https://doi.org/10.23925/2176-2724.2026v38i4e75441

Relationship between audiometric findings and occupational aspects among military police officers

Relação entre achados audiológicos e os aspectos ocupacionais em policiais militares

Relacion entre los hallazgos de los exámenes audiológicos y los aspectos ocupacionales en policías miliatres

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Abstract

Introduction: Noise-induced hearing loss is a neurosensory, irreversible, and usually bilateral condition resulting from continuous exposure to high noise levels. Military police officers work in environments with intense noise, which may lead to auditory alterations before deficits become perceptible on pure-tone audiometry. **Objective:** To characterize the audiological profile and to associate audiological findings with auditory and extra-auditory complaints in military police officers exposed to occupational noise. **Methods:** 27 police officers participated and underwent pure-tone audiometry, high-frequency audiometry, assessment of ipsilateral and contralateral acoustic reflexes, and distortion-product otoacoustic emissions. **Results:** Alterations in pure-tone audiometry were observed in 18.5%

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Received: 03/15/2026
Accepted: 09/17/2026

of right ears and 14.8% of left ears, while high-frequency audiometry showed alterations in 22.2% and 18.5%, respectively. Otoacoustic emissions indicated outer hair cell impairment in 44.4% of right ears and 48.1% of left ears. Length of service showed a significant association with high-frequency audiometry abnormalities; however, no association was observed with the presence of auditory symptoms in the studied population. **Conclusion:** The results indicate a risk of early-onset auditory changes in this population, with a relationship observed between length of service and abnormal high-frequency audiometry results. These results reinforce the need for periodic audiological monitoring and the implementation of hearing conservation programs for this population.

Keywords: Hearing; Occupational Noise; Noise-Induced Hearing Loss; Occupational Health; Police.

Resumo

Introdução: A Perda Auditiva Induzida por Ruído é uma condição neurossensorial, irreversível, geralmente bilateral, decorrente da exposição contínua a ruídos elevados. Policiais militares atuam em ambientes com ruídos intensos, podendo desencadear alterações auditivas antes de déficits perceptíveis na audiometria tonal. **Objetivo:** Caracterizar o perfil audiológico e associar os achados audiológicos às queixas auditivas e extra-auditivas em policiais militares expostos ao ruído ocupacional. **Metodologia:** Participaram 27 policiais que foram submetidos à audiometria tonal limiar e de alta frequência, à pesquisa dos reflexos acústicos e às emissões otoacústicas evocadas produto de distorção. **Resultados:** Alterações na audiometria tonal ocorreram em 18,5% das orelhas direitas e 14,8% das esquerdas, e na audiometria de alta frequência em 22,2% e 18,5%, respectivamente. As emissões otoacústicas evidenciaram comprometimento em 44,4% das orelhas direitas e 48,1% das esquerdas. O tempo de serviço apresentou associação significativa com alterações na audiometria de altas frequências, no entanto, não foi observada associação com a presença de sintomas auditivos na população estudada. **Conclusão:** Os resultados evidenciam risco de alterações auditivas precoces nesta população, havendo uma relação entre tempo de serviço e audiometria de alta frequência alterada. Assim, reforça-se a necessidade de monitoramento audiológico periódico e implementação de programa de conservação auditiva nesta população.

Palavras-chave: Audição; Ruído Ocupacional; Perda Auditiva Provocada por Ruído; Saúde do Trabalhador; Polícia.

Resumen

Introducción: La pérdida auditiva inducida por ruido es una condición neurosensorial, irreversible y generalmente bilateral, derivada de la exposición continua a niveles elevados de ruido. Los policías militares actúan en ambientes con ruidos intensos, lo que puede desencadenar alteraciones auditivas antes de que se evidencien déficits en la audiometría tonal. **Objetivo:** Caracterizar el perfil audiológico y asociar los hallazgos audiológicos con las quejas auditivas y extraauditivas en policías militares expuestos al ruido ocupacional. **Metodología:** Participaron 27 policías que fueron sometidos a audiometría tonal y de altas frecuencias, evaluación de los reflejos acústicos ipsilaterales y contralaterales y emisiones otoacústicas evocadas por producto de distorsión. **Resultados:** Se observaron alteraciones en la audiometría tonal en el 18,5% de los oídos derechos y en el 14,8% de los oídos izquierdos, y en la audiometría de altas frecuencias en el 22,2% y el 18,5%, respectivamente.Las emisiones otoacústicas evidenciaron compromiso de las células ciliadas externas en el 44,4% de los oídos derechos y en el 48,1% de los izquierdos. La antigüedad laboral mostró una asociación significativa con los cambios en la audiometría de alta frecuencia; sin embargo, no se observó ninguna asociación con la presencia de síntomas auditivos en la población estudiada. **Conclusión:** Los resultados ponen de manifiesto el riesgo de sufrir una pérdida auditiva precoz en esta población, observándose una correlación entre la antigüedad en el servicio y las anomalías en la audiometría de alta frecuencia. Por lo tanto, se refuerza la necesidad de realizar un seguimiento audiológico periódico y de implementar un programa de conservación auditiva en esta población.

