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Effect of live ammunition shooting from an automatic rifle on sense of hearing in proffesional military personnel

Uticaj bojevog gađanja iz automatske puške na čulo sluha kod profesionalnih vojnih lica

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Abstract

Background/Aim. A short-term high-intensity noise from a gunshot impulse that occurs when using infantry weapon, can result in onset of auditory symptoms such as tinnitus, impaired hearing or feeling of pressure in one or both ears. The aim of this study was to examine the effect of live ammunition shooting from an automatic rifle on the hearing sense in professional military personnel. The examination was done in correlation with the conditions of the common shooting practice procedure. **Methods.** The research has been conducted on 22 professional soldiers serving in the Serbian Military, during their regular peacetime training shooting from the automatic rifle AP 7.62 mm M70. The training was conducted on the formational shooting field "Bubanj Potok". The written consent from all subjects was acquired. All subjects were submitted to medical examination prior and after the shooting session. The medical examination consisted of anamnesis, clinical otorhinolaryngological examination, audiometry and impedancemetry. All subjects filled out the following questionnaire forms: "The Questionnaire prior to shooting" and "The questionnaire after shooting." Subjects who were incapable to undergo shooting practice, whether from psychological or physical reasons were excluded from this study. **Results.** After the assessment of received data from 22 subjects, the results were as followed: in 2 (9%) subjects hearing impairment was diagnosed. Tinnitus was registered in 5 (22.7%) patients. One (4.5%) patient reported the feeling of pressure in one ear. One of two cases of one ear hearing impairment was on the rifle holding side and second case was on opposite lateral side. In both cases, hearing loss was of sensorineural type of milder degree, with a scotoma at 4,000 Hz in one case up to 50 dB and the second up to 55 dB. **Conclusion.** Auditory effects of impulse noise that occurs when shooting from automatic rifles cause hearing impairment, tinnitus and a feeling of pressure in the ears. The practical significance of this study lies in prevention which includes the mandatory use of personal protective equipment and functional arrangement of the practice shooting field.

Key words:
military medicine; firearms; noise; hearing tests; serbia.

Apstrakt

Uvod/Cilj. Kod pucanja iz pešadijskog naoružanja nastaje impulsna buka zbog koje se pojavljuju auditivni efekti. Ispoljavaju se u vidu zujanja, pritiska ili oslabljenog sluha na jedno ili oba uva. Cilj rada bio je da ispitamo uticaj bojevog gađanja iz automatske puške na čulo sluha kod profesionalnih vojnih lica u korelaciji sa uslovima izvođenja bojevog gađanja. **Metode.** Istraživanje je, uz pisani pristanak, sprovedeno nad 22 profesionalna pripadnika Vojske Srbije, koji su bili na svom redovnom mirnodopskom zadatku obuke gađanja iz automatske puške AP 7,62 mm M70, na formacijskom strelištu „Bubanj Potok". Kod svih je pre i posle gađanja urađena: anamneza, klinički otorinolaringološki pregled, audiometrijski i impedanciometrijski pregled. Popunjen je

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„Upitnik pre gađanja" i „Upitnik posle gađanja". Iz istraživanja su bili isključeni svi koji psihofizički nisu bili sposobni za gađanje. **Rezultati.** Posle kompletne obrade dobijenih rezultata od 22 ispitanika u dva (9%) slučaja je registrovano oštećenje sluha. Tinitus je registrovan kod pet (22,7%) ispitanika. Kod jednog (4,5%) ispitanika registrovan je osećaj pritiska u uvu. Registrovano je jedno oštećenje uva sa iste i jedno oštećenje uva sa suprotne strane u odnosu na rame o koje su oslanjali pušku. U oba slučaja oštećenje sluha je bilo senzorineuralnog tipa, lakšeg stepena, sa skotomom na 4 000 Hz, u jednom slučaju do 50 dB, a u drugom do 55 dB. **Zaključak.** Impulsna buka prilikom gađanja iz automatske puške dovodi do pojave auditivnih efekata. To su oštećenje sluha, zujanje i osećaj pritiska u ušima. Praktični značaj ove studije ogleda se u prevenciji, koja podrazumeva obaveznu upotrebu ličnih zaštitnih sredstava i uređenje strelišta.

