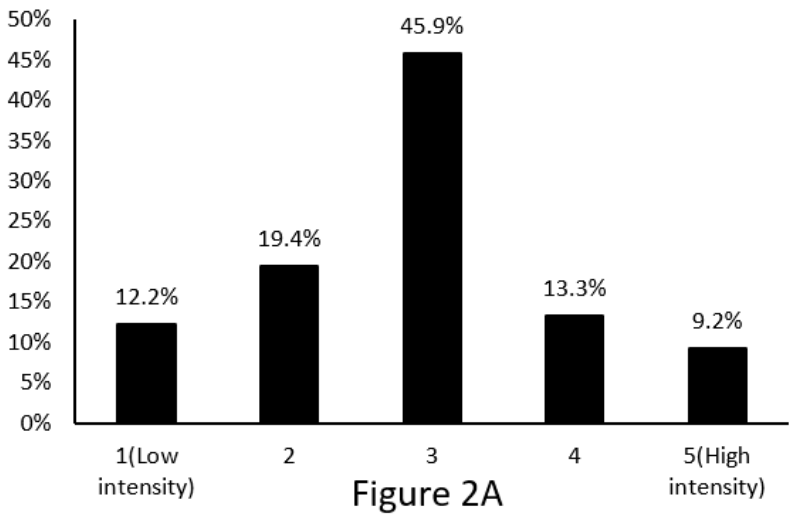


Figure 1

Types of high level noise exposure history of soldiers before enlistment



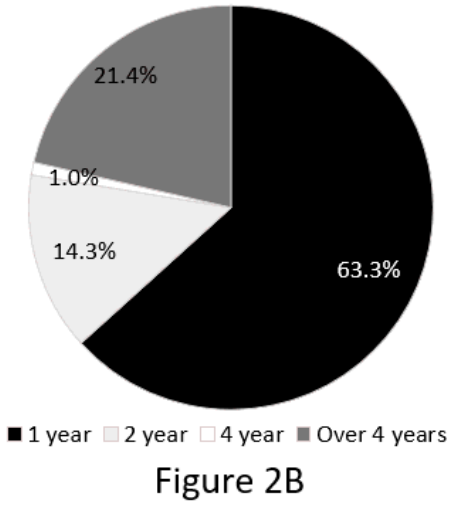
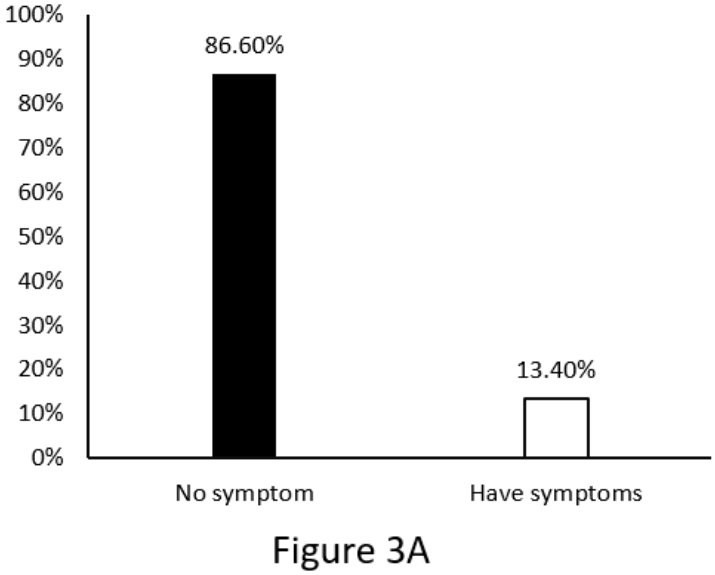


Figure 2

Specific characters of high level noise. A The intensity of high level noise exposure of officers and soldiers before joining the army. B The cumulative exposure time of officers and soldiers to high level noise before joining the army.



