Prevention of Acute Acoustic Trauma by Earmuffs during Military Training

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Background: *Impulse noise produced from firearms can potentially damage hearing organs resulting in sensorineural hearing loss (SNHL). In Chiang Mai during 1997, Detphithak et al reported a prevalence of acute acoustic trauma (AAT) in 22% of new military privates using an H.K.33 for shooting practice without hearing protection. The H.K.33 renders an average sound pressure level of 128 dBA. Earmuffs are claimed by their manufacturing company to attenuate noise 27 dB, and they have been recently introduced in Chiang Mai to prevent AAT.*
Objective: *To study the outcomes of hearing protection against AAT using earmuffs during shooting training (H.K.33) in the Military Reserve Officer Training Corps (MROTC).*
Material and Method: *A quasi – experiment study was conducted among 267 normal hearing MROTCs in the Reserve Officers Student Training Center (ROSTC) of the 33rd Military Circle, Chiang Mai, Thailand. Their condition of hearing was examined by an otolaryngologist and an audiologist using pure tone audiometry (PTA) before shooting practice, within 2 hours after the practice, 3 days after the practice at the ROSTC; and 1 month later at Fort Kawila Hospital, Chiang Mai, Thailand.*
Results: *All 267 MROTCs used earmuffs during shooting practice. Their mean age was 17.95 years. Average sound pressure level of an H.K.33 was 127 dBA (range; 126.5-130 dBA). AAT was found in 4 persons (1.5%) within two hours after shooting. Repeat testing 3 days later revealed that only one person (0.37%) still had SNHL. Fortunately, this case reached complete recovery within 1 month. When comparing these findings with those of 1997, earmuffs can reduce AAT by 15 times (95% confidence interval 5.3-40.5, p-value < 0.0001) to a negligible level.*
Conclusion: *Shooting training with an H.K. 33 produces a dangerous sound pressure level at the shooting site, resulting in a possible high risk of acute acoustic trauma. Earmuffs can effectively reduce this risk by approximately 15 times, and they should be widely used in all shooting training.*

Keywords: *Acute acoustic trauma (AAT), Sensorineural hearing loss (SNHL), Earmuffs, Military training*

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Exposure to very intense sound such as impulse noise from a firearm can result in sudden hearing loss. This is called acute acoustic trauma (AAT). It was found that 87.5% of AAT cases occurred among Finnish Defense Forces, due to unprotected ears[1]. The incidence of hearing loss from exposure to weapon noise was 28% and 20-30% among British Army and US Army personnel, respectively[2,3]. In Thailand, it was found that 64.35 % of military gun shooting advisors had sensorineural hearing loss (SNHL)[4] and 9.34% among sport shooters suffered hearing impairment at 3,000-8,000 Hertz[5]. Hearing can be protected by ear protection equipment such as earplugs or earmuffs. In

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2002, an AAT incidence of 6.9% was found among Thai medical cadets after shooting practice, with 81% of them applying cotton balls, tissue paper and cartridge cases as ear protectors[6].

In 1997, the incidence of AAT in privates with normal hearing, but without ear protection was 22% at the authors' military training site[7]. Two years later, earplugs were supplied to new recruits during shooting practice, and the incidence of AAT dropped dramatically to 7% (unpublished data). In 2005, these results encouraged the Director of the Reserve Officers Student Training Center (ROSTC) of the 33rd Military Circle, Chiang Mai, Thailand, to supply 100 pairs of earmuffs for shooting practice (with an H.K. 33) at the training site. The present study therefore aimed to assess the impact of these earmuffs on AAT incidence after shooting practice among MROTC in Chiang Mai.

Material and Method

A quasi – experiment study design was used. The samples were MROTCs trained at the ROSTC of the 33rd Military Circle in Chiang Mai from February to March 2006. The inclusion criteria were MROTCs who had neither history of any ear diseases nor excessive noise exposure and had normal hearing threshold level after being examined by an otolaryngologist and audiologist. The MROTCs were divided into several groups of 40 pairs. Each group entered the shooting practice line and practiced 13 shooting set in pairs (Fig. 1). A sound pressure level meter (TES Model 1350) was used to measure the sound intensity produced from an H.K.33 next to the trainees' ears at the shooting site. There were 6 measurement points on the shooting line. Before shooting practice, all MROTCs were examined by an otolaryngologist. Their hearing was assessed by an audiologist using a pure tone audiometer (Digital Diagnostic Audiometer, Maico Model MA 51 with audiocup under calibration AC:ISO R 389–1991) at levels of 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hertz. A hearing test was performed three times in a quiet room at the ROSTC which had ambient noise between 30 to 50 dB. The first hearing test was before the shooting, the second was within 2 hours after the shooting and the third was three days after the shooting. All MROTCs with SNHL problems found on the third day were reassessed one month later in the sound treated room which had ambient noise between 25 to 40 dB at the Fort Kawila Hospital. Diagnosis of AAT was defined as SNHL, with a hearing threshold level of more than 25dB in any frequencies after shooting. The incidence results were then compared to those from previous studies in Chiang Mai, and with the different methods of protection used to estimate the protective effects.

