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THE INFLUENCE OF THE IMPULSE NOISE ON OTOACOUSTIC EMISSIONS

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ABSTRACT
Otoacoustic emissions are low-intensity sounds that are produced by cochlea. The aim was to evaluate of the click evoked otoacoustic emission /TEOAE/ and distortion-product otoacoustic emission /DPOAE/ before and after shooting and compare it with conventional pure tone audiometry. Ten male soldiers /20 ears/ were exposed to impulse noise /15 single rounds of live ammunition at the maximum C-weighted peak sound pressure level of 156 dB/. They did not use any earplugs. OAE's were measured before and 10-15 minutes after shooting. The reduction amplitude of the TEOAE after shooting was found for the 3 kHz and 4 kHz for the right ear and 1 kHz and 2 kHz for the left one. The DPOAE greatest reduction concerned 1,0 and 3,0 kHz for the left ear. Any differences existing between the audiometric threshold before and after shooting were not noticed. Emissions seem to be more sensitive for monitoring early cochlear changes after shooting, than PTA.

1 - INTRODUCTION

The discovery of otoacoustic emission /OAE/ has given a new possibility in early diagnosis of the auditory system. Transient evoked otoacoustic emission /TEOAE/ and distortion product otoacoustic emission /DPOAE/ seem to be non-invasive, objective and frequency specific audiometric test for evaluating hair cell damage caused by noise and other etiological factors [1]. Sounds of high intensity often cause damage to the organ of Corti. It is well known that the outer hair cells often get damaged first [2]. There are data that OAEs in humans and in animals become weaker after short exposures to noise [3] and OAE measurements appear to be a sensitive method of monitoring the early cochlear changes after noise-induced trauma [4]. According to Oeken /1998/ measuring the DPOAE upon acute acoustic trauma could be relevant to prognosis for therapy [5]. Noise induced hearing loss is usually measured as temporary threshold shifts /TTS/ or permanent threshold shifts /PTS/ by pure tone audiometry but very seldom by OAEs. Firearms are a common source of impulse noise that may potentially damage hearing organ. It is very important for soldiers to identify their individuals susceptibility to noise exposure. The aims of this study were evaluation of the click evoked otoacoustic emissions /TEOAE/ and distortion-product otoacoustic emission /DPOAE/ before and after shooting and comparison with conventional pure tone audiometry.

2 - MATERIAL AND METHODS

Material comprises 10 male soldiers /20 ears/ who were in obligatory military service with an average age of 20 years. The soldiers were exposed to impulse noise from automatic gunfire. They did not use any hearing protectors.
For the evaluation of noise exposure the surveys were performed using a measuring system consisting of (i) a microphone type 4138 B&K (Bruel & Kjaer), (ii) a modular precision sound level meter type 2231

B&K, (iii) a tape recorder type 7005 B&K and (iv) a real-time frequency analyser type 2131 B&K with expansion unit type 5765 B&K. The microphone was located approx. 0,1 m from the entrance of external canal of the right and the left ear of shooting soldier. For each microphone positions were determined (i) C-weighted peak sound pressure level (SPL) ($L_{C\ peak}$), (ii) an equivalent continuous A-weighted SPL over shooting ($L_{A\ eq,T}$) and (iii) maximum A-weighted SPL ($L_{A,\ F\ max}$). Additionally, the frequency analysis using 1/3-octave bands in the frequency range from 40 Hz to 50 kHz was performed. The shooting range included 15 single rounds of live ammunition at (i) $L_{C\ peak}$ of 155-156 dB, (ii) $L_{A\ eq,T}$ of 111-112 dB and (iii) $L_{A\ F\ max}$ of 128-129 dB. Pure tone audiometry, tympanometry, TEOAE and DPOAE were measured before and 10-15 minutes after shooting. Otoacoustic emissions were recorded on an ILO 292 Echoport version 5.0. TEOAE recordings of 260 averages each were collected for every subject at stimuli levels of / 80 + − 2dB SPL/ using 80 ms duration clicks. Each response was windowed from 2.5 to 20 ms post stimulus and bandpass filtered from 500 to 6000 Hz. DPOAE were recorded with the DP-Gram procedure. The $2F_1$-F_2 DPOAE were recorded at a single level of 70 dB SPL. The f_2/f_1 ratio was held constant at 1,22 while f_1 and f_2 varied from 0,8 to 5,2 kHz and from 1,0 to 6,3 kHz. The TEOAE and DPOAE response level was calculated as the amount of signal above the noise base level at each frequency. The statistical analysis was done with the Wald-Wolfowitz test with a significance level set as $p<0,05$.

