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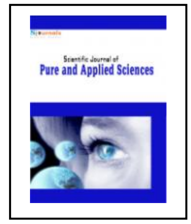

Original article

Prevention of noise damages causes by shooting fire of Kalashnikov (AK-47) rifle by regulation of suitable distance

G. Pourtaghi[a,]*, H. Mokarami[a,b], F. Valipour[c], M. Ghasemi[a]

[a]*Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, IR Iran.*
[b]*Department of Ergonomics, School of Health, Shiraz University of Medical Sciences, Shiraz, IR Iran.*
[c]*Faculty of Health, Baqiyatallah University of Medical Sciences, Tehran, IR Iran.*

*Corresponding author; Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, IR Iran.

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ABSTRACT

The aims of this study were control of rifle shooting noise by regulation of suitable distance and investigation of frequency characteristic of the noise caused by single Kalashnikov rifle (AK-47) in an open shooting field. Due to the condition of the trainees and other people in the shooting fields, the measurements were done in 2 stages of individual and groups of 20 individuals and at 1, 30 and 50 meters distance, respectively. At each stage of the experiment the sound pressure level and peak sound pressure level were measured in C and A networks, and audio frequency analysis in octave centers of Z network was done simultaneously. The results of this study showed that the sound pressure level in network A in the stage of single shooter and group of 20 individuals were 102 and 110.4 dB respectively and in network C they were 102.9 and 112.5 dB, respectively. Also the peak of sound pressure level in network C at the stage of single shooter and group of 20 individuals were 130.30dB and 132.8 dB at the same distance (one meter) and in network A it was 130.3 and 142.4 dB, respectively. To prevent the damage cause by sound, we recommend increasing the distance between an individual and the sound source. Additionally, the complications in shooting fields can be reduced by increasing the distance more than 20 meters for single shooting and 50 meters for group shooting.

1. Introduction

Armed forces are considered as the main pillars of a country's sustainability and have a very important role in its defense readiness; thus it is necessary to maintain their health and physical fitness. Military personnel have always encountered different occupational health problems such as those caused by noise and vibration due to machinery and warfare equipment and motor vehicles (Hughes et al, 2013; Stout et al, 2013). Furthermore; electricity, improper temperature conditions, repetitive movements, carrying heavy loads, and heavy physical work associated with inappropriate posture, chemicals, dust, gases and vapors are also other hazardous agents in military environments (Kelsall et al, 2004; Saunders and Griest, 2009).

One of the most important occupational health problems for the military personnel is exposure to loud or high pitched noise and its complications (Muhr et al, 2006). People who are working in shooting fields, armored units and music groups for parades, military parades, military industries and helicopters are at risk of complications due to such noise that may cause side effects, particularly, hearing problems in the soldiers (Muhr et al, 2011; Teo et al, 2008). A field survey indicated that the measured sound intensity while shooting is 105-113 dB for the shooter's right ear and 104-112 dB for the left ear, respectively (Rezaee et al, 2011). Valipour et.al. (2011) measured the exposure level of personnel in an academic complex of aerospace. The results of their measurement showed that these people encountered sound above the standard. Also the results of studies on Titan and Kinus cars for carrying tanks indicated that sound intensity caused by these cars at 30 cm distance was 94 and 87.7 dB respectively (Pourtaghi et al, 2002). While the limit for facing sound is 85 dB according to ACGIH standard and technical committee of the Iranian occupational health association (Golmohammahdi, 1999).

