Association of Pure Tone Audiometry with DPOAE in Students after Shooting Practice at East Java State Police Academy, Mojokerto, Indonesia

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Abstract

Objective: Analyzing the association between pure tone audiometry and distortion of otoacoustic emission (DPOAE) in students after shooting practice.

Methods: This study was conducted at the East Java State Police Academy, Mojokerto, Indonesia, from August 2018 to January 2019. Participants were examined for pure tone audiometry and DPOAE two weeks after shooting training. Participants previously had undergone shooting training for 5 months, with schedule of 4 times per week. The statistical test used an independent t test or Mann Whitney test with $p < 0.05$.

Results: All participants were men, with an average pure tone audiometry value of 27.50 ± 10.43 dB. The results of pure tone audiometry examination found that most participants had normal hearing (58.00%). This finding was inversely proportional to the results of DPOAE examination, in which most participants had "Refer" (78.00%). The mean pure tone audiometry value on participants with DPOAE "Refer" was 20.36 ± 3.47 dB and DPOAE "Pass" was 29.51 ± 10.87 dB ($p = 0.008$). Most participants had "Refer" DPOAE with normal pure tone audiometry as much as 36.00%, followed by participants with "Refer" DPOAE but mild hearing loss of pure tone audiometry as much as 24.00% ($p = 0.002$).

Conclusion: There is a significant association between pure tone audiometry with DPOAE. Many participants have normal audiometry but "Refer" DPOAE, and followed by participants experiencing mild hearing loss with "Refer" DPOAE.

Keywords: *acoustic trauma, pure tone audiometry, DPOAE, police*

Introduction

Patients with acoustic trauma often have abnormal distortion product otoacoustic emission (DPOAE) with normal audiometric examination [(1)]. A routine pure tone audiometry examination for shooting athletes cannot predict the risk of hearing loss. Patients with average audiometry have experienced hearing loss. This often causes the athletes to have hearing loss and late treatment[(2)].

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Acoustic trauma is a clinical condition of persistent or permanent hearing loss after exposure to impulses or loud sound waves [(3, 4)]. Acoustic trauma causes organic ear damage due to very large sound energy. Cochlea injury occurs due to excessive physical stimulation in the form of very large vibrations that damage hair cells. In repetitive exposure, damage does not only occur due to physical processes, but also chemical processes in the form of metabolic stimuli that excessively stimulate hair cells that results cells dysfunction which leads to a temporary hearing loss. Damage to hair cells can also result in permanent hearing loss [(5)].

Hearing loss caused by acoustic trauma often results in permanent disability in army and police personnel [4]. Exposure to firearms eruptions, both large and small caliber, can cause acoustic trauma. Noise from gunfire eruptions, including pure impulsive noise with light gun eruption, has intensity ranging from 150 to 190 decibels (dB). Exposure to high-intensity sound can cause excessive vibration in tympanic membrane that leads to a risk of tympanic membrane perforation. The vibration is then continued to the middle ear through hearing bone that results in a risk of dislocation and damage to hearing bone. The vibration is then delivered to the perilymph and endolymph to vibrate the basilar membrane. This will cause stimulation of hair cells on tectorial membrane excessively that results in reversible hair cell damage. Repeated acoustic trauma can cause hair cells to atrophy and permanent damage [6].

Based on the description above, this study aimed to determine the association of pure tone audiometry examination with DPOAE in students after shooting practice at the East Java State Police Academy.

Methods

Participants of this study were students of the East Java State Police Academy of 2017/2018. Participants should meet the inclusion and exclusion criteria of the study. Inclusion criteria included active participants in shooting training for 5 months and had intact tympanic membrane. Exclusion criteria included patients experiencing ear infections (otitis media), patients experiencing flu and tympanic membrane perforation. Participants have received an explanation regarding the objectives, benefits, rights, and obligations of the participant during the research process. Participants who were willing to take part in the research first filled in informed consent.

This research was conducted at the East Java State Police Academy, Mojokerto, Indonesia, from August 2018 to January 2019. This study employed a cross-sectional design with a total sampling method. The number of participants in this study were 50 participants. The researchers conducted an ethics test at the ethics committee Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, prior to the study. Participants were examined for participant characteristics, pure tone audiometry, and DPOAE. The examination was carried out after the participants had joined shooting exercises for at least 5 months, and the exercises were carried out 4 times a week. Pure tone audiometry and DPOAE examinations were performed two weeks after shooting practice.