Ključne reči:
medicina, vojna; puška, automatska; buka; sluh, ispitivanje; srbija.

Introduction

Sound is a physical phenomenon, which refers to creation of sound waves that stimulate the sense of hearing. Sound is produced by all objects and bodies that vibrate. The sound is created if the object oscillates and forms a tunable, harmonic vibration. Production of complex and inconsistent vibration is defined as noise [1]. Effects of noise can be non auditive, psychogenic, but primarily, the noise affects the hearing sense organ. Acute acoustic trauma is a consequence of short-term high-intensity noise, for example the gunshot. Due to the nature of their work and exposure to impulse noise from the gunshot, professional military personnel are at greater risk of developing hearing impairment. Symptoms that appear during the use of infantry weapons are: cloged ears, feeling of pressure in ears, tinnitus, impaired hearing (hearing impairment), ear pain (otalgia).

Acoustic trauma afects the inner ear in two ways: by mechanical energy, so-called blast waves, and by acoustic energy wich is absorbed by the sensory cells in cochlea [2]. The acoustic pulse waves formed by a gunshot from infantry weapons has a mechanical effect. Mechanical impulse creates vortices in fluid of the inner ear. The vortices are spread along the basilar membrane and cause direct damage to the ciliated cells, especially external ciliated cells. This may cause a rupture of Reisner membrane, folowed by mixing of endolymph and perilymph, and damage to the sensory cells.

Impulse noise leads to functional overload of sensory structure, caused by metabolic effects. The catabolic processes in cells prevail over the anabolic, which, followed by reduced blood perfusion, leads to vasospasm and hypoxia, causing the functional disorders in reaction of sensory cells [3].

The consequences of these changes are shorter or longer hearing impairment, followed by a „stage of adaptation", later by the "stage of fatigue" which is characterized by exhaustion of sensory cells and ultimately definite degenerative changes and loss of the cell.

Commonly, it is well known that short time after the exposure to the noise, a person has weaker sense of hearing. This is temporary hearing loss, which recovers after a certain period of time spent in silence. By audiometric parameters, it is described as temporary hearing impairment [Temporary Threshold Shift (TTS)]. If exposure to noise is prolonged, permanent hearing loss occurs [Peomanent Treshold Shift (PTS)] [4].

The aim of this study was to examine the effect of live ammunition shooting from an automatic rifle on the hearing sense in professional military personnel. The examination was done in correlation with the conditions of the common shooting practice procedure.

Methods

This prospective observational study was conducted as a pilot project. Approval to conduct the survey was obtained from the Ethics Committee of the Military Medical Academy (MMA), Belgrade, Serbia. The study was conducted on 22 subjects, professional soldiers serving in the Serbian Military, during their regular peacetime training shooting from the automatic rifle AP 7.62 mm M70. The shooting was done on the shooting range "Bubanj Potok". The written consent from all the subjects was acquired. The medical examination prior and after the shooting was done. It consisted of anamnesis, clinical otorhinolaryngological examination, audiometry and impedancemetry. Tonal liminar audiometry was performed by using Madsen Xeta aparatus and tympanometry was done by using Madsen Zodiac 901 aparatus. All subjects filled out the following questionnaire forms: "The questionnainre prior to shooting" and "The questionnaire after the shooting".

"The questionnaire prior to the shooting" had questions that explore previous exposure to impulse noise during active military service, data on how often were subjects exposed to shooting noise during one year, use or non-use of personal protective equipment. It also concidered information on the presence of symptoms after the shooting and whether the treatment was conducted. "The questionnaire after the shooting" contained questions that indicated use or non-use of personal protective equipment and presence of symptoms after the shooting. Subjects who were incapable of undergoing shooting practice, whether from psychological or physical reasons, were excluded from this study.

Noise measurements were done at the shooting range "Bubanj Potok", in the working environment, by professional MMA authority which issued an expert report. The measurement of sound pressure level was done on instrument for noise measurement and analysis, model 2250 D-DOO, with condenser microphone model 4941 manufactured by Brüel & Kjaer, Denmark.