The main risks that may be created due to noise relate to the sounds of explosions or hitting that cause hearing defects. Sudden exposure to high noises such as the sound of explosion and gun fire causes permanent damage to the inner and the middle ear. The most common symptoms caused by severe acoustic damage are hearing loss and tinnitus. Most of these people have been expose to sounds with the intensity of 140-160 dB (Cohen et al, 1996). In addition, chronic effects relate to noise which due to exposure with the values above the standard lead to sensorial-nervous hearing loss. Long term exposure to noise, usually causes damage to the inner ear and particularly Trichoid cells of Kurt's body. Other tissues that are in contact with Trichoid cells such as cochlear blood vessels, stria vascularis and stria terminals may also be damaged (Tanaka et al, 2009). The risk of hearing loss increases both by the occupation duration and increase of the age. Most of complications related to noise exposure occur during the early years. In fact most of the damages occur in the first 10 years of work. Non-auditory effects that are mostly common in military environments include physiological complications (such as increase of heart beat, blood pressure, oxygen consumption and number of breathes), nervous effects (such as the effect on digestive system), effect on the vestibular system, the visual organs and other complications (Prince, 2002). The reports of American military forces and other countries show that hearing loss and tinnitus are common problems among the military employees. Also according to these reports 22 % of U.S. military personnel have tinnitus and loud noise during deployment in 2003–2004 and also out of the 204 officers in a Swedish infantry regiment, 17 % reported experiencing tinnitus (Larry et al, 2005). One of the main sources of excessive noise exposure for military personnel is during shooting. The results of researches in fields of shooting with light guns showed that hitting sound of shooting may reach to 156 dB (Pawlaczyk-Luszczyńska et al, 2004). To the best our knowledge, rarely studies have been conducted in Iran on the amount and characteristics of different noises caused during shooting practice and maneuvers, while most of the military personnel encounter with such noises. This study was conducted in open shooting fields with the aim of measuring frequency characteristic of different sounds and noises caused by single Kalashnikov rifle which is commonly used in Iran's armed forces in order to identify the exposure level and risk to personnel and soldiers in shooting fields and to become aware of physical properties and measurement of noise generated in different conditions in shooting fields.

2. Materials and methods

This cross-sectional study was conducted in 2012. Since this study was aimed at measuring and investigating frequency characteristic of the noise caused by single Kalashnikov rifle (AK-47) in an open shooting field, one of the shooting training fields in Tehran was selected. The shooting operation is usually done in these fields either individually or collectively in groups of 10-20 individuals. The most heavy exposure to noise in shooting fields happens when the coaches have long training sessions during the days during different courses. The soldiers and trainees are usually not exposed to shooting and its noise after learning shooting and getting employment in armed forces and it's only the coaches that are exposed to these noises for many years, this research mostly focused on the noise level exposure for the coaches. In this regard and due to the condition of the trainees and other personnel in the shooting fields, the measurements were done in 2 steps, that is for the individual and groups of 20 individuals and at 1, 30 and 50 meters distances, respectively. These distances were related to the location that the coaches are usually present at training sessions while shooting and controlling the shooters. The shooters usually fire through the targets or bull's-eyes that are at the distance of 100 meters at the foot of the hill and in front of them. At each stage of the experiment, the sound pressure level and peak of sound pressure level were measured in C and A networks. In Z network sound pressure level at different frequencies was displayed by the sound level meter device without changing the quantity. Hence, audio frequency analysis in octave centers of Z network was done. Overall, at a training session, the shooters and the personnel were exposed to noise for 110 minutes. All the measurements were carried out by CEL-620 and its calibration was conducted according to the standard method at the frequency of 1 KHz and sound pressure level of 114 dB. To remove the effects of atmospheric conditions of the environment on the device's performance, the calibration of the device was conducted in the shooting field. To reduce the effect of wind on the device's performance, a microphone with foam protective cover was applied. All the measurements were carried out in October, 2012 and at the temperature of 29 ºC and relative humidity of air of 60%. Based on the individual and collective conditions of shooting we determined two types of acoustic emission sources: a) point source and b) discrete linear source. Therefore, the equation 1 was used to calculate the theory of sound pressure level at a certain distance from a point source of sound (Golmohammahdi, 1999):

Equation 1: $LP2 = LP1 - 20 \log r2/r1$

In discrete linear sources if there are some sources with distance b, by b/π distancing from each sound source, sound pressure level reduction similar to point sources can be calculated by equation 1. However, at distances of more than b/π sound pressure level can be calculated by equation 2.

Equation 2: $LP2 = LP1 - 10 \log r2/r1$

As a result in order to theoretically calculation of sound pressure level while shooting in the group of 20 individuals in 1 meter distance equation 1 was used and at 30 and 50 distances, equation 2 was applied.