Pure tone audiometry is a subjective hearing examination to determine the degree of hearing loss with an audiometer (Interacoustics AD226 Clinical Audiometer; Assens, Denmark). The examination was carried out in a soundproof room at the East Java State Police Academy, Mojokerto, Indonesia. The room's noise level was 40 to 45 dB. Pure tone audiometry check started at 1kHz 40 dB. If the participant did not respond, the frequency was raised by 5 dB until the hearing threshold was obtained, and the participant responds was reduced by 10 dB. The valuated frequency of air conduction was at frequencies of 250Hz, 500Hz, 1kHz, 2kHz, 4kHz, and 8kHz. The evaluated bone conduction frequencies were 500Hz, 1kHz, 2kHz, and 4kHz. The results were grouped according to severity based on the International Standard Organization (ISO) and the American Standard Association (ASA), with the following categories: normal (<25 dB), mild degree (26-40 dB), moderate degree (41-60 dB), severe degree (61-80 dB), and profound (>81 dB).

DPOAE examination is a hearing examination that can detect damage to outer cochlear hair cells using the AuDX-I Bio-logic tool (Natus Medical Inc; CA, USA). DPOAE occurs when two pure tone stimuli with different frequencies are given simultaneously (f1 and f2). Previously set DPOAE filtering parameters include SPL 65/55 dB stimulus intensity levels for lower f1 frequencies (L1) and higher f2 frequencies (L2). The overall passing criteria are DPOAE for the difference in noise level of 6 dB for three of the four f2 test frequencies (f2 of 5, 4, 3, and 2 kHz) [7]. DPOAE is normal if "Pass", and declared abnormal if "Refer". Participants were asked to sit in a comfortable chair, and the probe was placed in the participant's ear canal. Participants were encouraged to be calm and not move their heads during DPOAE recording [8]. This test took around 1 - 5 minutes in ideal conditions, with optimal test techniques [9].

This research had been declared feasible to be carried out because it passed ethical approval from The Ethics Committee Dr. Soetomo General Academic

Hospital, Surabaya, Indonesia (0926/KEPK/II/2019).

The results of the study were presented in the form of mean ± standard deviation (SD) or median (Quartile 1 - 3) and percentage (%). Statistical analysis used an independent t test or the Mann Whitney test (95% CI). Static analysis used IBM SPSS Statistics software version 23.0 (IBM Corp., Armonk, NY, USA). Statistical test results were significant if $p < 0.05$.

Results

Characteristics of Participants

The participants age ranged from 18 years to 21 years, and most students aged 20 years (42.00%). All students were male. There were participants who experienced a momentary hearing loss (10%). Most participants experienced momentary tinnitus as much as 96.00%. Most participants experienced acoustic trauma as much as 56.00% (Table 1).

Audiogram Results

The average audiogram examination results for each frequency were as follows: 250Hz at 26.60 ± 10.47 dB, 500Hz at 26.50 ± 8.64 dB, 1kHz at 25.00 ± 8.33 dB, 2kHz at 28.50 ± 11.44 dB, 4kHz at 31.10 ± 14.15 dB, 6kHz at 26.40 ± 14.88 dB, and 8kHz at 25.70 ± 14.92 dB. The average audiogram results were 27.50 ± 10.43 dB. Audiometry examination results showed that some participants experienced mild to moderate hearing problems. Most participants had an audiometric value within the normal limit (58.00%; Table 1).

DPOAE Results

The results of DPOAE examination were as follows: Pass and Refer, where most participant had Refer result (78.00%), while 22% of participants were in "Pass" category (Table 1).

Association of Pure Tone Audiometry with DPOAE

This study found a significant difference between the results of pure tone audiometry examination with DPOAE, with a mean participant value with DPOAE "Pass" and "Refer" at 20.36 ± 3.47 dB and 29.51 ± 10.87 dB, respectively ($p = 0.008$). The results of pure tone audiometry results were higher in the "Refer" DPOAE group compared to "Pass" group ($p < 0.05$). The examination results of each frequency could be seen in Table 2.

The pure tone audiometry examination results were categorized into three. Most participants had a normal result (58.00%). Most DPOAE examination results belonged to "Refer" category as much as 78.00%. Most students had "Refer" DPOAE but with normal pure tone audiometry (36.00%), and followed by participants with "Refer" DPOAE but with mild pure tone audiometry in pure tone audiometry results (24.00%; $p = 0.002$; Table 3).