Statistical methods used for the analysis of primary data were descriptive statistical methods and method for statisti-

cal hypotheses testing. Descriptive statistical methods that were used were measurement of central tendency (mean, median), rate variability (standard deviation) and the relative numbers (structure indicators). The methods for testing statistical hypotheses were Wilcoxon test and the McNemar test. The statistical hypotheses were tested at the level of statistical significance (alpha level).

Results

The measured level of impulse noise on the site for shooting supervisor, site number 2, during live ammunition single shooting from AP 7.62 mm M70, on the line of fire in the right sector was 133.1 dB. The measured level of impulse noise on the site for shooting supervisor, site number 2, during burst shooting from AP 7.62 mm M70, on the line of fire in the right sector was 138.2 dB.

Table 1 shows some of variables which were followed during this research and were examined in the questionnaire prior to shooting.

An average age of the subjects was 35.5 ± 6.3 years, the youngest subject was 27 and the oldest one was 51 years old.

The median of active military service of the subjects was 13 years (range 4–26).

The median frequency of shooting with an automatic rifle in one year was 4 times a year (range 2– 11 times a year).

The median frequency of shooting from smaller caliber arms in one year was 2 (range 0–11).

The median frequency of shooting from weapons of greater caliber in one year was 0 (range 0–3).

Forteen % of the subjects relied a rifle on the left shoulder, while 86% of the subjects relied a rifle on the right shoulder.

Personal protective equipment in the previous training shooting sessions was never used by 32% of the subjects, was occasionally used by 41% of the subjects while it was continuously used by 27% of the subjects.

For regular medical assessment 18% of the subjects reported once per year, 73% of the subjects reported once in every two years, while 9% of the subjects reported less frequently than specified. Nine percent of the subjects reported acute hearing problem. Nine percent of the subjects reported different health problems. All the subjects (100%) were physically and psychologically fit for the shooting.

Seven (32%) subjects used personal protective equipment during shooting. Two (9%) subjects used ear plugs, 5 (23%) subjects used cotton plugs. Fifteen (68%) subjects did not use any kind of protection.

Table 2 shows objective examination findings before and after the shooting (otoscopy, regular othorinolaringology examination, audiogram, tympanogram).

All the subjects (100%) had normal otoscopic examination findings before and after the shooting both on left and right ear.

Normal findings had 59% of the respondents, 36% had a diagnosis of *Deviatio septi nasi*, and 5% had a diagnosis *Polyposis nasi*.

Ninety-one percent of the subjects had normal tympanogram on the left ear prior and after the shooting which was calculated as not statistically significant ($p = 1.000$).

The tympanogram of the left ear prior and after the shooting was: Type A had 91%, Type B had 4.5% and Type C had 4.5% of the subjects.

Eighty-six percent of the subjects had regular tympanogram on the right ear prior and after the shooting which was calculated as not statistically significant ($p = 1.000$).

Tympanogram on the right ear prior and after the shooting was: Type A had 86%, Type B had 5% and Type C had 9% of the subjects.

Regular audiogram after the shooting was found in 91% of the subjects. One subject had a damage on the same side as the gun relied shoulder, and one had a damage on the opposite side from the side on which the gun was relied.

In relation to the degree of hearing impairment, in both cases sensorineural hearing loss of the lower level was registered in the form of scotoma at 4,000 Hz. In one case up to 50 dB, while in the other one up to 55 dB.

Table 1

Variables examined in the questionnaire prior to shooting

Variables	Values
Number of subjects	22
Age (years), x ± SD	35.5 ± 6.3
Years of service, median (range)	13.0 (4.0–26.0)
Fequency of shooting from AR/year, median (range)	4.0 (2.0–11.0)
Fequency of shooting from arms of smaller calliber than that of that of AR/year, median (range)	2.0 (0.0–11.0)
Fequency of shooting from arms of greater calliber than AR/year, median (range)	0 (0–3.0)
Rifle lining shoulder, n (%)	
left	3 (14)
right	19 (86)
Use of protective equipement in previous shooting, n (%)	
never	7 (32)
periodically	9 (41)
permanently	6 (27)