3. Results

The results of this study showed that the sound pressure level in A network in the status of single shooter and group of 20 individuals was 102 and 110.4 dB respectively and in C network 102.9 and 112.5 dB. Also at this distance the peak of sound pressure level in C network in case of single shooter and group of 20 individuals was 130.3 and 132.8 dB respectively and in A network it was measured 130.3 and 142.4 dB respectively. The mean time of exposure of coaches to noise was 110 minutes per day. By the increase of measurement distance from source, the sound pressure level and peak noise were reduced so that at the distance of 50 meters sound pressure level in A network in the status of single shooter and group of 20 individuals was 67.3 and 92.3 dB respectively and in C network it was 68.1 and 94.6 dB. The results of measuring the sound pressure level and peak of sound pressure level in C and A networks and 1, 30 and 50 meters distance for single shooter and group of 20 individuals are shown in table 1.

The results of audio frequency analysis in octave centers in Z network indicated that distribution patterns of sound energy in different frequencies were similar for the single shooter and group of 20 individuals at measured distances. The sound pressure level was increased from 16 Hz to 500 Hz and was reduced after it. In fact the highest amount of sound pressure level was in frequency of 500 Hz. At 1, 30 and 50 meters distances and for the single shooter, the amount of sound pressure level in this frequency was 98.5, 68.6 and 64.1 dB respectively and in case of a group of 20 individuals it was measured to be 108, 92.1 and 87.7 dB. Figure 1 shows the results of sound frequency analysis for single shooter at 1, 30 and 50 meters distances. The results of sound frequency analysis for a group of 20 individuals at 1, 30 and 50 meters distances are shown in figure 2.

Table 1
The results of measuring the sound pressure level in 1, 30 and 50 meters distances.

Number of Shooters	**Distance (Meters)**		**LP-(Sound Pressure Level)**		
		dB-C	**dB-A**	**dB-C peak**	**dB-A peak**
	1	112.5	110.4	142.8	142.4
20 Persons	30	97.7	96.6	127.9	127.7
	50	94.6	92.3	121.7	120.9
	1	102.9	102	130.3	130.3
single	30	72.4	71	106.2	106
	50	68.1	67.3	96.6	95.7

4. Discussion

Technical committee of the Iranian's occupational health organization has set legal limits on noise exposure at the workplace. These limits are based on a worker's time weighed average over 8 hours a day. With noise, standard for facing sound is 85 dBA for all workers for an 8 hour day. This standard uses a 3 dBA exchange rate. This means that when the noise level is increased by 5 dBA, the amount of time a person can be exposed to a certain noise level to receive the same dose is reduced to half. Also, the peak of exposure for C network was determined as painful threshold or 140 dB and at higher levels hearing protection devices should be used (Golmohammahdi, 1999). The results of this study showed that at 1, 30 and 50 meters distances from shooters for the group of 20 individuals and at 1 meter distance for single shooter the sound pressure level is higher than the standard. Also, the peak of sound pressure level at 1 meter distance for a group of 20 individuals was higher than 140 dB. The results of the current study indicated that other people who were in the shooting field such as coaches and audiences are also exposed to the dangers of high sound pressure level. This danger can be much more for the coaches who are at close distance from the shooters (usually 1 meter) compared with the shooters. According to the results of this study great danger that threatens coaches auditory system is their presence at 1 meter distance at the time of collective shooting. The results of this study compared with the standard values showed that the presence of the coaches near the trainees at 30 meters distances for individual shooting was within the permissible limit and for group of 20 shooters at all distances, the amount of noise was more than the permissible limit. Thus maintaining the safety distance from shooting place and using personal protective equipments is necessary to prevent deleterious effects of noise. The results of our study showed that in the case of collective shooting with group of 20 shooters if the distance is 1 meter, the sound pressure level will be 112.5 dB. According to equation 2 it is expected that at 30 and 50 meters distance (higher than b/π) the sound pressure level will be 97.7 and 95.5 dB respectively. Also in the case of individual shooting, according to the measured sound pressure level of 102.9dB at 1 meter distance according to equation 1, it is expected that the sound pressure level at 30 and 50 meters distances will be 72.9 and 68.9 dB. The findings of this study indicated that the measured sound pressure levels were close to these levels. A small difference observed may be due to the difference in shooting time and the environmental or climatic effects. Thus by having the amount of noise created by the shooting weapon, we can specify the permissible distances and the distances at which the people in the shooting field should use hearing protective devices. The results of frequency analysis showed that sound pressure level increased to 500 Hz and the sound pressure level were reduced after this frequency and acoustic energy is mostly focused at frequency range of 125-2000 Hz. Pawlaczyk-Luszczyńska et al. Indicated that the measured acoustic energy of weapon mostly focuses at 100-1600 Hz (Pawlaczyk-Luszczyńska et al, 2004). The results of the researches showed that in the case of short-caliber weapons the acoustic energy mostly focuses at 150-2500 Hz (Ylikoski et al, 1995; Marlund, 2010). With these data, it is better to use ear protection devices that mostly control the frequencies of 150-2500 Hz while shooting with short-caliber weapons.