Palabras clave: Audición; Ruido ocupacional; Pérdida auditiva inducida por ruido; Salud Laboral; Policía.

Introduction

Military police officers are professionals within the administrative police structure of the State Executive Branch responsible for overt and preventive policing and immediate law-enforcement actions aimed at maintaining public order[1]. In general, they perform their duties in outdoor environments and are continuously exposed to different sound sources, such as urban traffic, radio communication devices, sirens, and other environmental noise[2]. Exposure to unwanted sound at high intensities and for prolonged periods is known to adversely affect human health[3].

Firearms used as occupational tools generate high-impact noise. Therefore, during their professional activities, military police officers are exposed to occupational risks associated with intense and continuous noise. Excessive noise exposure may lead to auditory disorders, such as noise-induced hearing loss (NIHL) or acoustic trauma, as well as auditory and non-auditory symptoms, including dizziness, tinnitus, sleep disturbances, cardiovascular disorders, stress, fatigue, psychological tension, nervousness, difficulties in social relationships, irritability, and alterations in the nervous, cardiovascular, pulmonary, metabolic, and endocrine systems[4].

NIHL is defined as a gradual decline in hearing acuity resulting from continuous exposure to high noise levels and is characterized as sensorineural hearing loss that is typically bilateral and irreversible, with progression tending to cease after exposure to the harmful agent is discontinued[5].

A study conducted with 200 military police officers in the state of São Paulo identified occupational hearing loss in 22.75% of the participants, with the left ear affected in 48 individuals (24%) and the right ear in 43 individuals (21.5%)[6]. Another study involving 43 police officers exposed to noise demonstrated a statistically significant difference in hearing thresholds at 6.0 kHz compared with the control group. The authors showed that, although most of the evaluated population had hearing thresholds within normal limits, there was a significant prevalence of auditory alterations suggestive of NIHL[7]. In addition, evidence has demonstrated the prevalence of NIHL among traffic police officers in Bangladesh, with hearing loss identified in 24% of the officers studied, particularly at frequencies of 4 and 6 kHz[8]. In addition to hearing loss, auditory symptoms such as tinnitus have also been reported8, further highlighting the adverse effects on quality of life.

Noise exposure also negatively affects quality of life. A study involving 46 military police officers showed that 50.4% believed that noise regularly affected their health, 56.5% their overall well-being and disposition, and 52.6% their attention and concentration during occupational activities[4].

The literature has indicated that length of service is a determining factor in the progressive increase in hearing thresholds, demonstrating that prolonged exposure to occupational noise is associated with a greater risk of auditory alterations. Studies have shown that workers exposed to high noise levels for prolonged periods tend to exhibit greater hearing impairment than those with shorter exposure durations[9-11].

Thus, occupational hearing health should be a concern in this population, and actions aimed at promoting hearing health and preventing hearing loss should be implemented within hearing conservation programs. Therefore, early identification of hearing loss is important, considering that hearing impairment resulting from noise exposure is progressive and irreversible[4].

Among the strategies used to monitor workers' hearing health is periodic assessment by means of pure-tone audiometry (PTA). However, occupational hearing loss may remain underdiagnosed in its early stages when assessment is restricted to conventional audiological methods, since cochlear alterations at high frequencies may not be identified[12].

Within this context, high-frequency audiometry (HFA) and otoacoustic emissions are complementary and more sensitive procedures for assessing and monitoring hearing acuity. HFA has been described in the literature as a method for the early diagnosis of hearing loss because it evaluates the most basal region of the cochlea13. Scientific evidence indicates a 40% increase in the identification of auditory alterations when high-frequency audiometry is performed in addition to conventional pure-tone audiometry, demonstrating the greater sensitivity of HFA for the early detection of cochlear impairment[13].

Another procedure that is sensitive to the early identification of occupational hearing loss is distortion-product otoacoustic emissions (DPOAEs). DPOAEs provide objective measures of outer hair

cell function, allowing cochlear impairment to be identified even when conventional audiometric thresholds remain within normal limits[14].

The literature documents that individuals with NIHL tend to show initial involvement at higher frequencies, which is often reflected in reduced DPOAE amplitudes. Thus, the combined use of HFA and DPOAEs represents a highly sensitive approach for the early diagnosis of auditory alterations related to occupational noise exposure[14]. Accordingly, investigating these two procedures within the same population is highly valuable for supporting the selection of the most appropriate hearing-monitoring protocol for hearing conservation programs.