***Variables according to "Questionnaire prior to shooting".**
AR – automatic rifle

Table 2

Objective examination findings before and after the shooting

Variables	Values
Otoscopy finding left prior to shooting – normal, n (%)	22 (100)
Otoscopy finding right prior to shooting – normal, n (%)	22 (100)
ORL finding prior to shooting, n (%)	
normal	13 (59)
DSN	8 (36)
polyposis nasi	1 (5)
Audiogram prior to shooting, n (%)	
normal	15 (68)
right impairment	0 (0)
left impairment	3 (14)
both sides impairment	4 (18)
Tympanogram left prior to shooting - normal, n (%)	20 (91)
Tympanogram right prior to shooting - normal, n (%)	19 (86)
Otoscopy finding left after shooting- normal, n (%)	22 (100)
Otoscopy finding right after shooting- normal, n (%)	22 (100)
ORL finding after shooting, n (%)	
normal	13 (59)
DSN	8 (36)
polyposis nasi	1 (5)
Audiogram after shooting, n (%)	
normal	13 (59)
right impairment	1 (5)
left impairment	4 (18)
both sides impairment	4 (18)
Tympanogram left after shooting – normal, n (%)	20 (91)
Tympanogram right after shooting – normal, n (%)	19 (86)

ORL – otorhinolaryngology; DSN – *deviatio septi nasi.*

Table 3 shows summary audiogram for the left ear prior and after shooting at frequences from 250 Hz to 8,000 Hz.

Table 4 shows sumary audiogram for the right ear prior and after shooting at frequences from 250 Hz to 8000 Hz.

The median value of audiograms prior and after shooting for the left and right ear are given in Tables 4 and 5. A statistically significant difference in median values of audiogram prior and after the shooting, for the left ear was present at 2 KHz (p = 0.046). The difference was close to significance for the the left ear at 6 and 8 KHz and at 2 KHz for the right ear to, but did not reach significance threshold.

Table 3

Summary audiogram for the left ear before and after shooting

Audiogram (left ear) at various frequences	Prior to shooting	After shooting	p
	median value (range)	median value (range)	
250 Hz	10 (10–20)	10 (10–25)	0.250
500 Hz	10 (10–20)	10 (10–25)	0.518
1 KHz	10 (10–20)	10 (10–20)	0.480
2 KHz	10 (10–15)	10 (10–20)	0.046
4 KHz	10 (10–40)	15 (10–50)	0.337
6 KHz	15 (10–45)	15 (10–50)	0.062
8 KHz	15 (10–55)	15 (10–65)	0.088

Table 4

Summary audiogram for the right ear before and after shooting

Audiogram (right ear) at various frequences	Prior to shooting	After shooting	p
	median (range)	median (range)	
250 Hz	10 (10–40)	10 (10–35)	1.000
500 Hz	10 (10–35)	10 (10–35)	0.180
1 KHz	10 (10–35)	10 (10–40)	0.317
2 KHz	10 (10–35)	10 (10v35)	0.083
4 KHz	10 (10–50)	10 (10–65)	0.389
6 KHz	15 (10–60)	15 (10–65)	0.439
8 KHz	17.5 (10–65)	20 (10–65)	0.378

Table 5 shows the auditory effects (hearing loss, tinnitus, pressure in the ear) and their total sum.

Table 5

Auditory effects after shooting (total sum)

Variables	n (%)
Number of subjects, n (%)	22 (100)
Number of auditive effects, n (%)	8 (36)
Number of hearing impairments, n (%)	2 (9)
Number of reported – tinitus, n (%)	5 (23)
Number of feeling of ear pressure, n (%)	1 (5)

Tinnitus was registered in 5 (23%) patients, hearing loss in 2 (9%) and in one (5%) case, feeling of pressure in the ears. In total, some of the auditory effects of shooting from an automatic rifle were registered in 8 (37%) subjects. In 14 (63%) subjects non-auditory effect was detected.

