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Hearing Analysis of Welding Workshop Workers Exposed to Noise in Makassar: A Cross-Sectional Study

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KEYWORDS
Pure Tone Audiometry, Otoacoustic Emission, and Noise-Induced Hearing Loss

ABSTRACT:

Introduction: Noise-induced hearing loss (NIHL), which is typically brought on by noise in the workplace, is caused by exposure to loud noise over an extended period of time. The early identification of NIHL requires the use of Pure Tone Audiometry (PTA) and Distortion Product Otoacoustic Emission (DPOAE)..

Objectives To examine the hearing of noise-exposed welding industry workers in Makassar in 2023.

Methods: A cross-sectional study in Makassar in the period January–March 2023. Consisting of 30 welding workshop workers who were exposed to noise with an intensity of ≥85 dB. Hearing loss was assessed using DPOAE and PTA. Data analysis using SPSS v. 26 Chi-square and Fisher tests were used.

Results: Of the 30 workers, 13 right ears (43.4%) were normal, 14 right ears (46.7%) had mild hearing loss, and 3 right ears (10.0%) had moderate degrees; 5 left ears (16.7%) were normal; 20 left ears (66.7%) had mild hearing loss; 4 left ears (13.3%) had moderate degrees; and 1 left ear (3.3%) had severe degrees based on PTA. Based on DPOAE, 3 right ear (10%) pass and 27 right ear (90%) refer; 1 left ear (3.3%) pass and 29 left ear (96.7%) refer. There is conformity between the DPOAE and PTA results of both ears at frequencies 3KHz, 4KHz, and 6KHz ($p < 0.05$).

Conclusions: There is conformity between the DPOAE and PTA results of both ears at frequencies 3KHz, 4KHz, and 6KHz.

1. Introduction

Long-term exposure to noise at an intensity of 85 to 120 decibels can cause loss of a person's hearing function, which is called sensorineural hearing loss (SNHL). This type of hearing loss is better known as noise NIHL. This is due to the noise causing the organ of Corti to degenerate permanently and irreversibly (Setyawan FE, 2021)

Around 36 million people, or 16.8% of the country's population, had hearing loss as a result of noise in Indonesia in 2014, according to the National Committee for the Prevention of Hearing Loss and Deafness (Komnas PGPKT, 2014). Research by Panggeleng AM, et al, of the 40 respondents, there were 17 who experienced hearing loss (42.5%). Age, noise intensity, length of work, use of ear protection equipment, had a relation with hearing loss in these workers (Panggeleng AM, 2022)

Several studies have shown that otoacoustic emissions (OAE) are more sensitive for assessing cochlea damage due to noise exposure. (Helleman HW, 2018). OAE is more effective at NIHL early detection than audiometry. Boger et al compared pure tone audiometry with OAE in industrial workers and found that distortion product otoacoustic emission (DPOAE) could detect NIHL at an earlier stage compared to pure tone audiometry. Workers with normal hearing thresholds experienced a high decrease in DPOAE examination, as indicated by a reduction in cochlear outer hair cells that was not detected by pure tone audiometry examination (Boger ME, 2012)

The purpose of this study was to examine the suitability of hearing loss in noise-exposed welding workshop workers utilizing pure tone audiometry and DPOAE.

2. Methods

Study Design and Research Subjects

This research used a cross-sectional design and was carried out in the period January–March 2023. Sampling

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was carried out by purposive sampling. The research sample was made up of welding workshop workers who were exposed to noise at ≥85 dB with working hours of ≥8 hours per day and a length of work of ≥5 years, ages 20–50 years. History of external ear infections, middle ear disorders, history of using ototoxic drugs, history of head trauma, having hobbies related to noise exposure, congenital ear abnormalities, having worked in an environment exposed to noise before, and having a living environment close to noise exposure were excluded from the study.

Tools and Measurement Methods

OAE uses the Grason-Stadler (GSI) Corti TM brand DPOAE tool, with pass criteria (if there is a wave where the signal noise of ratio (SNR) is <6 dB on the 2 frequencies tested) and refer criteria (if the signal noise of ratio (SNR) is 6 on >2 tested frequencies).