Furthermore, the systematic collection of epidemiological data on occupational hearing loss and its impact on police officers is essential to support the development of public policies, as well as the implementation of measures for hearing health promotion, prevention, and surveillance. Therefore, the present study aimed to characterize the audiological profile of military police officers and to investigate the associations between audiological findings, auditory and non-auditory symptoms, and occupational factors.

Methods

This observational, cross-sectional study with a quantitative approach was conducted at a public university. The study was conducted in accordance with Resolution No. 466/12 of the Brazilian National Health Council and was approved by the institution's Research Ethics Committee under CAAE No. 6.293.392 on September 11, 2023. All participants were informed about the objectives, procedures, and risks of the study and provided written informed consent by signing the Informed Consent Form.

Sample and selection criteria

The sample consisted of military police officers from the state of Espírito Santo working in the Greater Vitória metropolitan area. Participants were selected using non-probability convenience sampling, characterized by the recruitment of individuals who are readily accessible to the researcher[15]. The study was publicized through electronic flyers posted on social media and informational materials distributed at military police battalions.

Individuals were included if they met the following criteria: being on active duty in the police force; being between 25 and 55 years of age; having at least five years of experience in outdoor activities; and having undergone 14 hours of auditory rest before the examinations. Individuals older than 55 years were excluded to reduce the possibility of age-related hearing loss, such as presbycusis. Participants with a history of hearing loss prior to joining the police force and those presenting type B or type C tympanograms were also excluded[16].

Data collection procedures

All procedures were performed by qualified and trained speech-language pathologists and audiologists. All equipment used in the study was calibrated in accordance with ISO 389-1 SPL, ISO 389-3 SPL, ISO 389-5 SPL, and IEC 60645 standards.

The case history protocol was adapted from a previous study4 and administered through a structured interview to obtain sociodemographic, clinical, and occupational information, including length of service, workload, additional shifts, non-occupational activities, and auditory and non-auditory symptoms, thereby allowing characterization of the sample profile.

Before the audiological procedures, the external auditory canal was inspected using a *Center Medic* otoscope to rule out obstructive conditions that could preclude examination.

Conventional pure-tone audiometry was performed using air conduction and, when necessary, bone conduction to determine hearing thresholds at frequencies ranging from 0.25 to 8.0 kHz. High-frequency audiometry was performed at frequencies ranging from 10.0 to 18.0 kHz. Both assessments were conducted using the descending technique17. All procedures were performed using an *Interacoustics* AD629 audiometer with HDA 300 headphones. Conventional pure-tone audiometry results were classified according to the criteria proposed by Lloyd and Kaplan (1978), whereas high-frequency audiometry results were classified according to the criteria of Rodriguez-Valient et al. (2014), as cited by the Brazilian System of Speech-Language Pathology and Audiology Councils[17]. Both procedures were considered altered when at least one frequency showed a threshold above the normal reference value.

Acoustic immittance measurements were performed using tympanometry with a 226-Hz probe

tone, assessment of contralateral acoustic reflexes at 0.5 to 4 kHz, and ipsilateral acoustic reflexes at 1 and 2 kHz. An *Interacoustics* AT235h device with TDH39P headphones was used. Tympanometric curves were classified according to established criteria[16]. Ipsilateral acoustic reflexes were considered "normal" when present and "altered" when absent, whereas contralateral acoustic reflexes were considered "altered" when present at reduced levels, present at elevated levels, or absent[17].

To assess the integrity and function of outer hair cells, distortion-product otoacoustic emissions (DPOAEs) were also evaluated at frequencies of 1.0, 1.4, 2.0, 2.8, 4.0, and 6.0 kHz. A maximum of 1,000 recorded stimuli was established. However, data collection could be terminated when all frequencies reached a signal-to-noise ratio of 6 dB and a signal level ≥ 0 dB SPL, with a minimum of 230 stimuli. An *Otodynamics ILO*, version 6, system was used, with L1 set at 65 dB and L2 at 55 dB, and F1 and F2 frequencies presented at an f2/f1 ratio of 1.22. The analysis of response presence at each frequency followed previously recommended criteria[18]. The examination was considered "altered" when at least one frequency showed a signal-to-noise ratio < 6 dB.

It should be noted that objective measurements of noise levels in the different occupational environments of the evaluated population were not performed.

Statistical analysis

Quantitative data were organized in electronic spreadsheets and subjected to descriptive and inferential statistical analyses. Mean and median values were calculated for the continuous variables age and length of service. The observed length-of-service values, expressed in complete years (8, 9, 10, 11, 12, 14, 16, 17, 26, 29, 31, and 41 years), were treated as distinct categories when constructing contingency tables.

Associations were investigated between occupational factors (length of service and police occupation/specialty) and the presence of auditory symptoms and audiological test results. Associations between these variables were analyzed using Fisher's exact test and the Mann–Whitney test, with the level of statistical significance set at 5%.

