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PREVENTION OF HEARING IMPAIRMENT IN SPORT SHOOTERS

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Abstract

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Background: Noise associated with training and competition poses a serious risk on sport shooters. Hearing trauma is one of the most important health hazards in this group of sportspersons.

Aim of the study: We assessed measures undertaken by individuals to prevent hearing trauma and searched for associations between parameters of noise exposure and health disturbances.

Material and methods: We surveyed 197 sport shooters (104 women and 93 men) aged 12-56, who represented 18 sport clubs from within one European country (Poland). Their level of performance varied from III sport class to champion class (Olympic champions). The length of exposure to shooting-noise was from under 1 year to more than 12 years.

Results: We have found that between 32-53% of women shooters and 39-48% of men shooters did not use any kind of hearing protection during training/competition. It was striking that though hearing disturbances were present in more than 20% of shooters only 36% of women and 53% of men underwent an audiometric examination during their careers.

Conclusions: Sport shooters are not sufficiently protected against hearing trauma and they do not undergo proper audiological screening. Preventive measures such as careful otolaryngological observation and wearing hearing protectors need further dissemination and application in this group of sportspersons.

Key words: *firearms, sports, noise-induced hearing loss, prevention, protective devices*

Introduction

Sport shooters are exposed to a specific acoustic environment of impulse character. During training and competition they receive an uncommonly high number of acoustic stimuli that derive from their own and other competitors' weapon.

Specific hearing trauma linked to exposure to impulse noise has been well documented (1-8). Audiometric evaluation in sport shooters typically reveals chronic hearing loss at 4 and 6 kHz (9-11).

Weapon-associated hearing loss is strongly dependent on individual predispositions (9). However the risk posed on the hearing organ may be substantially decreased by wearing individual hearing protection, performing regular hearing tests as well as through proper scheduling of shooting training/competition.

In an observational, cross-sectional study we wanted to assess measures undertaken by individual sport shooters to prevent hearing impairment. We also searched for associations between: the length of noise exposure, sport class, shooters' age and application of hearing protectors and hearing/health disturbances.

Material and methods

We surveyed 104 women (aged 12-30) and 93 men (aged 13-56) who participated in national shooting championships. They were members of 18 sport clubs from different parts of Poland. Studied subjects represented international champion class/champion master (Olympic champions), I, II or at least III sport class. The length of their exposure to noise varied from under 1 year to more than 12 years.

Every sportsperson was asked to reveal any chronic diseases (and time of their diagnosis) and list medications received actually or in the past. Individuals with chronic conditions diagnosed prior the start of shooting training and ones that used potentially ototoxic agents were not included in the present investigation. Characteristics of the study group are presented in Figures 1-3.