Discussion

Aleksić [3] was examining the frequency and degree of hearing impairment as a result of the use of small arms among members of the Serbia and Montenegro Military and came to the following conclusions. When shooting with an automatic rifle 7.62 mm M70, maximum sound pressure levels ranged between 133 dB and 161 dB (threshold limit values were 140 dB by civil and military standards). Audiological tests showed significantly higher incidence and degree of hearing loss in the group of exposed subjects, as compared to the control group [3].

Weckl et al. [5], were examining the impact of use of small arms on hearing in the Army of Brazil and found that 20.79% of the subjects had a hearing loss, with a significant difference in incidence compared to civilians.

Heupa et al. [6] were examining soldiers who were exposed to noise from infantry weapons and reported that in 23% of the cases the shooting was folowed by onset of tinnitus, and in 7.6% of the cases of hearing loss.

Dhammadejsakdi et al. [7], examined the use of protective headphones at subjects from Thailand military and concluded that the incidence of acute acoustic trauma was reduced 15 times [7].

Honet et al. [8], confirmed that hearing damage could occur following the first exposure to shooting without protection at a shooting range, which emphasizes the importance of preventive use of personal protective equipment.

Guida et al. [9], recorded the occurrence of noise with a peak to 146 dB, by measuring the level of noise at shooting ranges and found that it was was significantly above the recommended 120 dB.

Berg et al. [10], reported more frequent incidence of damage to the left compared to the right ear due to the shadow effect of screening.

Meinke et al. [11] concluded that a risk of hearing damage was reduced if shooting from a standing position, and when using personal protective equipment.

Saedi et al. [12] in the results of their research confirmed that exposure to impulse noise when shooting from automatic small arms, without adequate protection can pose a major threat to hearing, particularly at high frequencies.

Our research confirmed the influence of impulse noise which occurs following gunshot from an automatic rifle on the sense of hearing in professional military personnel. In our case, the observed effects on 22 subjects were: the loss of hearing, tinnitus and feeling of pressure in the ear. Hearing impairment was recorded in 2 (9%) of the cases. It was of the sensorineural type, milder degree, in a form of scotoma at 4,000 Hz, in one case, up to 50 dB, and in another up to 55 dB. It is understandable that the damage occurs at peak value of 4,000 Hz. This is because the short duration high-intensity noise (bang) that occurs following a gunshot from small arms affects mainly the cells in the cochlear basal curve of Chorty body, corresponding to the area C5 (4000 Hz). The effect is mechanical damage to the cell organ of Chorty. Sudden strong impulse is followed by movement of endolimfe and creation of vortices in the basal membrane. This leads to direct damage to the ciliated cells, primarily external (followed by anatomical order) and then, according to sound intensity, to the internal cells which are partially anatomically protected [1–4].

Tinnitus, immediately after the shooting, was registered in 7 cases, 2 of which had spontaneous recovery and in 5 cases tinnitus was present in the examination done few hours after the shooting. Tinnitus occurs as a result of stimulation of the cochlea and it has higher incidence than hearing impairment. It usually heal spontaneously in a period of few hours after exposure to the noise, but it can remain as permanent impairment [1–4].

In one (5%) patient, the feeling of pressure in the ear was registered. This is a subjective feeling which is hard to distinguish from the feeling of fullness or humming in the ear.

It is noted that in both patients with registered hearing impairment there was no subjective symptoms (hearing loss, tinnitus or any other symptom). It was also noted that none of 2 subjects, in which hearing impairment was registered, did not use any protective agent.

Further researchs on a larger sample are maded for more detailed analysis of an influence of live ammunition shooting on sense of hearing in proffesional military personel.

Conclusion

The effect of pulse noise following live ammunition shooting from automatic rifle can be divided into extraauditory and auditory. Primarily the effect is audible and is expressed as: tinnitus, loss of hearing, feeling of pressure in the ears. This study confirmed the occurrence of those auditory effects. Further research on a larger sample are needed to confirm the statistical significance of these effects. The practical significance of this study lies in prevention where the mandatory use of personal protective equipment and organization of the shooting range, can have a direct impact on reduction in incidence of hearing loss, as the most important, tinnitus and other auditory effects. All this can influence the decrease of treatment cost regarding these diseases.

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