Results

A total of 27 military police officers participated in the study, of whom 24 (88.89%) were male, and three (11.11%) were female. The mean age of the participants was 35.3 years (SD = 6.33), with a median of 34 years and a range from 28 to 49 years.

Regarding the functional distribution across police specialties, 18 participants (66.67%) worked in Area Battalions in radio-dispatched incident response (RO), four (14.81%) belonged to the Tactical Force (FT), four (14.81%) to the Mounted Police Regiment (RPMont), and one (3.70%) to the Canine Operations Battalion (BAC).

The mean length of service was 14.3 years (SD = 8.76), with a median of 10 years and a range from 8 to 41 years. Table 1 presents the data regarding self-reported auditory symptoms among the military police officers.

Table 1. Distribution of self-reported auditory symptoms (n = 27)

Symptom		n (%)
Headache	No	14 (51.9%)
	Yes	13 (48.1%)
Irritabiility	No	18 (66.7%)
	Yes	09 (33.3%)
Insomnia	No	15 (55.6%)
	Yes	12 (44.4%)
Hearing difficulty complaint	No	14 (51.9%)
	Yes	13 (48.1%)
Tinnitus	No	18 (66.7%)
	Yes	09 (33.3%)

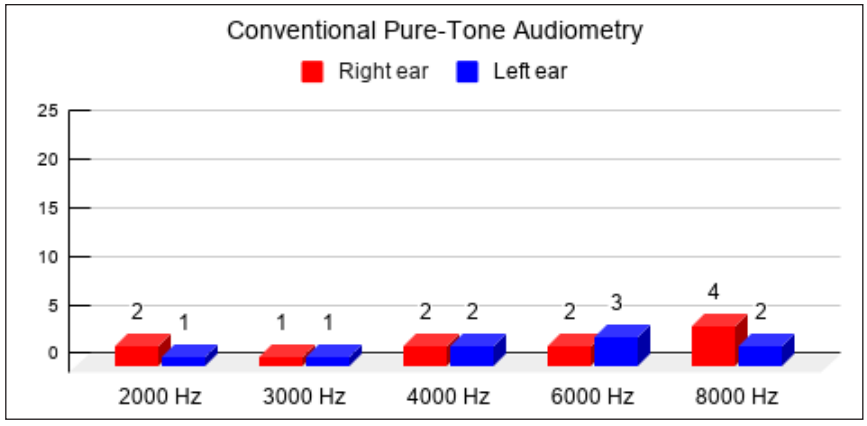
Table 2 presents the results of the audiological examinations for both ears. For the analysis of DPOAEs, data from 26 participants were considered as one participant did not complete this stage of the assessment. A higher proportion of alterations was observed in high-frequency audiometry than in conventional pure-tone audiometry. Overall, contralateral acoustic reflexes and DPOAEs showed a higher frequency of alterations compared with the audiometric assessments (Table 2).

Table 2. Distribution of conventional pure-tone audiometry, high-frequency audiometry, ipsilateral and contralateral acoustic reflex (n = 27), and distortion-product otoacoustic emission results (n = 26)

Audiological assessment		n (%)
PTA – RE	Normal	22 (81.5%)
	Abnormal	5 (18.5%)
PTA – LE	Normal	23 (85.2%)
	Abnormal	4 (14.8%)
HFA – RE	Normal	21 (77.8%)
	Abnormal	6 (22.2%)
HFA – LE	Normal	22 (81.5%)
	Abnormal	5 (18.5%)
Ipsilateral AR – RE	Normal	21 (77.8%)
	Abnormal	6 (22,2%)
Ipsilateral AR – LE	Normal	23 (85.2%)
	Abnormal	4 (14.8%)
Contralateral AR – RE	Normal	16 (59.3%)
	Abnormal	11 (40.7%)
Contralateral AR – LE	Normal	13 (48.1%)
	Abnormal	14 (51.9%)
DPOAEs – RE	Normal	14 (51.9%)
	Abnormal	12 (44.4%)
	Not performed	1 (3.7%)
DPOAEs – LE	Normal	13 (48.1%)
	Abnormal	13 (48.1%)
	Not performed	1 (3.7%)

Abbreviations: PTA, pure-tone audiometry; HFA, high-frequency audiometry; AR, acoustic reflex; DPOAEs, distortion-product otoacoustic emissions; RE, right ear; LE, left ear.

