Observational Study

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Noise-induced hearing loss in Turkish special forces personnel

Yonca Coluk, MD[a,*], Omer Hizli, MD[b], Serkan Kayabasi, MD[c]

Abstract

Noise-induced hearing loss is a significant occupational hazard for police personnel. Intense noise from training and military activities can permanently damage the inner ear, leading to hearing loss. The aim of this study is to compare the hearing of Turkish Special Forces personnel with that of healthy individuals. We included 50 male police from Turkish special police forces team and 51 healthy males in the study. After a detailed medical history and a comprehensive otolaryngologic examination, pure-tone audiometry was conducted. Hearing levels were compared between the special forces and the control group. The study included 50 male police from Turkish special police force (study group, mean age 32 ± 3 years) and a control group of 51 healthy males (mean age 32 ± 6 years). Right ear hearing thresholds of 500, 1000, 2000, 4000, 6000, and 8000 Hz were significantly greater in the special forces group, compared to the control group ($P < .001$ and $P = .002$, respectively). In addition, left ear hearing thresholds of 500, 2000, 4000, 6000, and 8000 Hz were significantly greater in the special forces group, compared to the control group ($P = .03$ and $P < .001$, respectively). This study revealed significantly higher hearing thresholds in special police forces compared to a healthy control group. This suggests chronic loud noise exposure during training and military operations might be causing hearing loss among these personnel. To safeguard the auditory health of this population, robust hearing conservation programs must be implemented. Early identification of hearing loss is essential for mitigating its impact and providing appropriate support.

Abbreviations: DALY = disability-adjusted life years, dB = decibels, HC = hair cell, NIHL = noise-induced hearing loss, ROK = Republic of Korea, SRT = speech reception threshold, TTS = temporary threshold shift, WHO = World Health Organization.

Keywords: noised induced hearing loss, occupational hearing loss, special police force

1. Introduction

Noise-induced hearing loss (NIHL) is a sensorineural hearing loss that develops due to long-term exposure to noise. Exposure to sound exceeding 85 dB (decibels) can cause NIHL, though individual susceptibility varies.[1] It begins at the higher frequencies (3000–6000 Hz) and increases gradually with chronic exposure to noise. While NIHL usually affects both ears equally, exposure to loud sounds from specific sources, such as firearms or sirens, can result in asymmetric hearing loss. Moreover, hearing loss due to exposure to short-duration high-intensity sound is referred to as acoustic trauma.[2]

According to the World Health Organization (WHO), over 5% of the world's population, or 430 million people (including 34 million children), have disabling hearing loss and require rehabilitation. By 2050, this number is projected to exceed 700 million, affecting 1 in 10 people worldwide.[3]

Occupational NIHL is a type of NIHL caused by high levels of noise in the workplace. NIHL remains the second most prevalent self-reported occupational disease or injury, even after decades of dedicated research, workplace interventions, and established regulations.[4]

Noise-induced hearing loss is a significant occupational hazard for military and police personnel,[5] including Turkish Special Forces. Exposure to high-intensity noise during training and military operations can damage the delicate structures of the inner ear, resulting in permanent hearing loss. It is evident that hearing protection devices offer significant benefits in specific situations and/or for individuals, such as in high-intensity noise environments, for military personnel, and occupational workers. In addition to that, the performance of sound localization and speech perception was not negatively affected for those wearing hearing protection devices.[6] Moreover, due to operational constraints, Turkish special forces often forego the use of ear protection equipment in

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high-risk missions leading them to potential auditory health issues.

This study aimed to compare the hearing levels of Turkish Special Forces personnel with that of healthy individuals. While there are studies in the literature evaluating NIHL in military personnel from various countries, to the best of our knowledge, this study is the first to assess the hearing of Turkish Special Forces personnel in English literature. This makes our study significant in contributing to the existing body of knowledge on hearing health in this specific population.

2. Methods

This study was conducted in line with the dictates of the World Medical Association Declaration of Helsinki and approved by the local ethic committee (IRB Number: KAEK-66). We included 50 male police from Turkish special police forces team and 51 healthy males in the study. Prior to inclusion in the study, participants were questioned about their exposure to high-intensity noise or traumatic events within the previous 72 hours. Only individuals without a history of such exposure within the previous 72 hours were enrolled. Written informed consent was obtained from all participants.