3 - RESULTS

All subjects had bilateral audiometric thresholds to 20 dB HL for the audiometric frequencies to 3 kHz, and 25-30 dB HL for 4 to 8 kHz. The tympanograms were normal /type A/ and the presence of acoustic reflex at normal levels. The results were separately analysed for each ear immediately after noise exposure. The mean change in TEOAE level was calculated separately for each frequency band. Reduction amplitude of the TEOAE after shooting was found for the frequencies 1, 1,5, 2, 3, 4, kHz for the right ear / mean change 2,6 dB SPL / and especially for 3 kHz / 3,1 dB SPL $p<0,02$/ and 4 kHz / 5,1 dB SPL /, $p<0,03$/.

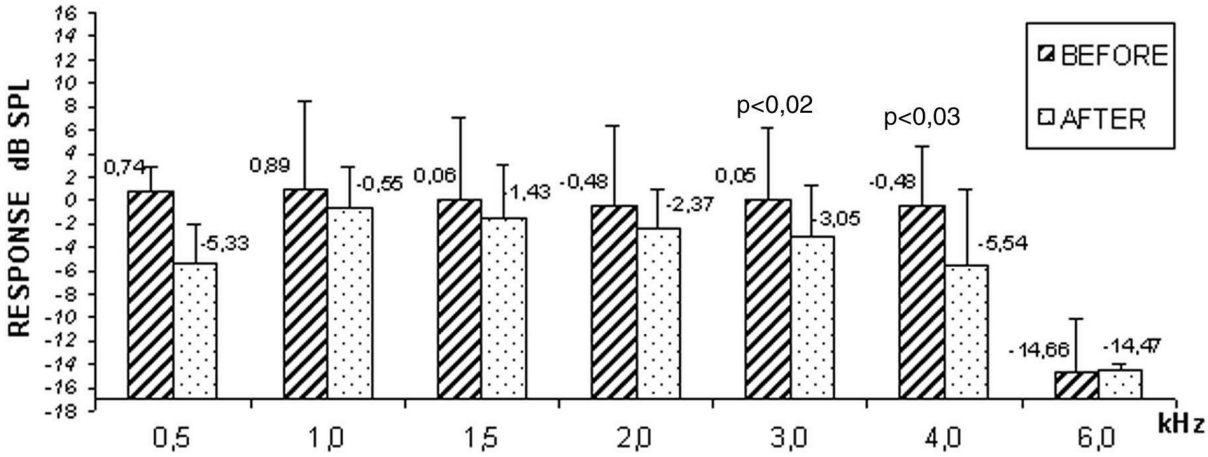

Figure 1: Mean TEOAE before and after shooting for right ear.

The decrease in amplitude of the TEOAE was significant for the left ear for the 1 kHz /4,3 dB SPL, $p<0,01$/ and 2 kHz / 0,6 dB SPL, $p<0,05$/ after noise exposure.

DPOAE alteration was seen in 19 of the tested ears. In 1 ear we did not notice any change. The mean amplitude of the DPOAE was decreased over the whole range. The mean change for the right ear was 0.8 dB SPL, and for the left ear 2,0 dB SPL for the frequency 1, 2, 2,5, 3, 4, 5, 6 kHz. The highest reduction concerned frequencies 1,0 kHz / 3,8 dB SPL, $p<0,01$ / and 3,0 kHz / 2,9 dB SPL, $p<0,04$ / for the left ear.