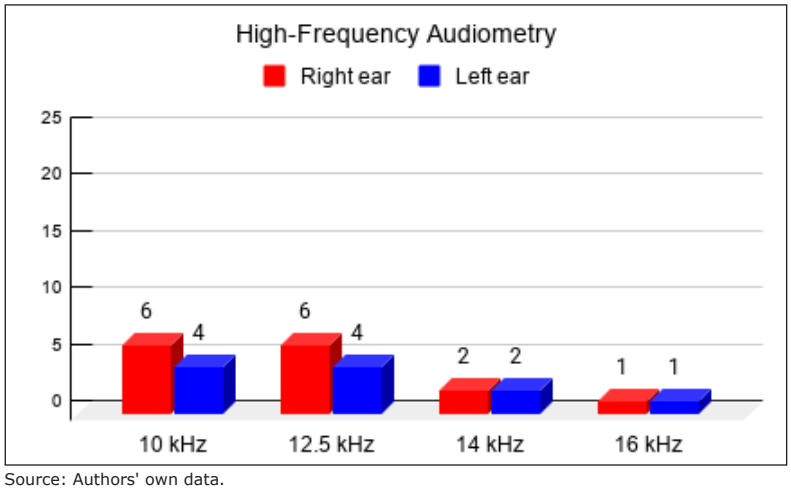
Figure 1 shows the number of right and left ears affected at each frequency. For conventional audiometry, 22 participants had hearing thresholds within normal limits (≤ 25 dB) in the right ear (RE), and 23 had thresholds within normal limits in the left ear (LE). Five participants presented hearing loss, four of whom had bilateral hearing loss. Accordingly, five individuals showed impairment in the RE: three had isolated hearing loss at a single frequency (2 or 8 kHz), one had isolated sensorineural hearing loss at three frequencies (4, 6, and 8 kHz), and one had mild sensorineural hearing loss. Regarding the LE, four participants showed auditory alterations: one had isolated hearing loss at a single frequency (6 kHz), and three had isolated sensorineural hearing loss, including two participants with alterations at three frequencies (4, 6, and 8 kHz) and one participant with alterations at two frequencies (2 and 3 kHz).



Source: Authors' own data.

Figure 1. Distribution of hearing alterations according to frequency in conventional pure-tone audiometry (n = 27).

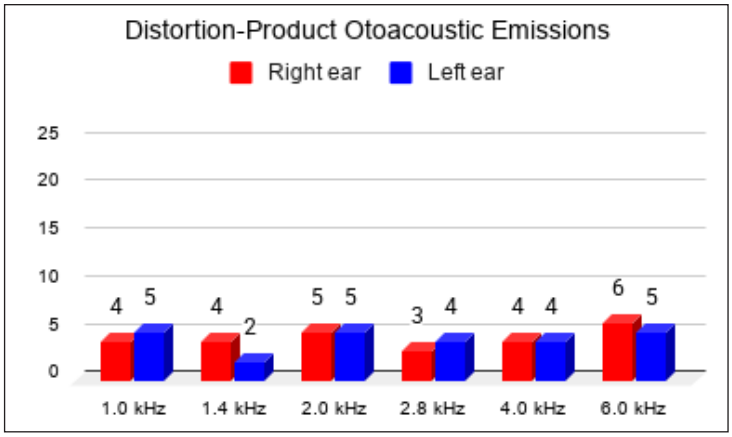
Figure 2 presents the number of altered frequencies in the right and left ears, illustrating the distribution of high-frequency hearing loss.



Source: Authors' own data.

Figure 2. Distribution of hearing alterations by frequency in high-frequency audiometry (n = 27).

Regarding the distribution of altered DPOAE frequencies, shown in Figure 3, the highest prevalence of alterations in the right ear (RE) occurred at 4.0 and 6.0 kHz. In the left ear (LE), 1.0 kHz showed the highest percentage of altered results, followed by 6.0 kHz.



Source: Authors' own data.

Figure 3. Distribution of distortion-product otoacoustic emission alterations according to frequency (n = 26).

When the association between military police specialty and auditory symptoms and audiological findings was analyzed using Fisher's exact test, no statistically significant associations were observed for any of the symptoms or audiological findings ($p > 0.05$), as shown in Table 3.

Table 3. Association between police specialty and auditory symptoms, high-frequency audiometry, conventional pure-tone audiometry, ipsilateral and contralateral acoustic reflex (n = 27), and distortion-product otoacoustic emission results (n = 26)

Variable	
Auditory symptoms	**p-value**
Headache	1.000
Irritability	0.113
Insomnia	0.909
Hearing complaint	0.139
Tinnitus	0.113
Audiological assessments	
PTA – RE	0.429
PTA – LE	1.000
HFA – RE	1.000
HFA – LE	1.000
Ipsilateral AR – RE	0.835
Ipsilateral AR – LE	0.628
Contralateral AR – RE	0.912
Contralateral AR – LE	0.158
DPOAEs – RE	0.521
DPOAEs – LE	1.000

Abbreviations: PTA, pure-tone audiometry; HFA, high-frequency audiometry; AR, acoustic reflex; DPOAEs, distortion-product otoacoustic emissions; RE, right ear; LE, left ear.