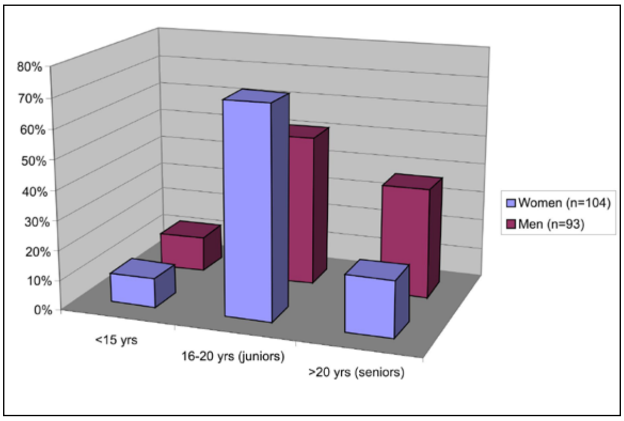


Fig. 1. *Age and sex of surveyed shooters*

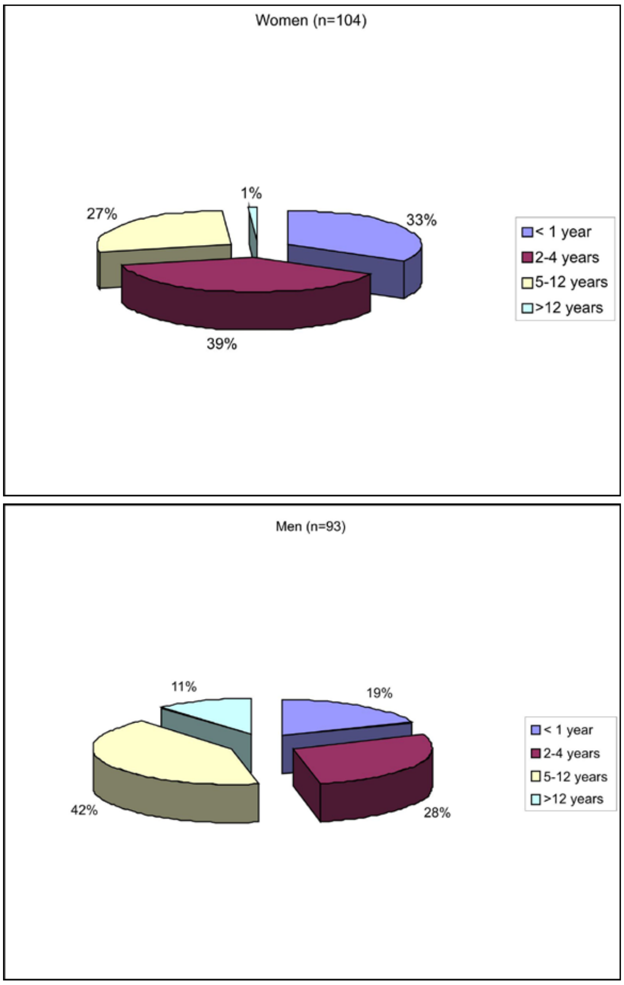


Fig. 2. *Length of exposure to impulse noise (according to Dieroff et al. (12))*

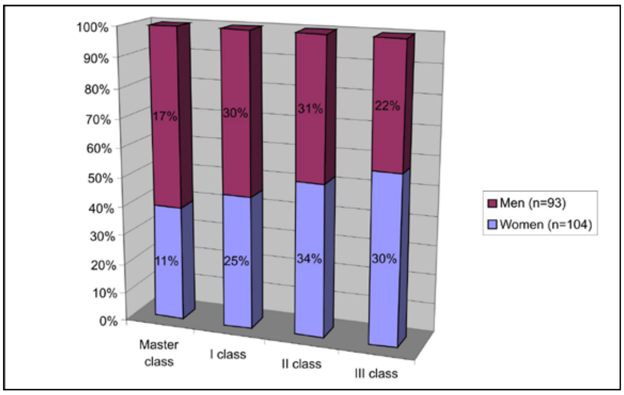


Fig. 3. *Sport class of surveyed subjects*

In a self-applied questionnaire surveyed subjects answered following questions.

1. Do you wear individual hearing protectors during training sessions: yes/no?
2. Do you wear individual hearing protectors during competitions: yes/no?
3. What kind of hearing protection do you use – note the brand and the type name?
4. Do you use hearing protectors designed specially against impulse noise: yes/no?
5. If you do not wear hearing protectors please give reasons why.
6. Do you undergo audiometric testing: yes/no?
7. Have you experienced any kind of transient/permanent hearing deterioration, recurrent otitis media or tinnitus: yes/no?
8. Can you see any effects of noise exposure on your daily life (e.g. headaches, somnolence, increased irritability/increased apathy in daily life, reduced stress tolerance, a habit of loud speaking): yes/no?
9. Who should control noise exposure in shooters (in your personal view)?

We assigned studied shooters to four phases of acoustic trauma according to classification by Dieroff (12):

1. habit phase, up to one year of exposition, with a considerable transient threshold shift,
2. compensation phase, from 2 to 4 years of exposition, adaptation to noise is most effective,
3. collapse phase, from 5 to 12 years of exposition, fastest dynamics of hearing impairment, saturation phase, hearing deterioration starts to slow down (Figure 2).

All statistical analyses were performed with use of Statistica 5.1 (1998, StatSoft, USA). Associations between variables were assessed by means of Chi-squared test. The level of statistical significance was determined at $p<0.05$ and $p<0.01$.

Results

During competition 48% of women and 61% of men declared to wear individual hearing protectors. During training these numbers were 68% and 52% respectively (Figure 4).

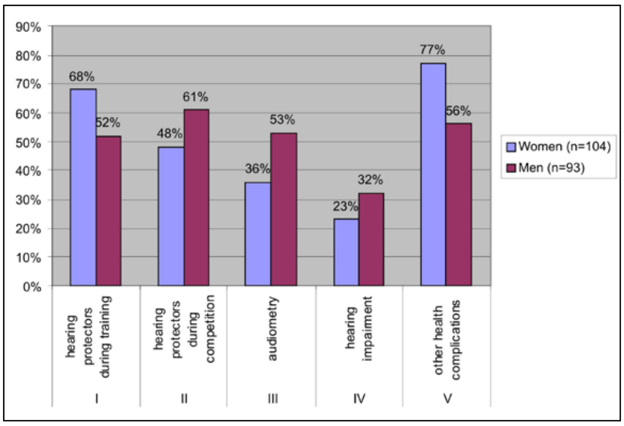
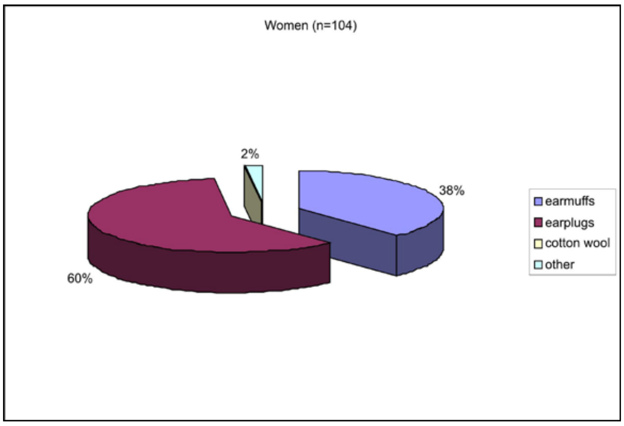