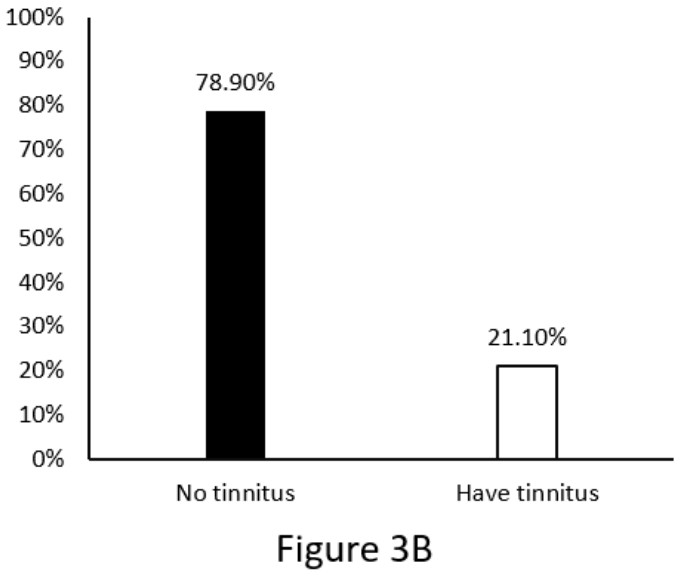


Figure 3

The status of symptoms due to acute acoustic injury after high level noise exposure before enlistment. A The proportion of people with acute acoustic injury symptoms after high level noise exposure. B The proportion of tinnitus due to acute acoustic injury before enlistment.

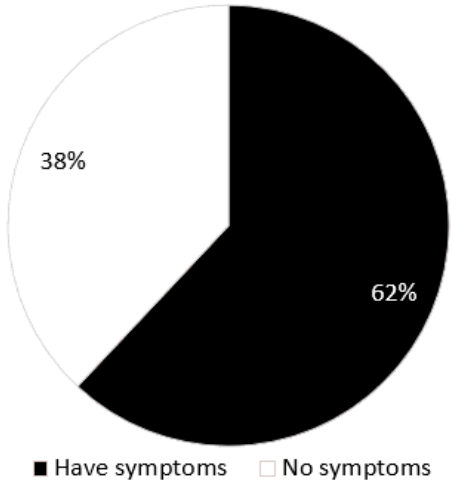


Figure 4A

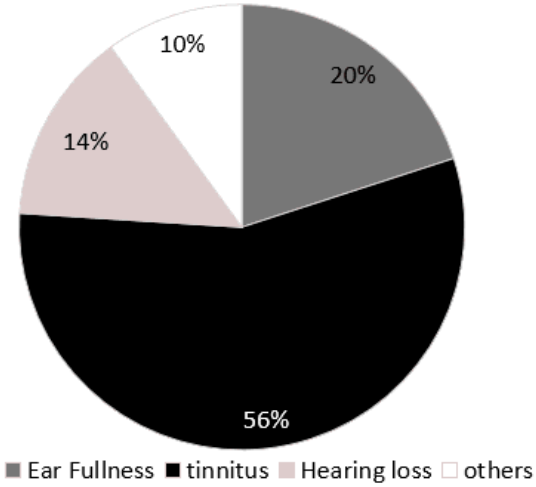


Figure 4B

Figure 4

The status of symptoms due to acute acoustic injury after enlistment. A The proportion of people with acute acoustic injury symptoms after high level noise exposure among all solders. B The proportion of specific symptoms among solders who have acute acoustic injury after shooting training.