A statistically significant association was observed between length of service and alterations in some audiological tests, particularly high-frequency audiometry in the right (p = 0.006) and left ears (p = 0.040), as well as conventional pure-tone audiometry in the left ear (p = 0.015). In contrast, no significant associations were observed between length of service and auditory symptoms or the other audiological examinations (p > 0.05), as shown in Table 4.

Table 4. Association between length of service and auditory symptoms, high-frequency audiometry, conventional pure-tone audiometry, ipsilateral and contralateral acoustic reflex (n = 27), and distortion-product otoacoustic emission results (n = 26)

Variable	
Auditory symptoms	**p-value**
Headache	0.506
Irritability	0.310
Insomnia	0.308
Hearing complaint	0.727
Tinnitus	0.563
Audiological assessments	
PTA – RE	0.102
PTA – LE	0.015*
HFA – RE	0.006*
HFA – LE	0.040*
Ipsilateral AR – RE	0.349
Ipsilateral AR – LE	0.956
Contralateral AR – RE	0.169
Contralateral AR – LE	0.413
DPOAEs – RE	0.797
DPOAEs – LE	0.678

Abbreviations: PTA, pure-tone audiometry; HFA, high-frequency audiometry; AR, acoustic reflex; DPOAEs, distortion-product otoacoustic emissions; RE, right ear; LE, left ear.
*Statistically significant association at p < 0.05 (Fisher's exact test).

As shown in Table 5, the Mann–Whitney test revealed no statistically significant difference in length of service between police officers with and without auditory or related symptoms (headache, irritability, insomnia, hearing complaints, and tinnitus; p > 0.05). In contrast, longer length of service was significantly associated with audiological alterations, particularly in high-frequency audiometry in both the right (p = 0.006) and left ears (p = 0.038), as well as in conventional pure-tone audiometry (RE: p = 0.022; LE: p = 0.008). No statistically significant differences were observed for the remaining examinations (p > 0.05).

Table 5. Comparison of length of service (years) according to the presence or absence of symptoms and normal or abnormal audiological test results

Variable	Group	n	Length of service, mean (SD), years	Length of service, Median, years	p-value
Symptoms					
Headache	No	14	17.6 (11.1)	10.5	0.310
	Yes	13	10.8 (2.73)	10.0	
Irritability	No	18	14.9 (9.64)	10.0	0.793
	Yes	9	13.1 (7.03)	10.0	
Insomnia	No	15	13.9 (9.41)	10.0	0.803
	Yes	12	14.8 (8.27)	10.0	
Hearing complaint	No	14	13.6 (8.25)	10.0	0.359
	Yes	13	15.1 (9.56)	10.0	
Tinnitus	No	18	13.4 (7.46)	10.0	0.358
	Yes	9	16.1 (11.2)	10.0	
Audiological assessments					
HFA – RE	Normal	21	10.6 (2.40)	10.0	**0.006***
	Abnormal	6	27.5 (10.4)	29.0	
HFA – LE	Normal	22	12.0 (5.52)	10.0	**0.038***
	Abnormal	5	24.8 (13.1)	29.0	
PTA – RE	Normal	22	12.1 (6.21)	10.0	**0.022***
	Abnormal	5	24.0 (12.4)	26.0	
PTA – LE	Normal	23	12.0 (6.08)	10.0	**0.008***
	Abnormal	4	27.5 (11.1)	27.5	
Ipsilateral AR – RE	Normal	21	13.5 (8.59)	10.0	0.341
	Abnormal	6	17.3 (9.48)	13.5	
Ipsilateral AR – LE	Normal	23	14.3 (8.83)	10.0	0.917
	Abnormal	4	14.5 (9.68)	10.0	
Contralateral AR – RE	Normal	16	12.4 (8.05)	10.0	0.137
	Abnormal	11	17.2 (9.35)	12.0	
Contralateral AR – LE	Normal	13	10.0 (1.53)	10.0	**0.050***
	Abnormal	14	18.4 (10.7)	14.0	
DPOAEs – RE	Normal	14	10.7 (2.58)	10.0	0.122
	Abnormal	12	18.9 (11.5)	12.5	
DPOAEs – LE	Normal	13	11.4 (4.62)	10.0	0.287
	Abnormal	13	17.5 (11.1)	11.0	

Abbreviations: SD, standard deviation; PTA, pure-tone audiometry; HFA, high-frequency audiometry; AR, acoustic reflex; DPOAEs, distortion-product otoacoustic emissions; RE, right ear; LE, left ear. Mann–Whitney test.
*Statistically significant difference.

Discussion

The present study had limitations that were considered when interpreting the results. The relatively small sample size and the study design based on a non-parametric dataset should be highlighted, as these factors may limit the generalizability of the findings to other populations. The limited sample size resulted primarily from difficulties in participant adherence associated with operational aspects inherent to police work, including rigid duty schedules, limited time availability, and the need to travel to the audiology laboratory. This scenario is consistent with methodological challenges described in the literature, which indicate that studies involving military police officers frequently face barriers related to access, recruitment, and engagement because of the institutionally restricted nature of police organizations and logistical difficulties in contacting potential participants. In this context, conducting studies with this population requires formal authorization, adaptation to work routines, and specific recruitment strategies, factors that may affect sample composition and favor self-selection bias, a condition consistent with that observed in the present study[6].

