*Original Article*

# Comparative Study of Hearing Loss between Using and Not using 5-Wing Type Ear Protection of Thai Military Training Conscripts

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***Background:*** At present, ear protective devices during gunfire by Thai military training conscripts are not routinely used. The 5-wing type ear protection was invented to protect them from hearing loss with lower cost and better transmitted speaking voice.

***Objective:*** To study the effectiveness of 5-wing type ear protection in shielding sensorineural hearing loss (SNHL) from military shooting training.

***Materials and Methods:*** The study design was a randomized control trial (RCT) study. Sixty conscripts during routine training were enrolled and randomized in 2 groups: not using ear protection and 5-wings type ear protection groups as they routinely trained. Audiogram and Distortion Product Otoacoustic Emission (DPOAE) was performed before and after firing within 24 hr, 3rd day and 7th day in both groups.

***Result:*** Immediately after gunfire, those not using ear protection group had SNHL more than the other group at a high frequency (53.2% vs. 0%, $p < 0.05$). At day 3, the hearing levels were gradually improved at all frequencies except 6,000 Hz. At day 7, three conscripts (10%) in the not using ear protection group still had SNHL detected by audiogram, 12 individuals (40%) had abnormal outer hair cell (OHCs) function detected by DPOAE.

***Conclusion:*** The 5-wing type ear protection could prevent SNHL immediately after gunfire training. DPOAE had higher sensitivity than audiograms in detecting OHCs deficiency up to 30%.

***Keywords:*** Sensory neural hearing loss, Audiogram, DPOAE , 5-wing type ear protection

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Hearing loss level can be examined using audiograms. The Audiogram and Distortion Product Otoacoustic Emission (DPOAE) are the hearing measurement. It can early detect the SNHL even when the audiogram result is normal. The DPOAE is essential in analyzing the abnormality of OHCs function within the cochlea. The measure can detect SNHL at 4,000 to 6,000 Hz and considered a high sensitivity measurement[(1)]. However, it cannot report the hearing loss level similar to using audiograms.

Multiple earplug models are available. Hanchumpol[(2)] has researched hearing protective device efficiency. He has studied six protective devices named rubber plug, foam with plastic-covered plug, sponge plug, big mold plug, small mold plug and 5-wing plug. The laboratory result has shown that the 5-wing plug produced the maximum efficiency. It can reduce the high frequency (more than 2,000 Hz) better than the human voice (500-2,000 Hz) about 40.48 dB on average. Because each wing of the 5-wing plug (Figure 1) is slim, it allows lower frequency sound through the inner ear more than higher frequency sound. After inserting in the ear, it creates a small gap between each wing. This gap also protects from noise and the outer wing is thick and is able to prevent high frequency sounds better than lower frequency sounds. Soldiers who use these devices are also able to hear commands. However, no systematic study has been conducted about the efficiency of hearing protective devices in actual use.

Presently, military shooting training has never used standard hearing protective devices, and some conscripts use only cotton balls or bullet sheaths. M16

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rifles produce 115 - 126 dB[3], and HK33 rifles produce 124 dB, creating the risk of developing SNHL during shooting training. Therefore, the authors investigated the 5-wing type ear protection developed by Thai researchers. Because this innovation is cheaper and more convenient than foreign products; consequently, the researchers studied to provide information in preparation for SNHL protection from gunshot and explosive devices in the military training.

## Materials and Methods

The study design was a randomized control trial. Sixty conscripts during routine training were enrolled and randomized by systematic random sampling in two groups: the not using ear protection as they routinely trained, and the 5-wing type ear protection group. The conscripts who had ear abnormalities, e.g., tympanic membrane perforation or underwent ear operations were excluded. All were trained to use HK 33 rifles and fired approximately 157 shots. The GSI61 Grason-Stadler Audiogram model and ILOV6 Otodynamics DPOAE were performed before and after shooting within 24 hr, 3rd day and 7th day in both groups by the same audiologist. The analysis of general information used average, standard deviation and percentage. The comparison between two groups used Chi-square test as the information was categorized. The significance level was set at 0.05. This study was approved by the Ethics Committee Institutional Review Board of the Royal Thai Army Medical Department.

## Results

The demographic data before shooting training showed no significant difference as presented in Table 1.