Statistical analysis

Sound pressure level data were analyzed using a mean. An AAT status was analyzed using proportions. Chi-square test was used for comparing these proportions. Statistical analysis were done using Epi Info program version 6.

Results

Before shooting

The total of 272 MROTCs (third year MROTC) were examined for physical and hearing condition. During the examination, five persons were excluded, one due to chronic otitis media and four due to SNHL. The remaining 267 MROTCs were included in the present study. They comprised 228 healthy males and 39 healthy females, aged ranged from 17 to 28 years with the mean age of 17.95 years.

During shooting practice

The average sound pressure level produced from an H.K. 33 at the shooting site was 127 dBA (range; 126.5-130 dBA). It was 12 dBA higher than the standard safety level according to the 1983 - Occupational Safety and Health Administration (OSHA) regulation[8]. At 6 meters away from the shooting site, the sound pressure level was about 123.5 and 124.5 dBA at the bullet distribution post and waiting line, respectively (Fig. 2).

Fig. 1 The 40 pairs of the MROTCs at the shooting line during shooting practice with H.K.33

Fig. 2 The bullet distribution post line (long arrow) and the waiting line (asterisks) at 6 meters away from the shooting site (short arrow)

After the shooting

The hearing threshold level among the 267 MROTCs was reassessed within 2 hours after the shooting. Four males (1.5%) had developed SNHL. Three cases had their right ears affected while the other one had both ears affected. It was also found that three of them had their hearing affected only at 4 kHz and the remaining case had affected hearing at 3 kHz, 4 kHz and 6 kHz (Fig. 3). Among these four cases, only one (0.37%) still had high frequency SNHL 3 days after shooting practice (Fig. 4). Fortunately, this case completely recovered within one month.

Estimation of protective effects:

When comparing the AAT incidence found in the present study with that of 1997[7] among unprotected shooting recruits, it was found that earmuff-protection results in lowering AAT incidence after shooting practice by approximately 15 times (95% confidence interval 5.3-40.5, p-value < 0.0001). In addition, results from a 1999 study (unpublished data) among new normal hearing recruits wearing earplugs showed that earplugs can reduce the incidence of SNHL by approximately 3 times, when compared with the non-protected group of the 1997 study (95% confidence interval 1.3 - 6.8, p-value < 0.01) (Table 1).

Discussion

The high average sound pressure level produced from the H.K. 33 at this site is obviously harmful to hearing organs. To date, there has been no approved treatment for AAT[8,9]. A few studies reported that hearing protection by earplugs or earmuffs could reduce highly intense sound to the hearing organs[10-12]. In a situation where the sound pressure level of this firearm (H.K.33) cannot be reduced, effective personal hearing protection needs to be applied during shooting practice. Theoretically, the most effective type of hearing protection equipment is earmuffs. They consist of two solid cups containing a sound absorbing material such as foam, sealed to the sides of the head with a soft malleable gasket. It is designed to have sufficient pressure in order to produce an airtight seal. However,

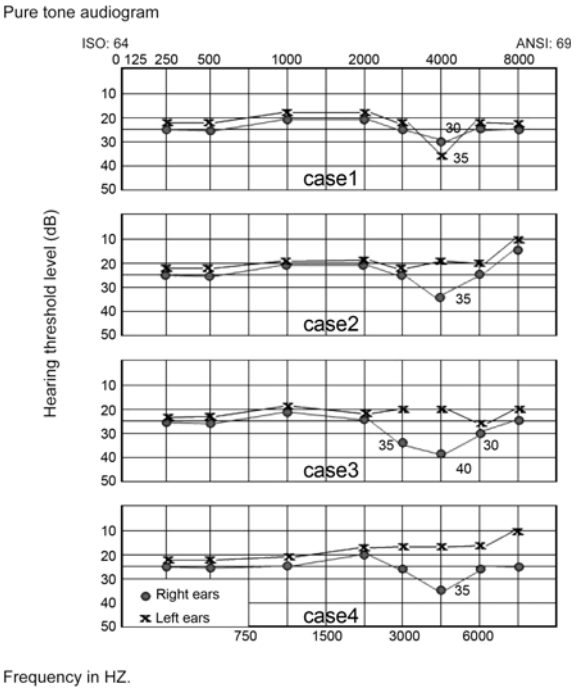

Fig. 3 Different audiometric configurations in 4 cases of AAT, 2 hours after shooting practice