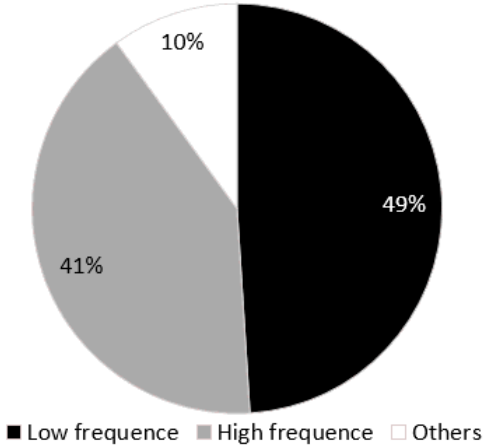


Figure 5A

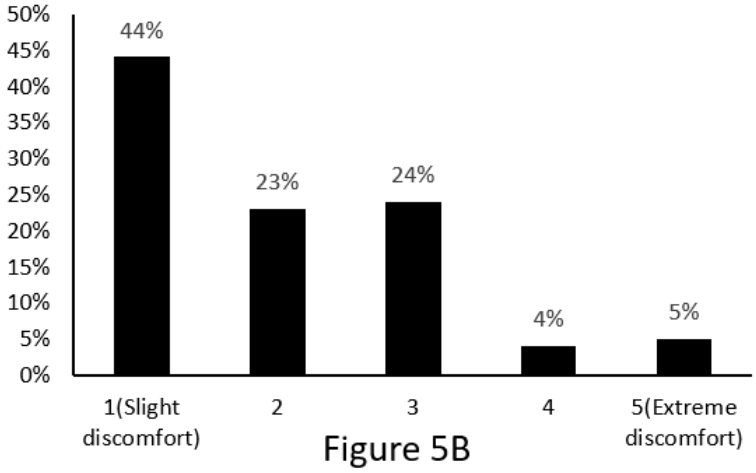


Figure 5B

Figure 5

Characteristics of tinnitus after shooting training. A Tonal characteristics of tinnitus after shooting training; B The evaluation of tinnitus discomfort after acute acoustic injury due to shooting training.

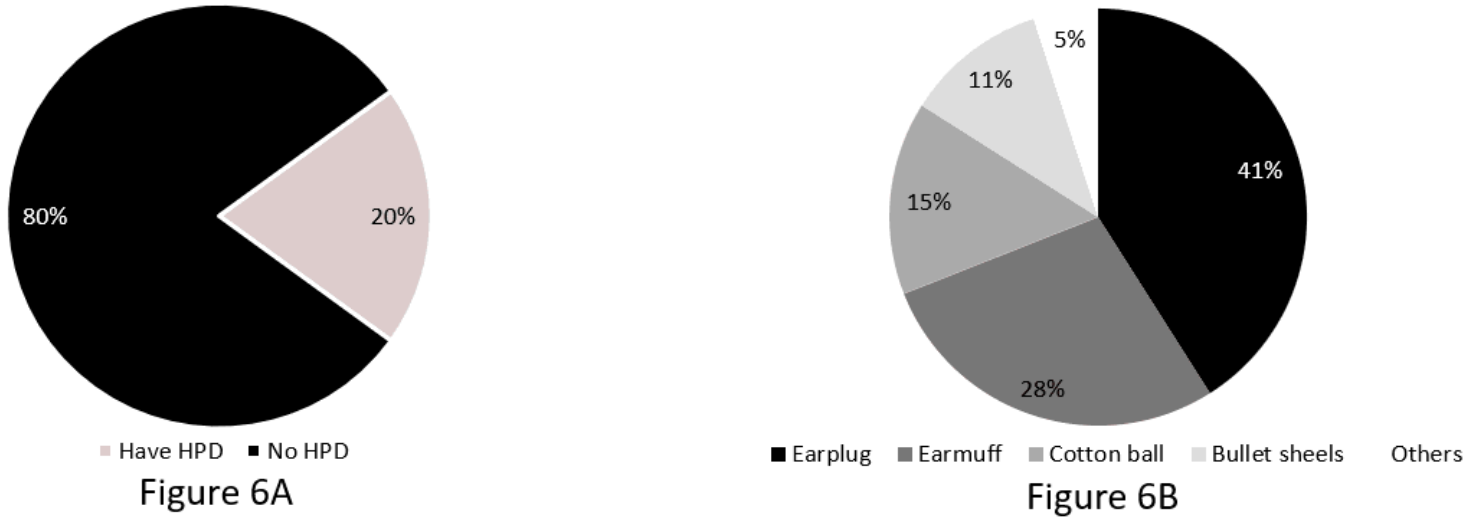


Figure 6

Current status of wearing HPD in officers and soldiers in shooting training. A Proportion of HPD wearers in officers and soldiers. B Specific types of HPD worn by officers and soldiers.