Pure tone audiometry uses the Audio Traveler type AA222 to measure the degree and type of hearing loss and deafness by assessing a person's hearing at frequencies of 0.5, 1, 2, 3, 4, 6, and 8 KHz. According to the WHO, the range of hearing loss is as follows: normal = ≤25 dB; mild > 26-40 dB; moderate > 41-60 dB; severe > 61-80 dB; and deafness = ≥81 dB. (WHO, 2008)

Ethical Clearance

This research carried out actions carried out with permission from sufferers who met the criteria to be used as research samples by filling out an informed consent form and were declared to have met the ethical requirements for implementation from the ethical commission for biomedical research on humans, Faculty of Medicine, Hasanuddin University, Makassar, with number: 61/UN.4.6. 4.5.31/PP36/2023.

Statistical Analytics

Data analysis used the Statistical Program for Social Science computer software 26 version. Characteristics of research subjects (age, length of work, use of ear protective equipment, and noise intensity) were assessed in the form of frequencies and percentages. The degree of hearing loss based on PTA and DPOAE is also expressed in terms of frequency and percentage. The correspondence of hearing loss based on PTA and DPOAE was tested using the chi-square test and the Fisher test if the chi-square test conditions were not met. A p-value <0.05 was considered significant

3. Results

This study consisted of 30 welding workshop workers who were exposed to noise with an intensity of ≥85 dB. The characteristics of the research subjects are presented in Table 1. Age 36–50 years (70%), length of work >10 years (60%), not using ear protection (63.3%), and exposure to noise ≥85–94 dB (75%) are the most dominant factors in this research.

Table 1. Characteristics of research subjects

Characteristics	Frequency(n=30)	Percentage (%)
Age		
20-35 years	9	30
36-50 years	21	70
Length of work		
5-10 years	12	40.0
>10 years	18	60.0
Use of ear protection equipment		
Yes	11	36.7
No	19	63.3
Noise intensity		
≥85- 94 dB	25	75
>95 dB	5	25

Based on table 2, the degree of mild hearing loss in the left (46.7%) and right ear (66.7%) is the highest compared to other degrees, and there is a difference in the degree of hearing loss between the left ear and the right ear.

Table 2. Degree of hearing loss and deafness based on PTA

Degree of hearing loss and deafness based on PTA	Right PTA		Left PTA	
	n (30)	%	n (30)	%
Normal	13	43.4	5	16.7
Mild	14	46.7	20	66.7
Moderate	3	10.0	4	13.3
Severe	0	0.0	1	3.3
Extreme	0	0.0	0	0.0
Total	30	100	30	100

Based on table 3, 27 right ears (90%) had refer results, 29 left ears (96.7%) had refer results, and the others had pass results.

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Table 3. Degree of hearing loss and deafness based on DPOAE

DPOAE	Right		Left	
	n (30)	%	n (30)	%
Pass	3	10	1	3.3
Refer	27	90	29	96.7
Total	30	100	30	100

The distribution of hearing loss based on the degree of hearing loss and ear involvement is presented in Table 4.

Table 4. Hearing loss and deafness for each research subject

Subject	Unilateral	Bilateral	Severity of hearing loss and deafness (Left)	Severity of hearing loss and deafness (Right)
Subject 1	-	Bilateral	Mild	Mild
Subject 2	-	Bilateral	Mild	Mild
Subject 3	-	Bilateral	Mild	Mild
Subject 4	-	Bilateral	Severe	Moderate
Subject 5	Left	-	Mild	Normal
Subject 6	Left	-	Mild	Normal
Subject 7	-	Bilateral	Moderate	Moderate
Subject 8	-	Bilateral	Moderate	Moderate
Subject 9	Normal	Normal	Normal	Normal
Subject 10	Left	-	Moderate	Normal
Subject 11	-	Bilateral	Mild	Mild
Subject 12	Left	-	Mild	Normal
Subject 13	-	Bilateral	Mild	Mild
Subject 14	-	Bilateral	Mild	Mild
Subject 15	-	Bilateral	Mild	Mild
Subject 16	Left	-	Mild	Normal
Subject 17	Left	-	Mild	Normal
Subject 18	Left	-	Mild	Normal
Subject 19	-	Bilateral	Mild	Mild
Subject 20	-	Bilateral	Mild	Mild
Subject 21	Normal	Normal	Normal	Normal
Subject 22	-	Bilateral	Mild	Mild
Subject 23	Normal	Normal	Normal	Normal
Subject 24	-	Bilateral	Mild	Mild
Subject 25	-	Bilateral	Mild	Mild
Subject 26	Left	-	Mild	Normal
Subject 27	Normal	Normal	Normal	Normal
Subject 28	Normal	Normal	Normal	Normal
Subject 29	-	Bilateral	Mild	Mild
Subject 30	-	Bilateral	Moderate	Mild