We took a detailed medical history of all participants, performed a comprehensive otolaryngologic examination. Excluded from the study were the participants with any chronic otitis media, tympanic membrane perforation, external ear infections and those who used ototoxic drugs.

Audiometric testing was conducted using Interacoustics AC40B, (Denmark). This test measures hearing thresholds at frequencies of 500, 1000, 2000, 4000, 6000, and 8000 Hz presented to each ear in a soundproof room with minimal background noise (20–25 dBA) to assess hearing. Pure-tone averages calculated using 500, 1000, 2000, and 4000 Hz frequencies. It is recommended to calculate the pure-tone average using 1000, 2000, and 4000 Hz to assess NIHL.[7] However, through a detailed comparison of hearing thresholds at all tested frequencies, we have provided a comprehensive assessment of auditory function between the 2 groups. The severity of hearing loss was assessed according to the WHO grading system. Normal hearing falls within 0 to 25 dB of hearing level (dB HL), mild impairment ranges from 26 to 40 dB HL, moderate impairment from 41 to 60 dB HL, severe impairment from 61 to 80 dB HL, and profound impairment exceeding 80 dB HL.[8]

Hearing thresholds of 500, 1000, 2000, 4000, 6000, and 8000 Hz, SRTs (Speech reception threshold) and pure-tone averages were compared between the special forces and the age-matched controls.[7]

2.1. Statistical analysis

Results of the study were presented as mean ± standard deviation. The independence and identically distribution conditions were met as the data originated from distinct individuals and audiometric evaluations were performed at separated time points using the same audiometry device. Additionally, because the sample size is relatively high (101 patients), the data were assumed to be normally distributed in accordance with the central limit theorem. Thus, Student *t* test was used for comparisons. All statistical analysis were performed on SPSS software for Windows (SPSS Inc., Chicago). A *P*-value <.05 considered statistically significant.

3. Results

In total, 50 male police from Turkish special police forces team (study group, mean age 32 ± 3 years) and 51 healthy males (control group, mean age 32 ± 6 years) were included in the study. The groups were age and gender-matched (0.983).

The comparison of audiometric parameters of the groups (Table 1) revealed that, left ear hearing thresholds of 1000 Hz, left SRTs and right SRTs did not significantly differ between the groups ($P = .209$, $P = .264$ and $P = .361$, respectively). However, right ear hearing thresholds of 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz were significantly greater in the special forces group, compared to the control group ($P < .001$ and $P = .002$, respectively). In addition, left ear hearing thresholds of 500, 2000, 4000, 6000, and 8000 Hz were significantly greater in the special forces group, compared to the control group ($P = .03$ and $P < .001$, respectively). Moreover, pure-tone averages, measured by both air and bone conduction, were significantly higher in both ears of the special forces group compared to the control group ($P < .001$) (Figs. 1 and 2).

4. Discussion

The current study investigated the hearing levels of Turkish special police forces personnel in comparison with a healthy control group. This study fills a critical gap in the literature by examining the auditory health of Turkish Special Forces operating in high-risk environments, where they are frequently exposed to blast injuries and excessive noise. This research provides valuable insights into the unique auditory health challenges faced by these elite units. The special forces group demonstrated significantly higher hearing thresholds in the right ear at 500, 1000, 2000, 4000, 6000, and 8000 Hz compared to the control group. Similarly, left ear hearing thresholds at 500, 2000, 4000, 6000, and 8000 Hz were also significantly higher in the special forces group. While the human ear exhibits maximum sensitivity to frequencies between 1000 and 5000 Hz, with the acoustic reflex providing the most protection at frequencies below 2000 Hz, NIHL is often characterized by notches observed at 4000, and 6000 Hz on pure-tone audiograms.[9] Therefore, we do not expect to find a significant difference at 1000 Hz in cases of NIHL, but rather at higher frequencies, such as 2000, 4000, and 6000 Hz. Additionally, pure-tone averages measured by both air and

Table 1

The comparison of audiometric parameters between the special forces and controls.