Both groups were examined immediately (within 24 hours) after gunfire. SNHL was found among 16 conscripts (53.2%) in the not using ear protection group higher than the using

5-wing type ear protection group at 3,000 to 8,000 Hz. (53.2% vs. 0%, $p < 0.05$), according to Figure 2. After DPOAEs were tested, the OHCs deficiency was found among 19 conscripts (63.3%) in the not using ear protection group compared to the used group who had only one affected individual or 3% (affected before gunfire), and statistically significant ($p<0.05$).

Three days after the gunfire, in the not using ear protection group five conscripts were affected (16.7%) at 6,000 Hz, = significantly more than the other group (16.7% vs. 0%; $p<0.05$). The hearing threshold level at other frequencies such as 3,000 Hz, 4,000 Hz, and 8,000 Hz improved according to Figure 3.

**Table 1.** Comparison of demographic data between using ear protection group and non-using ear protection group before the military training.

| | Using ear protection group (N=30) | Non-using ear protection group (N=30) | *p*-value |
|---|---|---|---|
| AGE(yr) | 21±3 ( 18-27) | 20±2 ( 18-26) | 0.412¶ |
| Audiogram (SRT)(dB) | 16±2 | 16±3 | 0.964¶ |
| Normal hearing persons(%) | 30(100%) | 30(100%) | 0.125δ |
| DPOAEs (dB) | -10.70-16.90 | -3.2-16.9 | 0.118¶ |
| Normal outer hair cell Function persons (%) | 29(97%) | 26(87%) | 0.324δ |

¶ Independent sample t-test

δ Chi-square test

**Table 2.** Comparison of SNHL after military shooting training seven days detected by audiogram and DPOAEs between using 5-wings type ear protection and non-using ear protection group.

| | Using ear protection group | Non-using ear protection group |
|---|---|---|
| SNHL persons (%) (Detected by audiogram) | 0 | 3 (10%) |
| -Mild | | 1 (3.3%) |
| -Moderate-severe | | 2 (6.7%) |
| Outer hair cells loss persons (%) (Detected by DPOAEs) | 1( 3%) | 12(40%) |

The DPOAE results after three days showed the OHCs deficiency was found among 17 conscripts (56.6%) in the not using ear protection group, which was significantly more than the using 5-wing type ear protection group (56.6% vs. 0%; $p < 0.05$).

At day 7, three conscripts (10%) in the not using ear protection group still presented hearing loss, 12 individuals (40%) presented abnormal OHCs functions by DPOAEs compared to 3% detected in the using ear protection group (affected before gunfire). The 5-wing type ear protection could prevent SNHL immediately after gunfire. DPOAEs had a higher sensitivity than audiograms in detecting OHCs abnormality up to 30% according to Table 2.

## Discussion

The study found that the conscripts not using the 5-wing type ear protection experienced SNHL immediately after shooting as the OHCs within the cochlea had been damaged. This was confirmed by Helfer[4] who studied American soldiers on shooting training for one year, and found that the incidence of permanent SNHL was about 29.3% detected by audiogram.

Hausler[5] studied the effect of acoustic overstimulation and found that temporary hearing loss could happen initially and could be restored to normal in 24 to 48 hours[6-8], called the temporary threshold shift (TTS). When subjects are exposed to loud noise for a long time, permanent threshold shift (PTS) could occur. The present study found that three conscripts or 10% who did not use the hearing protective device had SNHL detected by audiogram, and as many as 12 conscripts or 40% had OHCs deficiencies according to the DPOAE test. Only one individual or 3% of those who used ear protecting device presented OHC deficiency (affected before gunfire). These conscripts had risk of permanent threshold shift when they were exposed to loud noise for a longer period. The present study result was similar to the study of Prasitvechakul[9]. Three conscripts or 7.69% presented hearing deficiency seven days after the training.

The authors found that the highest SNHL was at 6,000 Hz. This confirmed the study results of Prasitvechakul[9] and Pelausa[10] who studied the hearing level of conscripts after shooting training reporting the highest SNHL at 6,000 Hz. This showed that loud noise from gunfire damages the basal turn of the cochlea, which receives high-pitch frequency SNHL.