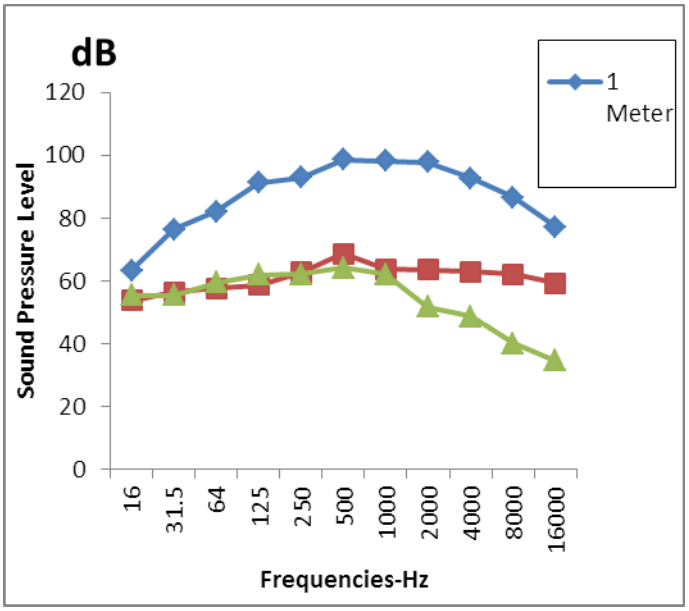

Fig. 1. The results of sound frequency analysis for the status of single Shooter.

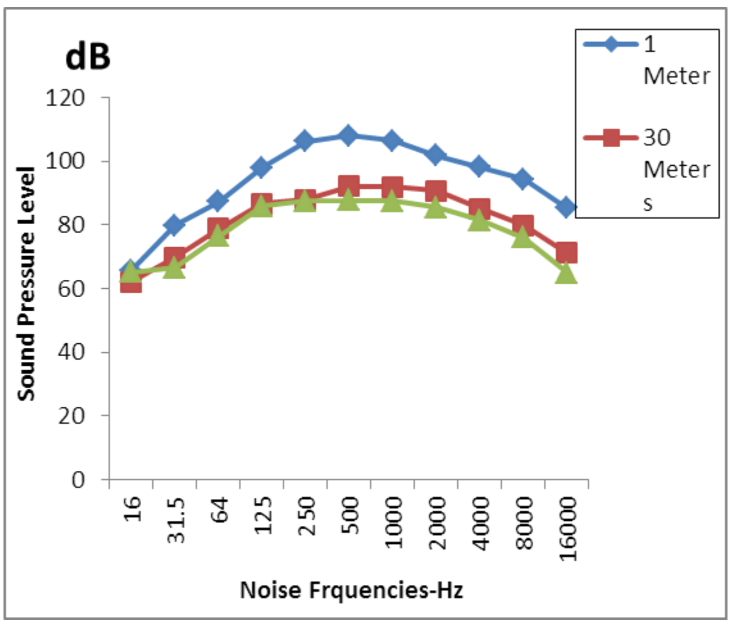

Fig. 2. The results of sound frequency analysis for the status of group of 20 individuals.

5. Conclusion

The results of this study showed that both shooters and personnel in the field were exposed of unallowable sound pressure levels. Since due to some reasons we cannot reduce the sound created by gun by engineering methods, it is better that shooters and other individuals in the field use sound protection devices. Also in order to prevent the damages of sounds with sound pressure levels of more than 100 dB, it is suggested to use ear muff and ear plug simultaneously for more protective efficiency. It is necessary to mention that this research was conducted only on the noise created by Kalashnikov rifle (AK-47) and it is recommended that a similar research be carried out on other rifles in Iran armed forces particularly G3 rifle.

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Authors Contribution

All authors in this study have made extensive contribution

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