There is conformity between the results of DPOAE and PTA of the right ear at frequencies of 2 KHz, 3 KHz, 4 KHz, and 6 KHz with the respective p-values (0.010; 0.024; 0.046; 0.049). There is conformity between the results of the DPOAE examination and pure tone audiometry of the left ear at frequencies of 3 KHz, 4 KHz, and 6 KHz with p-values of 0.036, 0.034, and 0.010, respectively (Table 5).

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Frequency	Ear	SNR	Type of Hearing Impairment		Total	P-value
			Normal	SNHL		
2000 Hz	Right	Pass	10 (66.7%)	5 (33.3%)	15	0.010*
		Refer	3 (20.0%)	12 (80.0%)	15	
	Left	Pass	4 (25.0%)	12 (75.0%)	16	0.336**
		Refer	1 (7.1%)	13 (92.9%)	14	
3000 Hz	Right	Pass	10 (62.5%)	6 (37.5%)	16	0.024*
		Refer	3 (21.4%)	11 (78.6%)	14	
	Left	Pass	4 (25.0%)	12 (75.0%)	16	0.036**
		Refer	1 (7.1%)	13 (92.9%)	14	
4000 Hz	Right	Pass	7 (58.3%)	5 (41.7%)	12	0.046*
		Refer	6 (33.3%)	12 (66.7%)	18	
	Left	Pass	3 (25.0%)	9 (75.0%)	12	0.034**
		Refer	2 (11.1%)	16 (88.9%)	18	
6000 Hz	Right	Pass	10 (52.6%)	9 (47.4%)	19	0.049**
		Refer	3 (27.3%)	8 (72.7%)	11	
	Left	Pass	3 (15.8%)	16 (64.0%)	19	0.010**
		Refer	2 (18.2%)	9 (81.8%)	11	
8000 Hz	Right	Pass	2 (100.0%)	0 (0.0%)	2	0.179**
		Refer	11 (39.3%)	17 (60.7%)	28	
	Left	Pass	0 (0.0%)	2 (100.0%)	2	1.000**
		Refer	5 (17.9%)	23 (82.1%)	28	
10000 Hz	Right	Pass	5 (62.5%)	3 (37.5%)	8	0.242**
		Refer	8 (36.4%)	14 (63.6%)	22	
	Left	Pass	2 (25.0%)	6 (75.0%)	8	0.589
		Refer	3 (13.6%)	19 (86.4%)	22	
12000 Hz	Right	Pass	2 (100.0%)	0 (0.0%)	2	0.179**
		Refer	11 (39.3%)	17 (60.7%)	28	
	Left	Pass	0 (0.0%)	2 (100.0%)	2	1.000**
		Refer	5 (17.9%)	23 (82.1%)	28	

Table 5. Conformity between DPOAE and PTA results

4. Discussion

Noise is a loud sound that is unwanted by any individual and is also a frequent health problem. Through direct injury to the auditory system, noise can cause hearing loss and tinnitus. (TLR Health-Europe, 2023; Liu F, 2022). Based on the PTA results, our subjects mostly had mild degrees of hearing loss, although there were also subjects who had degrees of hearing loss in both ears. Continuous noise exposure throughout the workday and over many years is more damaging than intermittent noise exposure, which allows the ear to have periods of rest (Dobie RA,2018). The main mechanisms of NIHL are damage to the organ of corti, decreased blood flow leading to inner ear hypoxia, reactive oxygen species (ROS) oxidative stress, and degeneration of the nerves in the spiral ganglion cells and synaptic terminals of cochlear nerve fibers (Yang CJ,2016). The difference in hearing loss in the left ear and the right ear can be caused by the noise in the welding workshop being discontinuous and intermittent, resulting in exposure to noise of different intensities.