By comparing the hearing level between

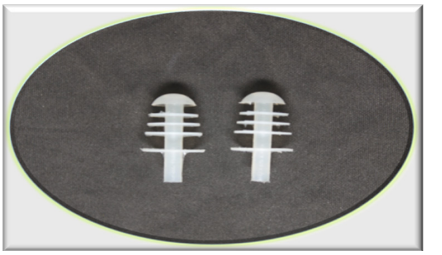

**Figure 1.** The 5-wings type ear protective device

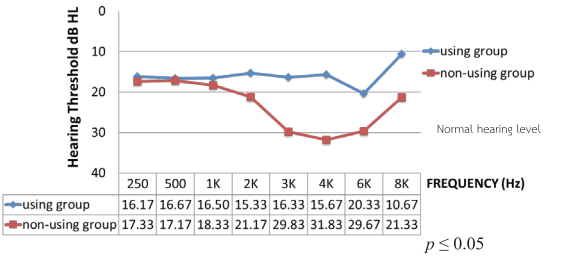


**Figure 2.** Comparison of the audiogram results immediately after the military shooting training between using 5-wings type ear protection group and non-using ear protection group.

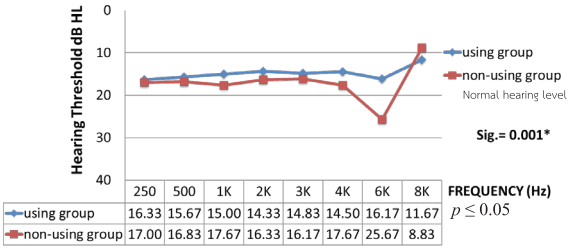


**Figure 3.** Comparison of the audiogram results three days after the military shooting training between using 5-wings type ear protection and non-using ear protection group.

audiogram and DPOAES, OHC deficiency could be detected immediately by DPOAEs and could eventually be recovered in the next three and seven days, respectively. This examination was confirmed by audiogram. For those who did not use the hearing protective devices, three conscripts or 10% presentedthe deficiency detected by audiogram while as many as 12 conscripts or 40% were detected regarding abnormality by DPOAEs. This showed that nine conscripts or 30% presented an OHC deficiency that could not be detected using audiograms. DPOAEs could detect OHC deficiency faster than audiograms similar to the studies of Marshall L[11] and Konopha W[12]. Further studies can be performed to indicate the time when

DPOAEs returns to preshooting level and those nine conscripts should be careful followed regarding hearing loss potential when exposed to loud noise without using standard hearing protective devices. Conscripts are advised to use the hearing protective devices while shooting. and those nine conscripts would be followed up by DPOAEs periodically. DPOAEs are important and can be used as a tool to check OHCs deficiency especially for those exposed to loud noise and presented DPOAEs. Audiogram results should indicate normal to prevent permanent SNHL.

The 5-wing type ear protection could prevent the chance of permanent SNHL. Hearing loss was not found among those who used the 5-wing type ear protection. However, Pelausa[10] who studied hearing protective devices found 11% deficiencies. The 5-wing type ear protection was able to prevent hearing loss is a product of Thai researchers and is also cheaper than foreign devices. In the future, the authors will study the 5-wing type ear protection compared with foreign ear protective devices.

## Conclusion

The 5-wing type ear protection could prevent SNHL immediately after gun shooting training. DPOAEs had a higher sensitivity than audiogram in detecting OHCs deficiency up to 30%.

Exposure to very loud noise especially gunfire or explosive devices leads to SNHL.

Protection should be ensured using hearing protective devices and the DOAE check-up is required after exposure to loud noise though audiogram results are acceptable to monitor OHC function to prevent permanent SNHL.

## What is already known on this topic?

SNHL is a problem and urgent condition of military shooting training. Related studies in the U.S. reported that American soldiers on shooting training for one year, presented an incidence of permanent SNHL detected by audiogram. Moreover, one study in Canada reported that 11% of subjects who used hearing protective devices had SNHL. Hearing protective devices are important to prevent permanent SNHL.

## What is this study adds?

This report described the usefulness of the 5-wing type ear protection. It was able to prevent hearing loss and it constitutes a product of Thai researchers and is cheaper than foreign devices. It could prevent the chance of permanent SNHL detected by audiogram and early detected by DPOAEs. It can be used as a tool to check OHCs deficiency especially among those who are exposed to loud noise.


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## Potential conflicts of interest

The authors declare no conflict of interest.

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