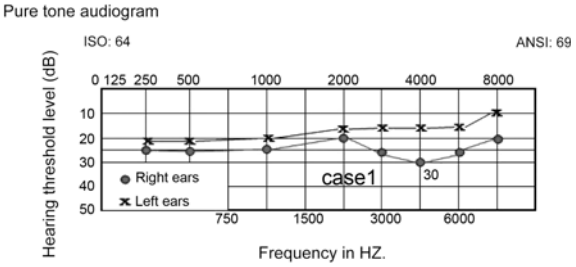

Fig. 4 Audiometric configurations of the only one case of AAT at 3 days after shooting practice

Table1. Comparisons of acute acoustic trauma (AAT) incidences among 3 groups with different types of ear protection from 3 studies in Chiang Mai

Year of study	Group characteristics	Ear protectors	Total number	AAT incidence	Relative risk	
					None vs. EM[a] (95% CI)[c]	None vs. EP[b] (95% CI)[c]
1997[7]	Privates age 21-23 yrs	None	155	34 (22 %)	15** (5.3-40.5)	3* (1.3-6.8)
1999 (unpublished data)	Privates age 21-23 yrs	Earplugs	82	6 (7 %)	-	-
2006 (the present study)	MROTCs age 17-20 yrs	Earmuffs	267	4 (1.5%)	-	-

EM[a] = Earmuffs
EP[b] = Earplugs
** = p-value < 0.0001 by Chi-square test
* = p-value < 0.01 by Chi-square test
[c] = 95% confidence interval of relative risk

earmuffs are less comfortable to wear than earplugs[13]. The authors, therefore, considered earmuffs as suitable for sharing among a great number of MROTCs, due to their effectiveness and convenience for sharing and cleaning.

Applying a randomized control trial study design to assess the protective effects of any ear protectors against AAT caused by shooting practice may be considered as unethical and unacceptable when no ear protection is used as a control. The present study was the third in a series of similar incidence studies conducted as part of the otological services to shooting training. AAT incidences in these studies were measured in the same fashion with the same team and equipment. The similar characteristics of these training groups, therefore, provide rather stable grounds for comparing results across the studies.

All 4 cases of SNHL that occurred in the present study completely recovered within 1 month. Therefore, it can be concluded that at the first AAT stage, temporary threshold shift (TTS) occurred and recovered within 24-48 hours after shooting practice[14]. While permanent threshold shift (PTS) can be caused by high intensity noise or repeated exposure[14], it was fortunately not found among the MROTCs in the present study. This can be partly explained as a result of using earmuffs during shooting practice.

The estimated protective effects of earmuffs found at the site are remarkable. The protection size (Table 1) outweighs the bias normally found in a quasi-experiment study. It can be concluded that earmuffs reduce AAT risks from shooting practice by 5-40 times, when comparing with no ear protection. The pure tone audiogram of acute acoustic trauma usually shows an acoustic notch at 3, 4 or 6 kHz[13]. This corresponds to the outcome of the present study, which had the most affected frequency at 4 kHz.

The observation of high sound pressure levels at the bullet distribution post and waiting line also raised concern. These levels could also be harmful to trainees in those areas. Therefore, the authors proposed to training staff that everybody in these areas should be wearing earmuffs. The Director of the ROSTC, Chiang Mai, accepted these findings and recommendations. Additional earmuffs were then provided during shooting training in 2006.

Conclusion

Shooting training with an H.K. 33 produces harmful sound pressure level at a shooting site and results in high risk of AAT in an MROTC where ear protectors are not worn. Earmuffs can effectively reduce that risk by approximately 15 times, and they should be widely used at every shooting practice. If earmuffs are not available, it is suggested that earplugs be used instead because they are cheaper and widely available.