Based on DPOAE examination, the right ear referred 27 people (90%), and the left ear referred 29 people (96.7%), where DPOAE was more sensitive for detecting subclinical disorders than pure tone audiometry. This is in accordance with research conducted by Boger et al., where there were differences in data from pure tone audiometry and DPOAE examinations on 120 carbon workers, where workers with normal hearing had poor DPOAE results. A decrease in the number of cochlear outer hair cells cannot be detected by audiometry, and while DPOAE can detect NIHL at an early stage, it is more sensitive in detecting cochlear damage before symptoms of hearing loss appear than pure tone audiometry (Boger ME,2012).

Pure tone audiometry's main drawback is that it is not sensitive to minute noise-induced changes in the cochlea. Subjects with normal audiograms and a history of noise exposure can develop NIHL (Attias AJ, 2001). According to Korres et al., PTA is influenced by all frequencies, while DPOAE is influenced by high frequencies. DPOAE has twice the sensitivity of PTA for detecting cochlear abnormalities. PTA can assess general hearing thresholds but does not specifically indicate the location of damage. DPOAE can examine the function of the outer hair cells of the cochlea, which are easily damaged when exposed to noise, but cannot assess a person's hearing threshold (Korres GS, 2009)

The research results show that the DPOAE results are in accordance with PTA at frequencies of 3 KHz, 4 KHz, and 6 KHz. In accordance with Bashiruddin et al.'s research, there is concordance in the results between the DPOAE and PTA examinations (Bashiruddin J, 2018). In Guida et al.'s research, which indicated that the DPOAE and pure tone audiometry had a significant association based on statistics at frequencies of 3 KHz, 4 KHz, and 6 KHz with each p-value <0.001. The DPOAE amplitude decreases with increasing pure tone audiometry threshold (Guida HL, 2012). Due to their suitability, it is hoped that PTA and DPOAE tests work in conjunction to help identify NIHL early. DPOAE cannot check the hearing threshold but can provide information about the condition of the outer hair cells of the cochlea. Exposure to noise causes hearing loss and can cause changes in feelings such as irritability, fatigue, and symptoms related to stress, sleep disorders, heart problems, and hypertension (Guida HL, 2012l Mathias B, 2014).

DPOAE may reveal earlier changes in hearing function compared with PTA (Meng L, 2022). In this study, although pure tone audiometry examination could not measure frequencies of 10 kHz and 12 kHz, DPOAE showed damage to hair cells at frequencies of 10 kHz and 12 kHz due to noise exposure. DPOAE can be used as a rapid and objective tool to assess cochlear status and thus

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complement pure tone audiometry in the early detection of NIHL (Moepeng M, 2017).

A person may already have NIHL, but it is indistinguishable by pure tone audiometry because the damage begins at higher frequencies. After prolonged exposure to noise, more extensive damage occurs involving speech frequencies, which can be detected with pure tone audiometry. Because of this, several researchers have suggested OAE for the early diagnosis of NIHL. Due to noise exposure, hearing thresholds at frequencies greater than 8 KHz (i.e., 10, 12, 14, 16, 18, and 20 KHz) are impacted earlier (Mehrparvar AH,2018)

Our study may represent and confirm previous studies where DPOAE can be used as an early screening for NIHL compared with PTA. We also analyzed the relationship between the length of work and the use of protective equipment, which can reduce the risk of GPAB. The limitation of this research is that it is difficult to find samples because many workshops have switched to using electrical machines where measurements with a sound level meter do not reach 85 dB. A limitation of this research is that it is also difficult to find workers who have worked for more than 5 years because many have stopped working as welding workshop workers.

5. Conclusion

There is conformity between the results of DPOAE and PTA in both ears at frequencies 3 KHz, 4 KHz and 6 KHz

6. Acknowledgment

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