Fig. 4. *Percentage of shooters wearing individual hearing protectors during training (I) and during competition (II), undergoing audiometric control (III), reporting hearing impairment (IV) or other health complications (V)*

Fourteen percent of studied sportspersons revealed that the only reason to wear hearing protectors were competition regulations.

Women often used soft aural inserts (earplugs) that easily fit into external auditory canal. Among them were: Insta-Hold, AMPW Silence, Ear-Classic. Men were more likely to use earmuffs (earphones) such as: Peltor H-9, Peltor H-7, Bilsom 727, Silencio KPA 84, Opta-OS-5N. Cotton wool by Bilsom was used only by men shooters (Figure 5).



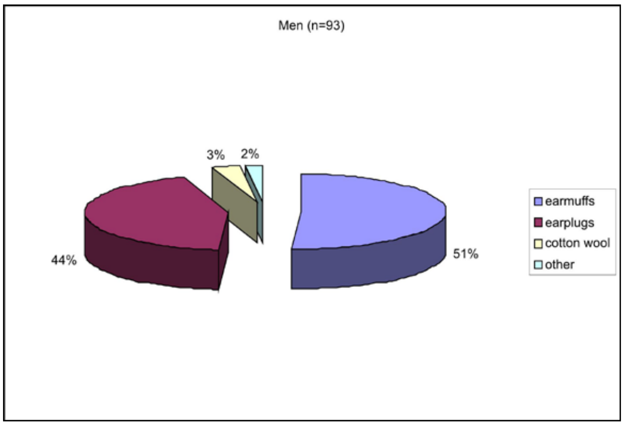


Fig. 5. *Types of individual hearing protectors used by studied shooters*

Wearing hearing protectors during training, but not during competition, was positively associated with the length of exposure to shooting noise and age in men shooters (Table 1). Among women situation was opposite. Application of hearing protection during competition was positively associated with the length of exposure and age (Table 1).

Table 1. *Associations between the length of shooting-noise exposure, sport class, age and application of hearing protectors*

	Hearing protectors during training		Hearing protectors during competition	
	Men	Women	Men	Women
Length of exposure	8.56*	4.91	1.47	8.26*
Sport class	3.3	2.85	3.54	3.14
Age	8.9*	2.84	5.92	3.96*

Chi-squared test; * $p<0.05$

Health problems were reported by 77% of women and 56% of men (Figure 4). Tinnitus, recurrent otitis media, transient hearing threshold shift or chronic hearing loss were present in 32% male and 23% female shooters (Figure 4). We have found a strong correlation between above conditions and sport class in men. Associations of hearing impairment with the length of exposure and age were less pronounced in studied subjects (Table 2).

Table 2. *Associations between length of shooting-noise exposition, sport class, age and hearing impairment/health complications*

	Hearing impairment		Other health complications	
	Men	Women	Men	Women
Length of exposure	8.5*	1.7	9.11*	0.44
Sport class	16.54**	0.125	5.49	8.07*
Age	8.33*	8.25*	13.33**	3.99

Chi-squared test; * $p<0.05$; ** $p<0.01$

In studied women, noise-induced hearing disturbances were associated with age, while symptoms such as headache, somnolence, increased irritability/apathy in daily life, reduced stress tolerance, habit of loud speaking correlated with sport class (Table 2).

Audiological tests are part of hearing impairment prevention programs. In our study group pure tone audiometry was performed more often in men (53%) than in women (36%) (Figure 4).

Discussion

Lack of individual hearing protection during shooting may result in transient or permanent hearing disturbances and a range of other health complications. A simple way to prevent such undesirable effects is to suppress acoustic stimuli before they reach shooter's ears.

In our observation a considerable group of shooters did not use any kind of hearing protection neither during training (32% of women and 48% of men) nor during competition (52% of women and 39% of men). However we have not noticed any consistent associations between application of hearing protectors and: length of exposure, sport class and age in the whole studied group (both genders considered).