Table 1. Characteristics of participants

Variables	n (%)
Age	
18	4 (8.00)
19	18 (36.00)
20	21 (42.00)
21	7 (14.00)
Momentary hearing loss	
Yes	5 (10.00)
No	45 (90.00)

Cont... **Table 1. Characteristics of participants**

Momentary tinnitus	
Yes	48 (96.00)
No	2 (4.00)
Hearing disorder	
Normal	29 (58.00)
Mild	12 (24.00)
Moderate	9 (18.00)
DPOAE	
Pass	11 (22.00)
Refer	39 (78.00)

Table 2. Comparison of pure tone audiometry frequency distribution with DPOAE

Audiogram	DPOAE		p
	Pass (n=11)	Refer (n=39)	
250Hz	19.55±8.50	28.59±10.19	0.019*
500Hz	21.36±7.10	27.95±8.56	0.032*
1kHz	18.64±5.04	26.79±8.23	0.002*
2kHz	21.36±5.45	30.51±11.96	0.010*
4kHz	23.18±8.14	33.33±14.75	0.049*
6kHz	17.27±4.10	28.97±15.82	0.018*
8kHz	16.36±3.93	28.33±15.82	0.024*
Peru tone average	20.36±3.47	29.51±10.87	0.008*

DPOAE = distortion product otoacoustic emission; *significant 0.05

Table 3. Correlation between DPOAE and pure tone audiometry

DPOAE	Pure Tone Audiometry			p
	HL Normal	HL Ringan	HL Sedang	
Pass	11 (22.00)	0 (0.00)	0 (0.00)	0.002*
Refer	18 (36.00)	12 (24.00)	9 (18.00)	

HL=hearing loss; *significant <0.05

Discussion

This study found a significant association between pure tone audiometry and DPOAE in students of East Java State Police Academy, Mojokerto, Indonesia. Police is a job with a risk of being exposed to excessive noise especially during shooting practice [10]. At the moment, weapons shooting training is capable of producing noise around 132-165 dB with a frequency spectrum between 150 to 2500 Hz. Noise exposure can cause acoustic trauma. If the condition lasts for a long time, it can cause police to become a group that is at risk of hearing loss [11]. Acoustic trauma will trigger damage to hair cells in cochlear organ. Hair cells are circular structures that will vibrate by acoustic signals of sound. Such mechanical vibrations are converted into electrical waves in the auditory nerve [1].

Acoustic trauma causes damage to basal hair cells due to high intensity noise exposure at high frequencies, whereas apex damage is caused by high intensity noise at low frequency. Differences in damage to basal and apex hair cells can be caused by tonotopic differences in the basal area to the cochlea apex, such as the condition of outer hair cell viability, vascularization, intrinsic susceptibility of basal hair cells to free radicals that make basal receptors more sensitive to damage. Antioxidant levels in basal are lower than in the apex, so that damage due to high frequencies is more easily occur in basal part [12].

Damage to outer hair cells makes DPOAE not appear even if given acoustic stimulation. Some cochlea can produce sounds spontaneously as internal sounds are processed and then amplified. Recording sound in cochlea requires a combination of earphones and microphones that can deliver vibrations of sound that enter cochlea and are returned to tympanic membrane that functions as a stethoscope. The installed probe must be impermeable so as to prevent outside sounds to enter the ear [13]. Meanwhile, audiometry is used to measure level of minimum intensity on frequencies that can still be heard by the participant. Audiometry evaluates external ear, middle ear, cochlea, Cranial nerve VIII, and central auditory system [14]. A person who is first exposed to noise will experience a variety of changes, which first appear to be hearing threshold increases at high frequencies. At the initial level, there is a temporary hearing threshold shift (TTS). When resting outside a noisy environment, hearing can usually return to normal. These conditions can be evaluated using pure tone audiometry [15].

Hearing loss by acoustic trauma occurs due to exposure to strong and sudden acoustic energy. Noise due to firearms eruption is loud and sudden so that it results in damage to middle and inner ear, vulnerable organs namely the tympanic membrane, hearing bone, cochlea and vestibular system. The exposure can occur once or several times and can affect one or both ears [4, 16]. The exposed organs can result in conductive hearing disorders, sensorineural, or mixed. Damage to outer hair cells makes OAE not appear even if given an acoustic stimulus. Some cochlea can produce sounds spontaneously as internal sounds are processed and then amplified. Recording sound in cochlea requires a combination of earphones and microphones that can deliver vibrations of sound that enter cochlea and are returned to tympanic membrane that functions as a stethoscope. The installed probe must be impermeable so as to prevent outside sounds enter the ear [13].

Damage to cochlear hairs was identified by the DPOAE examination, in which most of participant had "Refer". This condition was supported by results of pure tone audiometry, showing a higher DPOAE "Refer" compared to DPOAE "Pass" at each frequency. This condition is in accordance with the existing theory, in which acoustic trauma is difficult to be identified only by using audiometry but also by using DPOAE as confirmation. A short-term examination audiometry examination cannot optimally describe the condition of participant's hearing condition with acoustic trauma disorders. However, pure tone audiometry can give a picture of decreased hearing threshold after acoustic trauma. Thus, both methods have a significant association in examining patients with acoustic trauma.

Conclusions

This study found a significant association between pure tone audiometry and DPOAE. Most participants have normal audiometry but DPOAE "Pass", and followed by mild hearing loss and DPOAE "Refer".

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