	Special forces		Control group		
	Mean	SD	Mean	SD	*P*-value*
Age (yr)	32	3	32	6	.983
Right 500 Hz (dB)	13	7	9	3	<.001
Right 1000 Hz (dB)	11	5	9	3	.002
Right 2000 Hz (dB)	14	8	9	3	<.001
Right 4000 Hz (dB)	26	22	10	4	<.001
Right 6000 Hz (dB)	25	24	9	3	<.001
Right 8000 Hz (dB)	28	25	10	3	<.001
Left 500 Hz (dB)	11	5	9	3	.03
Left 1000 Hz (dB)	10	5	9	3	.209
Left 2000 Hz (dB)	15	12	9	3	<.001
Left 4000 Hz (dB)	29	26	10	4	<.001
Left 6000 Hz (dB)	28	26	10	3	<.001
Left 8000 Hz (dB)	30	27	10	4	<.001
Left AC PTA (dB)	14	9	9	3	<.001
Left BC PTA (dB)	8	8	4	3	<.001
Right AC PTA (dB)	14	7	9	2	<.001
Right BC PTA (dB)	8	7	4	3	<.001
Left SRT (dB)	10	4	9	3	.264
Right SRT (dB)	10	4	9	3	.361

AC = air conduction, BC = bone conduction, dB = decibel, PTA = pure-tone average, SRT = speech recognition threshold.

* Student *t* test.

bone conduction were significantly higher in both ears of the special forces group compared to the control group.

These findings highlight the significant risk of NIHL faced by special police forces personnel due to occupational noise exposure. This can have a detrimental impact on their ability to communicate effectively in operational settings, potentially compromising mission success and situational awareness. Additionally, hearing loss can negatively affect overall quality of life.

Adult-onset disabling hearing loss linked to occupational noise exposure accounts for a significant public health burden. Globally, this translates to 16% of such cases, exceeding 4 million disability-adjusted life years. The impact varies regionally, with a range of 7% to 21%.[4]

Occupational hearing loss is a prevalent problem in various occupational groups. Industrial workers, firefighters, shipyard workers and musicians who are regularly exposed to loud noises are at an increased risk for this condition. Military personnel also constitute an occupational group that is significantly at risk for NIHL.[5] As part of their daily operations, soldiers handle high-decibel equipment like firearms, explosives, and motorized vehicles, creating a constant risk of hearing loss.[10–12] Numerous studies have demonstrated that the risk of developing hearing loss increases with increased service duration.[12,13]

The prevalence of hearing loss and tinnitus among military personnel is significantly higher than in the general population. According to a study by Irgen-Hansen et al,[14] the prevalence of hearing loss among Norwegian navy personnel was 31.4 %. A study conducted by Kaewboonchoo et al[15] found that the prevalence of hearing loss among Thai navy officers was 39.6%. The study by Win et al[16] found a high prevalence of occupational NIHL among police force personnel in Brunei Darussalam, with 34.2% of the participants affected. They reported a significantly higher prevalence of NIHL in males (37.7%) compared to females (23.9%). Among males, the highest prevalence was observed in the 30 to 39 year-age group (40.8%), while for females, it was highest in the 50 to 59 year- age group (54.5%). Moreover, personnel who served for 16 to 30 years exhibited the highest NIHL prevalence across both genders (males: 50.5%, females: 72.7%).[16] These findings suggest an interaction between age, gender and duration of service in influencing NIHL susceptibility. In consistent with the previous studies, our study demonstrated that the hearing thresholds of Turkish Special Forces personnel were higher than the normal population across all frequencies.