Any differences existing between the audiometric threshold before and after shooting were not noticed.

4 - DISCUSSION

Exposure to impulse noise during compulsory military service depends on the number of shot, or explosion impulses, distance of injured ear from causal firearm as well as on hearing protectors. Changes induced by moderate or severe noise exposure that give rise to TTS, have been shown to alter the amplitude or frequency composition of transient evoked otoacoustic emissions /TEOAEs/, distortion product

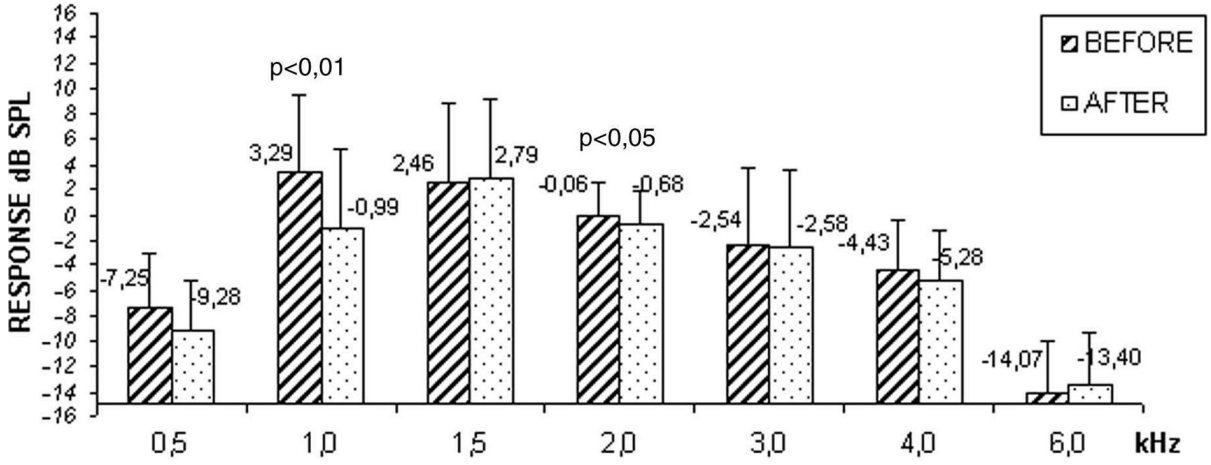

Figure 2: Mean TEOAE before and after shooting for left ear.

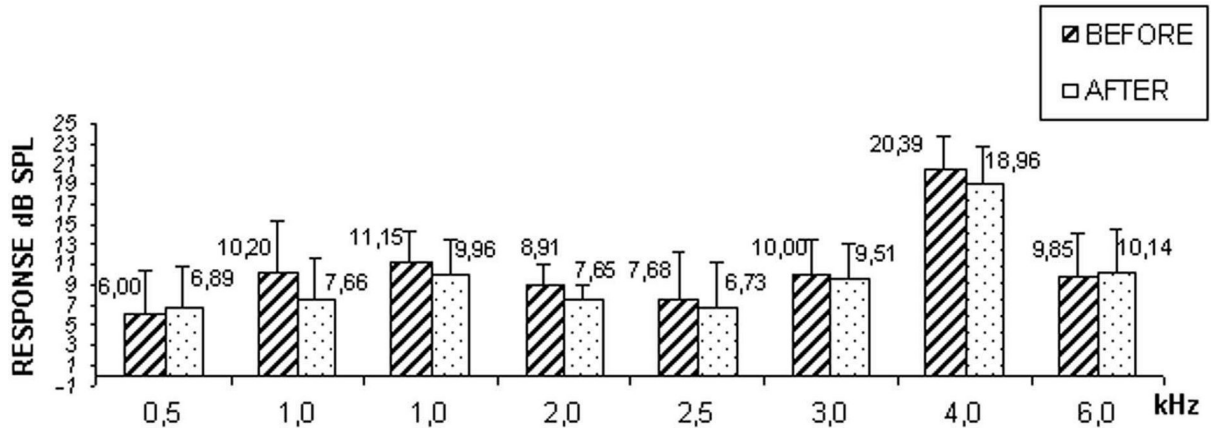

Figure 3: Mean DPOAE before and after shooting for right ear.