The sample was predominantly male (88.89%), a proportion that reflects the demographic profile characteristic of military police forces in Brazil19 and has also been reported in another study[6]. The mean age (35.3 years; SD = 6.33) and mean length of service (14.3 years; SD = 8.76) also place the study population within a period particularly relevant to the development of hearing loss associated with occupational auditory risk exposure. The literature indicates that hearing loss resulting from prolonged noise exposure tends to progress more markedly during the first 10 to 15 years of exposure[20], while a mean age of approximately 35 years reduces the potential influence of age-related factors.

Conventional pure-tone audiometry revealed hearing loss in 16.7% of the ears, with 6.0 and 8.0 kHz being the frequencies most frequently affected. These findings were similar to those reported in a previous study[6]. However, it is important to emphasize that, in the cited study, this percentage referred only to cases classified as NIHL according to the recommended classification criteria[6].

In the present study, the prevalence of alterations detected by HFA was 22.2% in the right ear and 18.5% in the left ear, values that were not substantially higher than those obtained with conventional pure-tone audiometry (14.8% to 18.5%). Most participants who showed alterations in conventional pure-tone audiometry also exhibited alterations in HFA. This finding is consistent with what has been widely described in the literature, which identifies HFA as a more sensitive marker of early cochlear impairment, capable of revealing subclinical changes even before they are detected by conventional audiological examinations. Scientific evidence highlights the fundamental role of HFA in monitoring individuals exposed to intense and continuous noise because it enables the identification of early changes, often preceding the onset of auditory complaints. From a physiological perspective, high frequencies correspond to the basal region of the cochlea, which is considered the area most susceptible to the harmful effects of occupational noise[13].

It is relevant to consider that the sample in the present study consisted predominantly of young adults, with a mean age of 35 years (SD = 6.33). Studies have reported that age is an important modulator of vulnerability to cochlear alterations and is associated with progressive deterioration of outer hair cell function and increased hearing thresholds, particularly at higher frequencies[21]. In this regard, a predominantly young population tends to exhibit less physiological deterioration of the auditory system, which may attenuate or even mask expected differences between assessment methods, particularly those designed to detect early subclinical alterations[21]. The discrepancies between the findings of the present study and those of previous investigations may also be related to the different classification criteria adopted to determine the degree of hearing loss. Whereas some studies used the classification proposed by Lloyd and Kaplan (1978), based on the three-frequency pure-tone average (≤ 25 dB) as the criterion for normal hearing, others applied the criteria described by Lopes, Munhoz, and Bozza (2015), which consider the analysis of each individual frequency within the normal range (≤ 25 dB).

Contralateral acoustic reflexes showed a substantial frequency of alterations, observed in 40.7% of right ears and 51.9% of left ears. These findings may suggest that acoustic reflex assessment can reveal functional impairments of the auditory system that are not identified by conventional pure-tone audiometry, particularly at early or subclinical stages. The literature indicates that, although the absence or elevation of acoustic reflex thresholds is not considered a highly sensitive marker for the early detection of NIHL, alterations in the reflex may reflect subtle dysfunctions of the auditory pathway, including cochlear impairment and/or changes in the integrity of the neurophysiological connections involving the middle ear and brainstem[23]. Studies involving populations exposed to occupational noise have demonstrated that individuals with mild or moderate hearing loss, and even those with normal hearing, may present altered acoustic reflex thresholds or patterns consistent with recruitment, suggesting the presence of auditory stress not detected by traditional psychoacoustic methods[24]. Although acoustic reflex assessment does not replace pure-tone audiometry and does not constitute an isolated marker of occupational hearing loss, its ability to reveal early functional alterations could justify its inclusion in audiological surveillance protocols. In the present study, the higher occurrence of alterations observed in the left ear may reflect differences in noise exposure or individual variations in susceptibility, phenomena previously described in literature[23,24].

Evidence from other studies also indicates that alterations in contralateral acoustic reflexes, even in the presence of normal audiometric thresholds, may indicate dysfunction of central auditory pathways because these reflexes involve neural structures related to Central Auditory Processing (CAP) abilities. Such alterations may affect auditory abilities and may therefore represent potential biomarkers of Central Auditory Processing Disorder (CAPD). Consequently, assessing contralateral acoustic reflexes is a relevant complementary tool in individuals with suspected CAPD[25,26]. In this context, complaints of hearing difficulty in the presence of normal hearing thresholds could be related to an association between occupational noise exposure and the integrity and functional characteristics of the structures comprising the stapedius reflex arc and their influence on auditory performance, rather than to a cochlear or sensory alteration. Controlled studies with larger samples could be conducted to investigate a possible association between occupational noise exposure, CAP alterations, and acoustic reflexes.