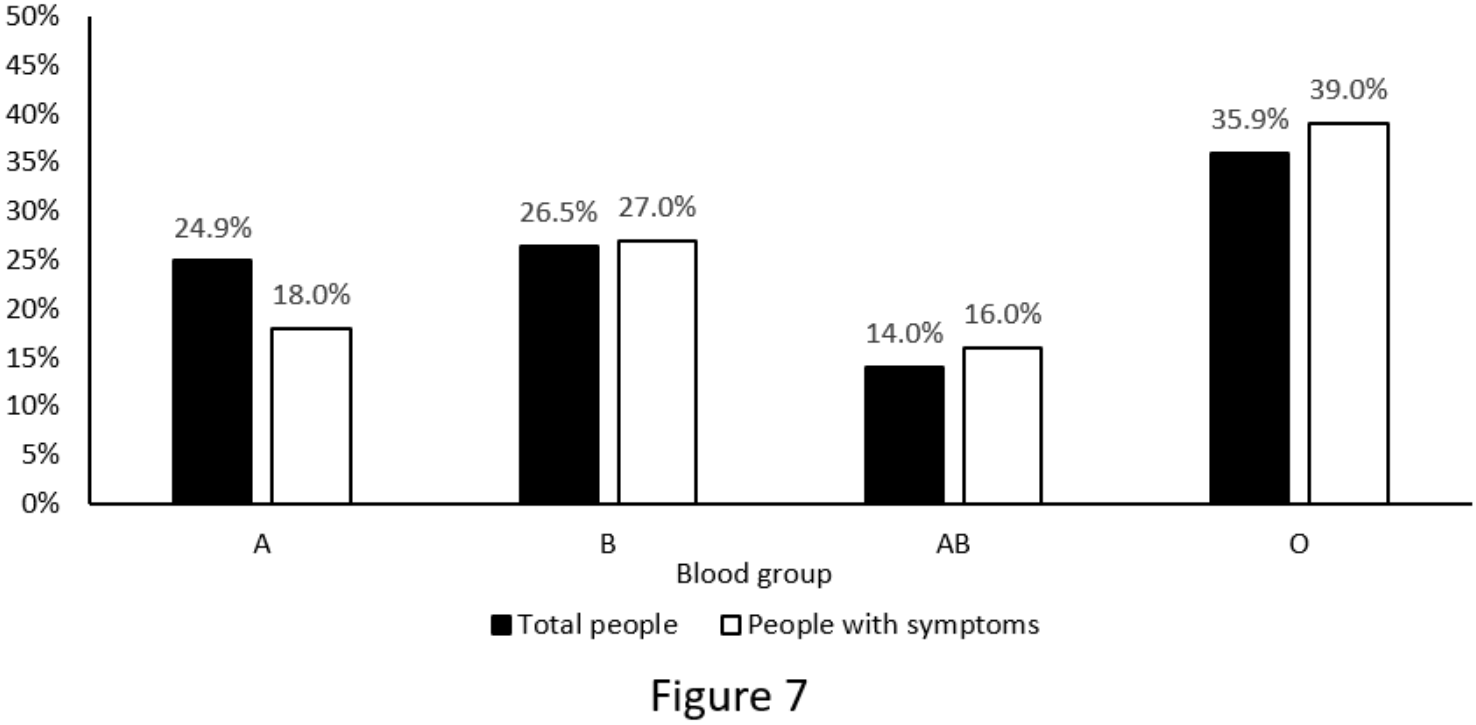


Figure 7

Blood group distribution of the general population participating in shooting training and blood group distribution of solders with acute acoustic injury symptoms after shooting training.