Hearing organ evaluation in shooters usually reveals significant hearing loss in the frequency range 4-6 kHz. Alterations are also found at lower frequencies. Hearing disturbances induced by impulse noise initially reveal as alterations at frequencies exceeding 8 kHz (3,13,14).

We have found that in spite of the fact that hearing impairment and other health problems were frequent in shooters of both genders, audiometric control was not performed in 64% of women and 47% of men.

Pure tone audiometry testing allows detection of early stages of hearing loss if performed systematically. Some authors recommend combined screening that should consist of conventional-range pure tone audiometry and high frequency audiometry. It is reasonable to perform pure tone audiometry in the first phase of training and temporary threshold shift evaluation just after training. Such measures let evaluate changes of the threshold values and time needed to achieve the pre-training status. In this way the length and the intensity of training can be optimized. Exposure to impulse noise in the phase of physiological fatigue may lead to pathological fatigue and a permanent threshold shift. Shooters should be also well-informed on potential ototoxicity of drugs such as aminoglicosydes, diuretics or chinine (13).

Impulse noise may not only cause mechanical lesions to the middle ear but also to the cochlear hair cells localized close to the cochlear base (they are responsible for reception of impulses of frequencies higher than 8 kHz). It is a common finding that cochlear hair cells impairment does not correspond with the low frequency hearing loss in pure tone audiometry (2,3,14,15). Impairment of cochlear hair cells may be monitored with the use of otoacoustic emissions (13,16,17).

Impedance audiometry enables assessment of acoustic energy suppression proximally to the perceptive part of the cochlea (9,13). Impedance value assessment is crucial in the first year of training as it is the time of greatest dynamics of hearing deterioration. The same testing should be repeated after 5 years of exposure when substantial acceleration of hearing loss generation is observed (12,18).

Evaluation of hearing protectors' effectiveness is performed by application of acoustic signals of defined, constant character. However many authors point to high inertia and non-linear response of the suppressive system to acoustic signals (4,7,10,19). Impulse noise in sport shooting is characterized by high values of acoustic pressure (that exceed occupational noise exposure limits), short periods of signals' power increases and evolution of power spectrum density (10,20-22).

Suppressive effects of passive hearing protectors that are designed for protection against constant noise have not been confirmed in impulse noise environment (4,7,15,22). Among many reasons of such situation is lack of unitary criteria in methodology of acoustic tests. Nevertheless benefits of passive hearing protection, as compared with no protection, were shown in studies applying pure tone audiometry and otoacoustic emissions. Subjects who wore protectors did not have any hearing threshold shift or otoacoustic emissions alterations (16,21).

In subjects studied by us a considerable group did not use hearing protectors because of physical discomfort (earmuffs) or skin allergic reactions (earplugs). Others reported difficulties in communication with colleagues or trainers. Several individuals indicated that hearing protectors negatively influenced their concentration. A few pointed to economical limitations as their individual expenses were not reimbursed by sport clubs.

In a number of studies proper fitting of hearing protectors has been emphasized. Training in earplugs insertion is important for good attenuation of impulse noise (15). Sufficient low-frequency attenuation may be achieved with combination of earmuffs and earplugs (5,6,23,24).

Individual preferences of shooters and matching acoustic environment with acoustic parameters of chosen protection (average sound suppression SNR, critical values levels for high, medium and low frequencies) are most important for fitting the protector (25-28). Hearing protectors attenuate noise by 10-30 dB, depending on the frequency (22). Their effectiveness against impulse noise is due to high frequency components of impulses (7). In rifle shooting the attenuation of earplugs (16 dB) and small-volume earmuffs (17dB) is not sufficient. In this discipline large-volume earmuffs are recommended. Any kinds of earmuffs are effective against impulses from large-caliber weapons with energy components at low frequencies. Also pistol and shotgun impulses are well attenuated by earmuffs. Especially effective against impulse noise of low frequency are earmuffs with regulation of suppression (7,20,28) .

We can conclude that a thorough examination of the hearing organ should precede commencement of any long-term shooting training. It is advisable to perform audiological screening every 6 months during the first year of training and continue it annually. Otolaryngologists should decide on most appropriate diagnostic tests (pure tone audiometry, impedance audiometry and otoacoustic emissions).

At the same time combined use of earplugs and earmuffs is recommended for majority of impulse noise sources. Sport shooters are not sufficiently informed and not fully aware of benefits of using hearing protectors during training and competition.

Conclusions

1. Application of individual hearing protectors in sport shooters is insufficient.
2. Individual hearing protectors should be adjusted to specific impulse noise exposure and preferences of individual competitors.

3. Both men and women shooters do not have proper audiological screening though they often suffer from noise-related health disturbances.
4. Laryngological/audiological evaluation is necessary not only before commencement of training, but in regular intervals during sport career as well.

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Author's contribution
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection