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Effect of impulsive noise on military personnel – A case study

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Present study measures effects of impulsive noise level and assesses audiologically occurrence of noise-induced hearing loss or temporary threshold shift (TTS) during gunshot practice by military men. No significant variation in hearing threshold in any frequency before and after gunshot practice was observed, thus no TTS was detected. Alterations in hearing thresholds at 6 kHz and 8 kHz were observed in individuals who already presented cochlear hearing loss. Individuals reported following effects: tinnitus, 21; dizziness, 13; discomfort under loud sounds, 26; and difficulties in speech comprehension, 26%.

Keywords: Acoustic measurements, Gunshot, Impulsive noise, Noise-induced hearing loss, Temporary threshold shift

Introduction

Industrial workers and inhabitants living near factories or construction sites are everyday exposed to high pressure levels of impulsive noise (IN) on a daily basis[1-3]. IN is a noise of transient nature and consists one or more bursts of sound energy. It can cause hearing damage, ranging from slight temporary threshold shift (TTS) to noise-induced hearing loss, or even acoustic trauma. Noise-induced hearing loss is gradual decrease in hearing capacity, due to continuous exposure to high pressure levels of sound. It is characterized by alterations in hearing threshold in high frequencies, also known as cochlear alteration (threshold fall between 3-8 kHz), which is irreversible, and capable of hampering speech intelligibility[4]. TTS is hearing deterioration after some hours of exposure to high pressure levels of sound, which is completely reversible within 24 h on average, once the subject is placed away from noise source.

Due to frequent training in gunshots, occupational environment that provides one of the highest pressure levels of sound to army personnel produces IN[5,6]. IN environment[5] in military is characterized by shorter durations, higher peak levels and lower repetition rates than in industry.

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This study measures effects of IN level and assesses audiologically occurrence of noise-induced hearing loss or TTS during gunshot practice by military men.

Materials and Methods

Measurement of Impulsive Noise (IN)

A common weapon used for gunshot training in Brazilian Army is 9 mm pistol M975 Beretta. Gunshot practice by military with Beretta pistol consisted of following sequence: 1) military distributed cartridges to shooters; 2) shooters prepared their guns and stood in shooting position; 3) after command given, five shooters positioned side-by-side shot their guns; and 4) shooters rested and reloaded their guns for next series. This procedure was repeated 3 times more, in a total of 4 shots by each shooter, and a total duration of 3 min and 47 s. In third sequence of shots, only 3 shots were given, while 5 shots were given in other sequences (Table 1). Gunshots produce IN with a very strong energy concentration in a short time interval. IN was measured with sound level meter, BK 2238[7] and results expressed in L_{AIm} in dB, which means impulsive sound levels weighed in scale A (Fig. 1). Data were analyzed in laboratory through BK 7820 software[8]. Frequency analysis of sound emissions, in real time, was performed using sound analyzer BK 2260[9]. According to ISO 1999, microphone of sound level meter was placed at 0.10 ± 0.01 m from external ear of the evaluated military[9].

Table 1—Levels of impulsive noise

First series of shots	L_{Im} dB(A)	Second series of shots	L_{Im} dB(A)	Third series of shots	L_{Im} dB(A)	Fourth series of shots	L_{Im} dB(A)
Shot 1	111	Shot 1	113	Shot 1	104	Shot 1	108
Shot 2	112	Shot 2	112	Shot 2	112	Shot 2	113
Shot 3	109	Shot 3	110	Shot 3	109	Shot 3	111
Shot 4	114	Shot 4	108			Shot 4	113
Shot 5	111	Shot 5	113			Shot 5	112

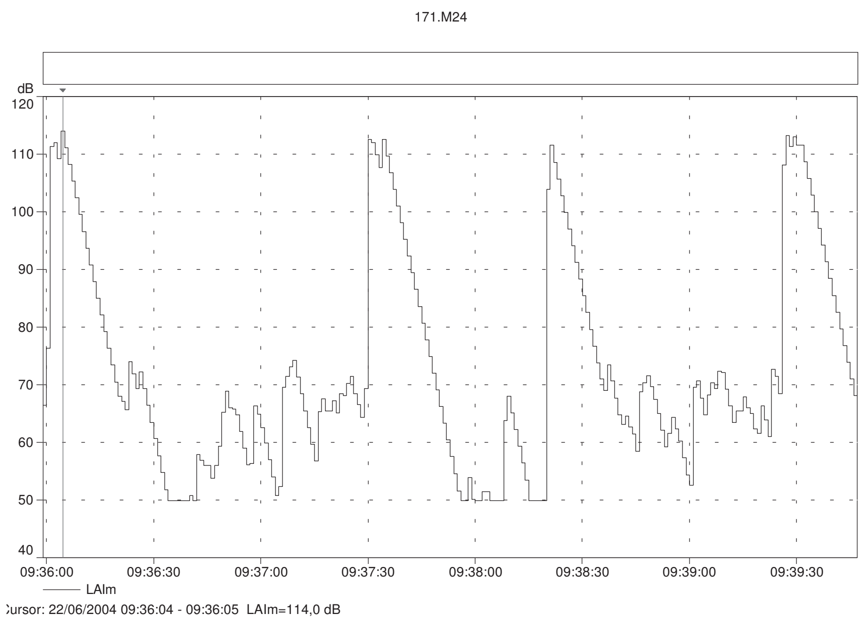

Fig. 1—*Datalog* measurements of impulsive noise of shots with Beretta pistol

Audiological Evaluation

A group of 23 military men (av age 22.96 y old, range 18 - 36 y old), based at a Headquarter of Brazilian Army, were taken for otoscopy, and audiometric examinations. Audiometric examinations were carried out in an acoustic cabin, using an audiometer Danflex DA65, before and after the practice of shots. A psychoacoustics questionnaire was given to military before audiometric exam.

Results and Discussions

Frequency analysis of each shot was performed at shooting moment, and corresponds to each one of the peaks of fluctuating noise (Fig. 1). Predominance of high sound levels of shots in band frequency between 250 - 8,000 Hz is very clear; highest noise levels were found in frequencies of 1,000 Hz and 2,000 Hz (Fig. 2). Measurements are characteristic of light weapons (pistols) that have a very short rise time and duration, and this sharp time-history produces a spectrum, which has a very large bandwidth[5]. Acoustic energy remains predominantly in the high frequency part of spectrum.

Among 23 military men (serving military for av time of 4.74 y, range 1-18 y), 95% reported having good hearing conditions. All participants wore ear protectors during their regular sessions of gunshot practice. Extra-hearing symptoms were reported in following participants: tinnitus, 21; dizziness, 13; discomfort when exposed to loud sounds, 26; and difficulties in speech comprehension, 26%. These symptoms have also been reported in several other studies[6,10,11].

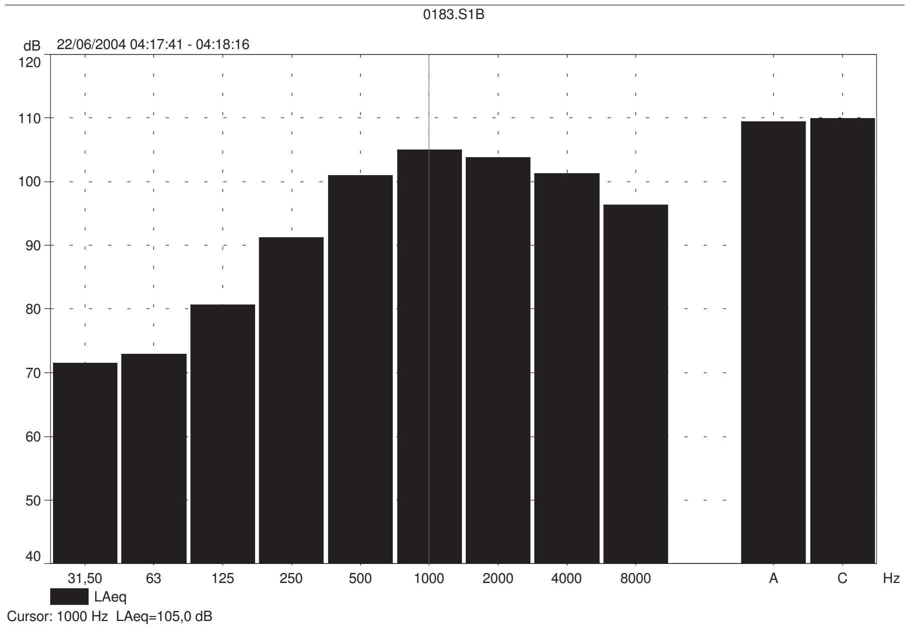

Fig. 2—Frequency analysis of first series of shots

Tinnitus in assessed military participants is usually related to exposure to high noise levels, which generate fatigue in bordering cells of the organ of Corti, located in the internal ear. These results are in agreement with those of Mrena [12] and Stewart [11], who report that most patients repeatedly exposed to loud sounds from gunshots suffer from both acoustic trauma and gradual neurosensorial hearing loss. Occurrence of tinnitus in 16.5% participants was also reported by another study with Brazilian military for 97 participants investigated[6]. Tinnitus may disappear after a while, may persist for a long time, or may never go away, seriously affecting person's life quality[12].

Dizziness is usually associated to sudden change in sound pressure that accompanies barotraumas[10]. Discomfort caused by high sound levels is described as a sign of lesion in external boarding cells, which was also observed by Silva *et al*[6]. Presence of background noise, reported by 26% of assessed military personnel, may be because hearing loss in high frequencies interfere with the ability of sound discrimination. Difficulties in speech discrimination for military personnel have also been reported earlier[10]. When a competitive sound is overlaid by another, capacity of detection of slight differences in speech sonority, rhythm and intonation is affected.

Results of the tonal threshold audiometry performed before the practice of shots verified that 53% of individuals found having hearing alterations of the cochlear type, characteristic of intense chronic noise exposure. High rates of hearing losses in people exposed to routine gunshot practice are reported in the study of Cox & Ford[10] (30%) and Silva[6] (38.1%).

In audiological assessment, considering the level of significance á = 0.05 (5%), no significant difference in present study was found in hearing threshold for right ear (Table 2) and left ear (Table 3) tested before and after shooting protocol. Occurrence of temporary threshold shift was not characterized. Although statistical test did not show any significant difference in hearing threshold before and after the shots, it was observed that 12 military men (53% of participants) displayed some audiometric alteration and 9 individuals (39% of participants) presented worse conditions with threshold at 6 and 8 kHz. Present finding indicates that people previously holding hearing losses are more sensitive to noise[6,10-12].

Conclusions

Gunshot practice using a 9 mm Beretta generated high pressure levels of impulsive noise, between L_{AIm} = 104 dB and L_{AIm} = 114 dB. Frequency analysis of shots has shown that this gun produces a spectrum with a very wide bandwidth, with most of acoustic energy concentrated in higher frequencies. This is potentially harmful to hearing ability of military personnel regularly

Table 2—Comparison using Wilcoxon Test of right ear performance before and after shot

Frequency Hz	Statistics Z	Probability P
250	0.050965	0.959354
500	0.458682	0.646465
1000	0.628971	0.529373
2000	1.885695	0.059345
3000	0.509647	0.610302
4000	1.372813	0.169820
6000	0.624758	0.532134
8000	1.172189	0.241130

Table 3—Comparison of left ear performance before and after the shot, using the Wilcoxon Test

Frequency Hz	Statistics Z	Probability P
250	0.559085	0.576107
500	0.968330	0.332887
1000	0.369175	0.712000
2000	0.235339	0.813947
3000	1.155841	0.247755
4000	0.627572	0.530289
6000	1.161365	0.245502
8000	0.663914	0.506750

exposed to gunshot impulsive noise. Audiometric tests have shown that, among 23 military men, 53% show hearing loss of cochlear type. In individuals who already presented cochlear hearing loss, alterations in hearing threshold at 6 and 8 kHz were detected. Some extra-hearing symptoms reported in participants in presence of impulsive noise were: tinnitus, 21; dizziness, 13; discomfort when exposed to loud sounds, 26; and difficulties in speech comprehension, 26%.

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