Exposure to noise can lead to various degrees of hearing loss, which can be either temporary or permanent. Temporary threshold shift is defined as a temporary reduction in hearing that typically recovers within 48 hours after exposure to noise. Although it is temporary, individuals who experience it are at an increased risk of developing permanent hearing loss later in life.[17] High-intensity noise exposure can overwhelm the cochlea ability to repair itself, leading to permanent hearing loss. This

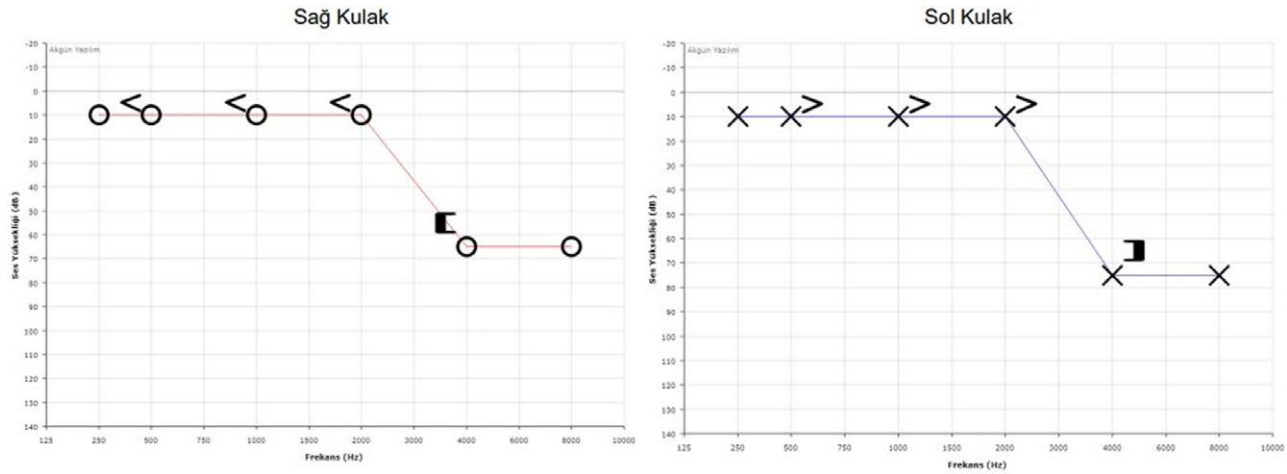

Figure 1. A sample audiogram of a special forces personnel exposed to excessive noise levels.

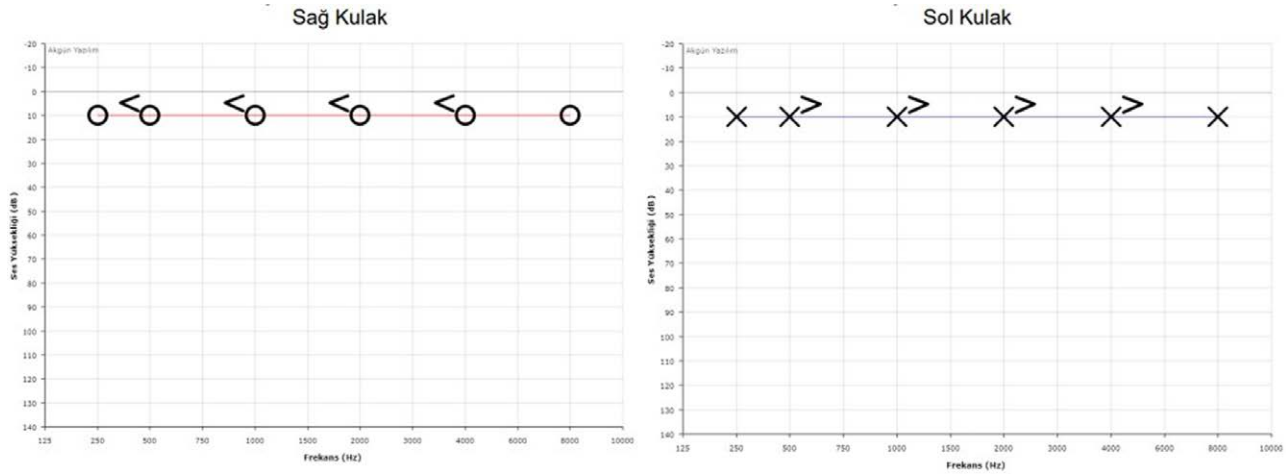

Figure 2. A sample audiogram of a participant from the control group.