Alterations in DPOAEs were also observed in the present study, indicating possible functional impairment of outer hair cells even in the absence of hearing loss detectable by traditional psychoacoustic methods. These findings are consistent with well-established evidence in the literature showing that DPOAEs constitute objective, sensitive, and early markers of cochlear damage in noise-exposed individuals with normal hearing. Cochlear injury may therefore be identified through reductions in otoacoustic emission (OAE) amplitude or the absence of emissions even when psychoacoustic assessments show no abnormalities[27]. In a cross-sectional study of workers exposed to occupational noise who had normal audiometric thresholds, the probability of absent otoacoustic emissions was approximately 12 times higher in the exposed group than in the control group, particularly at frequencies of 3, 4, and 6 kHz[11,28]. Two other studies reported that alterations in OAEs preceded increases in audiometric thresholds, suggesting that OAEs may serve as sensitive markers of subclinical cochlear damage28,29. These findings also indicate that conventional pure-tone audiometry alone may not be sufficient for the early detection of auditory alterations in this population and that OAEs may contribute to preventive interventions and occupational hearing health surveillance.

No association was observed between police specialty and auditory symptoms or audiological findings (Table 3). Previous studies have suggested that auditory risk is more closely related to cumulative exposure over time than to the specific occupational function performed[6,7].

In the present study, length of service was significantly associated with alterations in HFA thresholds (RE: $p = 0.006$; LE: $p = 0.038$), conventional pure-tone audiometry (LE: $p = 0.008$; RE: $p = 0.022$), and contralateral acoustic reflexes in the left ear ($p = 0.050$), indicating a higher frequency of auditory alterations among police officers with longer service duration. In this regard, studies indicate that the duration of occupational noise exposure is one of the main predictors of auditory alterations[4,6,29], particularly at high frequencies[10]. A longitudinal study showed that workers with more than 10 years of exposure presented moderate to severe hearing loss9. Furthermore, in a metallurgical company where workers were exposed to high noise levels (83–102 dB), the prevalence of cases suggestive of hearing loss was significant and was associated with duration of employment at the company[11].

However, in the present study, the influence of other factors cannot be ruled out, including recreational noise exposure, inappropriate use of personal stereo devices, and exposure to other risk agents, since these exposures were not controlled. Regarding the influence of age, the population in the present study consisted predominantly of young and middle-aged adults and was therefore less directly affected by the effects of cellular aging.

The results revealed that approximately half of the participants reported at least one auditory or non-auditory symptom, such as headache (48.1%), insomnia (44.4%), complaints of hearing difficulty (48.1%), or tinnitus (33.3%). Tinnitus was also frequently reported in other studies involving military police officers[6]. The literature indicates that such manifestations may be associated with the physiological stress caused by continuous noise exposure, even in the absence of audiological evidence of hearing loss[4], as well as with occupational stressors, sleep deprivation, emotional overload, and high work demands, conditions extensively documented in the literature involving public safety professionals[4,6].

Although nearly half of the participants reported non-auditory symptoms, no statistically

significant association was observed between these symptoms and the audiological findings. This indicates that the study population may be exposed to broader occupational risks that extend beyond sensory hearing impairment. Therefore, these findings reinforce the need for caution when relying exclusively on clinical reports as indicators of auditory impairment, particularly in occupational groups that may tend to underreport symptoms because of institutional culture, operational demands, and concerns regarding removal from duty.

The study findings indicate the need to implement structured hearing conservation programs (HCPs) specifically targeted at military police officers, including periodic monitoring using sensitive tests such as HFA and DPOAEs, guidance regarding auditory rest, health education, and appropriate use of personal protective equipment (PPE). The absence of systematic hearing surveillance policies for this occupational group, combined with increasing operational demands and exposure to impact noise, may render these professionals vulnerable to NIHL and other biopsychosocial consequences.

Future studies with longitudinal designs, larger samples, and control of occupational noise levels are needed to further elucidate the effects of occupational exposure on hearing among military police officers and to support the development of more effective public policies and healthcare practices.

Conclusion

The findings of the present study indicate that military police officers are at risk of alterations in audiological test results. A high frequency of alterations was observed in distortion-product otoacoustic emissions and high-frequency audiometry, suggesting impairment of cochlear integrity even in the absence of auditory complaints or elevated conventional audiometric thresholds.

An important association was observed between length of service and the presence of alterations in audiological examinations, particularly in conventional pure-tone audiometry and high-frequency audiometry, indicating a risk for the development of occupational hearing loss.

These findings highlight the importance of including complementary audiological assessments in occupational hearing health surveillance protocols.

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