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การใช้ที่ครอบหูเพื่อป้องกันประสาทหูเสื่อมจากเสียงในนักศึกษาวิชาทหาร

นิภาพรรณ ธรรมเดชศักดิ์, ศรีทนต์ บุญญานุกูล, สุรเดช จารุจินดา, อภินันท์ อร่ามรัตน์, สกล เอี่ยมตระกูล

ภูมิหลัง: *เสียงปืนจัดเป็นเสียงชนิด impulse noise สามารถทำอันตรายแก่หูชั้นในทำให้เกิดประสาทหูเสื่อม (sensorineural hearing loss, SNHL) เมื่อปี พ.ศ. 2540 นิภาพรรณ เดชพิทักษ์ และคณะ ได้ศึกษาในพลทหารใหม่ที่มีการได้ยินปกติก่อนฝึกยิงปืน พบว่า พลทหารเหล่านี้ฝึกยิงปืน H.K.33 ซึ่งมีระดับเสียงดัง 128dBA โดยไม่ได้สวมอุปกรณ์ป้องกันเสียง เกิดประสาทหูเสื่อมเฉียบพลัน (acute acoustic trauma, AAT) หลังการฝึกยิงปืนจำนวนร้อยละ 22 จึงได้มีการนำเอาอุปกรณ์ป้องกันเสียงชนิดครอบหู (earmuffs) ซึ่งบริษัทผู้ผลิตยืนยันว่าสามารถลดความดังของเสียงลงได้ 27 เดซิเบลมาใช้ เพื่อป้องกันการเกิดประสาทหูเสื่อมเฉียบพลัน*

วัตถุประสงค์: *เพื่อศึกษาผลการป้องกันการเกิดประสาทหูเสื่อมเฉียบพลันจากเสียงปืนโดยการสวมอุปกรณ์ป้องกันเสียงชนิดครอบหู ในนักศึกษาวิชาทหาร (นศท.)*

วัสดุและวิธีการ: *ใช้รูปแบบการศึกษาลักษณะกึ่งทดลอง (Quasi-experiment study) ทำการศึกษาในกลุ่ม นศท. ชั้นปีที่ 3 ซึ่งมีการได้ยินปกติ ของศูนย์การฝึกนักศึกษาวิชาทหาร มณฑลทหารบกที่ 33 (ศฝ.นศท.มทบ.33) จำนวน 267 นาย ทุกนายผ่านการซักประวัติ และตรวจร่างกายโดยโสต ศอ นาสิกแพทย์ ตรวจวัดระดับการได้ยินโดยนักแก้ไขการได้ยินที่ ศฝ.นศท.มทบ.33 ก่อนการฝึกยิงปืน หลังการฝึกยิงปืนทันทีภายใน 2 ชั่วโมง และหลังฝึกยิงปืน 3 วัน หาก นศท. รายใดยังคงมีประสาทหูเสื่อมจะนำมาตรวจการได้ยินซ้ำที่โรงพยาบาลค่ายกาวิละในอีก 1 เดือนต่อมา*

ผลการศึกษา: *ค่าระดับความดังโดยเฉลี่ยของเสียงปืนขณะทำการยิงเท่ากับ 127dBA (126.5-130 dBA) กลุ่มตัวอย่าง นศท. จำนวน 267 นาย อายุเฉลี่ย 17.95 ปี ทุกนายสวมที่ครอบหู (earmuffs) เป็นอุปกรณ์ป้องกันเสียงขณะฝึกยิงปืน ผลการตรวจการได้ยินหลังยิงปืนทันทีภายใน 2 ชั่วโมงพบว่ามีประสาทหูเสื่อมเฉียบพลัน (AAT) 4 นาย (1.5%) เป็นประสาทหูเสื่อมที่ความถี่สูง (3,000 – 6,000เฮิรตซ์) เมื่อตรวจซ้ำหลังยิงปืน 3 วันยังคงเหลือ นศท. ที่มี AAT เพียง 1 นาย (0.37%) จากการติดตามผลในอีก 1 เดือนต่อมา นศท. รายนี้มีการได้ยินกลับมาเป็นปรกติ เมื่อศึกษาทางสถิติเปรียบเทียบกับการศึกษาในปี พ.ศ. 2540 พบว่า การใส่ที่ครอบหูลดความเสี่ยงของการเกิดประสาทหูเสื่อมเฉียบพลัน (AAT) ลงมาได้ถึง 15 เท่า (95% Confidence interval 5.3-40.5, p-value < 0.0001)*

สรุป: *เสียงปืนระหว่างการฝึกยิง HK.33 มีอันตรายต่อหูชั้นใน ทำให้เกิดประสาทหูเสื่อมเฉียบพลัน (AAT) การใช้ที่ครอบหูของ นศท. ขณะฝึกยิงปืนสามารถลดโอกาสเกิดประสาทหูเสื่อมเฉียบพลัน (AAT) ลงได้ถึง 15 เท่า จึงควรจัดให้มีการใช้ที่ครอบหูอย่างกว้างขวางในพื้นที่การฝึกยิงปืน*