otoacoustic emissions /DPOAEs/, and spontaneous otoacoustic emissions /SOAEs/, [6]. Hotz et al. /1993/ used OAEs to monitor changes in cochlear function resulting from exposure to firearms. Significant changes in click evoked OAE amplitudes were observed in the frequency range 2-4 kHz [4]. Atias et al. /1996/ found reduced click evoked OAE levels for the frequencies 1, 2, 3 and 4 kHz in patients with normal audiograms, after noise exposure [7]. In our group reduction of the TEOAE amplitude was found especially for 3 and 4 kHz for the right ear and for 1 and 2 kHz for the left ear. The amplitude reduction of the TEOAE was actually greater in the right ear than in the left one for most frequencies. The greatest effect of noise exposure on the DPOAE amplitude concerned left ear for 1,0 and 3,0 kHz. All our shooters were right-handed and probably the asymmetrical effect resulted from the shooting posture depending on the shadow effect of the body. We did not notice any differences between audiometric threshold before and after shooting. Reduced TEOAE and DPOAE levels in noise exposed soldiers may be the first early indication of potential hearing loss. Clinical experience with otoacoustic emissions indicates that OAE may play a role as a screening method for the soldiers exposed to noise and as a tool for monitoring early changes in cochlea. In our opinion small changes in the function of the cochlea can be monitored by measuring TEOAE and DPOAE especially in cases where classical audiometry is less sensitive.

5 - CONCLUSIONS

- The effect of noise exposure on TEOAE was seen especially for 3 and 4 kHz and on DPOAE for 1,0 and 3 kHz.
- The amplitude reduction of the TEOAE was often greater in right ear while DPOAE in the left one.

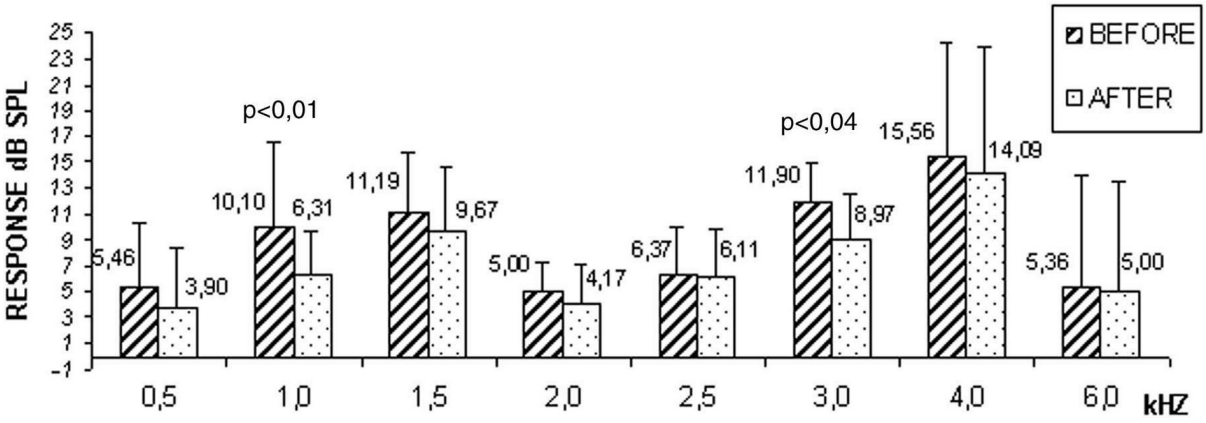

Figure 4: Mean DPOAE before and after shooting for left ear.

- Emissions seem to be more sensitive for monitoring cochlear changes than pure tone audiometry.

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