irreversible damage is primarily linked to hair cell (HC) loss and malfunction within the cochlea. However, damage to neurons and the lateral wall can also contribute to long-term hearing impairment.[18] Specifically, extremely loud noises, like those from explosions, can cause mechanical damage to the cochlea. This damage can involve direct disruption of the delicate HC structures called stereocilia.[18]

Research suggests that the noise level of a single gunshot can range from 75 to 90 dB for rifles and carbines. Discharges from M-16 rifles and artillery fire have been documented to produce even higher noise levels, reaching 170 dB and 180 dB, respectively. Exposure to such intense sounds can lead to NIHL and permanent hearing damage.[19,20] During both live combat situations and shooting drills, a variety of firearms are utilized. The optimal firing position for a shoulder weapon necessitates an angled head, leading to a disparity in sound pressure experienced by each ear. Therefore, right-handed shooters experience significantly higher noise exposure in their left ear, compared to their right ear, with a difference of around 40 dB due to the head-shadow effect.[21] In the case of revolver gunfire, the symmetrical head position relative to the sound source negates the head-shadow effect. Due to this positioning, both ears are exposed to similar sound pressure levels.[21]

The use of earplugs significantly reduces the risk of NIHL and contributes to the preservation of hearing functions.[22,23] Despite the Republic of Korea (ROK) Army, Navy, and Air Force providing personal hearing protection to military personnel in the form of earplugs and conducting training to prevent NIHL, there has been an observed increase in NIHL cases among ROK military personnel.[24] A study by Kim et al.[25] investigating hearing health among ROK military personnel found a significant association between earplug usage and hearing loss. Compared to the personnel who always used earplugs, those who occasionally wore them were 1.48 times more likely to experience hearing loss. The risk was even higher for those who never used earplugs, with a 1.53 times greater likelihood of hearing loss compared to the consistent earplug users.

In a study evaluating NIHL in South Korean military personnel, who fired the K-2 rifle, right-handed individuals were instructed to wear the earplug on their left ear, while left-handed individuals were instructed to wear them on their right ear. They showed that hearing loss was prevented by the head-shadow effect. According to their results, using a protective device on only 1 ear can effectively prevent hearing damage while still allowing for situational awareness and potentially avoiding safety incidents.[19]

The present study has some limitations. Firstly, the sample size was relatively small, potentially limiting the generalizability of the findings. Secondly, the study was the lack of precise information on the duration of noise exposure and the potential influence of additional noise sources, including recreational activities. However, this is the first study to investigate hearing loss among Turkish special police forces personnel.

Longitudinal studies with larger sample sizes are needed to track hearing health changes in Turkish special police forces personnel over time and establish a causal link with noise exposure. Investigating noise exposure patterns of training and operations can help identify specific high-risk activities. Evaluating the effectiveness of existing hearing protection measures and exploring potential improvements can inform preventive strategies.

Furthermore, the application of hearing aids in the rehabilitation of special forces personnel experiencing hearing loss warrants further investigation. The Matrix Sentence Test, specifically designed to assess speech intelligibility in noise, presents a promising tool for both device selection and efficacy evaluation.[26] Additionally, in a study conducted by Alberti et al,[27] they explored NIHL risks among specific healthcare professionals. Their proposed protocol incorporates questionnaires, audiometry, and additional diagnostic tests like the free-field Matrix sentence test. This comprehensive approach can effectively identify potential hearing disorders in healthcare workers exposed to loud noises during procedures. Integrating this protocol would offer a more in-depth analysis of potential hearing damage within noise- exposed population.

5. Conclusion

In conclusion, Turkish special police forces personnel had a significantly higher hearing thresholds compared to a healthy control group. These findings suggest that chronic exposure to loud noises during training and military operations may contribute to hearing loss among special police forces personnel. There is a need for effective hearing conservation programs to protect the hearing health of this population. Such programs should include measures to reduce noise exposure, such as the use of hearing protection devices, and regular audiometric monitoring to identify and track hearing loss. Early intervention can help minimize hearing loss and manage its consequences. And, educational programs for special forces personnel on the dangers of noise exposure and the importance of hearing conservation can promote safe practices and encourage compliance with hearing protection protocols.

Author contributions

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