

STUDY ON THE IMPACT OF AIRCRAFT NOISE ON THE HEARING OF MAINTENANCE PERSONNEL

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Abstract

Aircraft maintenance personnel are often exposed to loud noises, placing them at significant risk for noise-induced hearing loss (NIHL). This study assessed the characteristics of listening loss among aircraft maintenance personnel to provide insights and recommendations for the prevention and protection against NIHL. Auditory assessments and questionnaires were distributed to 124 male airline maintenance professionals. All subjects' 0.25, 0.5, 3, 4, and 6 kHz hearing thresholds were compared between ears. Under 30, 30–39, and 40+ were the age groups. Across age groups, 0.5, 1, 3, 4, 6, and 8 kHz hearing thresholds were examined, and hearing loss and tinnitus rates were also compared. Both ears exhibited equal hearing thresholds at 0.25, 0.5, 3, 4, and 6 kHz. However, 1, 2, and 8 kHz showed substantial variances. The right ear thresholds were substantially lower at 1 and 2 kHz than at 8 kHz. Hearing thresholds at 0.5, 1, 3, 4, 6, and 8 kHz were greater in 30–39-year-olds than < 30-year-olds and significantly higher in ≥ 40 -year-olds. At 6 kHz, the hearing threshold was substantially greater in the ≥ 40 age group than in the 30–39 age group. Hearing loss incidence was higher in the ≥ 40 years group (80%) compared to the < 30 years (15.14%) and 30–39 years (42.10%) groups. The group aged ≥ 40 years showed considerably lower tinnitus rates (0%) compared to the groups aged < 30 years (12.34%) and 30–39 years (34.21%). This research identified that age substantially affected hearing thresholds at 0.5, 1, 3, 4, 6, and 8 kHz, with older adults losing more hearing. However, tinnitus diminished with age.

Key words: noise, hearing loss, aircraft maintenance personnel, hearing threshold, tinnitus

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Introduction. The progression of industrialization has made noise pollution a significant public health concern, leading to both physical and psychological disorders [1]. Long-term exposure to high decibel levels can result in noise-induced hearing loss (NIHL), which is recognized as one of the leading global health risks [2]. It is projected that more than 900 million individuals will have debilitating hearing loss by 2050, with a substantial proportion related to noise exposure [3]. Research highlights the association of NIHL with cardiovascular diseases, endocrine disorders, and sleep disturbances, further demonstrating the far-reaching impacts of chronic noise exposure [4, 5].

In aircraft maintenance, workers are exposed to noise levels ranging between 120–130 dBA, working as close as 20–100 m from the noise source [6]. This exposure places them at high risk for NIHL and tinnitus. To address these concerns, the current study evaluates the auditory health of 124 aircraft maintenance personnel, focusing on identifying patterns of hearing loss. These findings aim to inform the early detection, prevention, and implementation of targeted protective measures to mitigate NIHL among high-risk populations.

Participants and methods. *Participants.* In total, 124 aircraft maintenance male personnel were selected for auditory examination and questionnaire survey, aged between 19–42 years with an average age of 27.48 ± 6.70 years and an average tenure of 8.38 ± 6.68 years.

Criteria for inclusion and removal. The requirements for inclusion were as follows: (1) Individuals who were Frontline staff, directly suffering from aircraft noise; (2) Putting on earmuffs or not; (3) Written consents were provided. Exclusions included: (1) Participants diagnosed with otolaryngological diseases; (2) Experiencing the history of ototoxic drug exposure; (3) Probably having a familial genetic hearing loss history; (4) Showing abnormalities in the external auditory canal and eardrum upon physical examination.

Test of pure tone audiometry. A test for pure tone audiometry was carried out employing the Madsen Xeta audiometer (frequency 0.25–8 kHz, maximum output 120 dB HL) in a quiet room (background noise < 30 dBA). The testing followed the basic pure tone air conduction measurement method specified in the national standard GB/T16403-1996. Pure-tone thresholds were used to characterize hearing loss > 25 dB HL at language frequencies and above. Tinnitus assessment was done via questionnaire.

Statistical analysis. All data were statistically analyzed employing SPSS 23.0. The measurement data was displayed by mean $\pm$ standard deviation and followed a normal distribution ($x \pm s$). If not, the median (interquartile) was adopted. For the former, paired *t*-tests were applied for quantitative data between both ears. For the latter, the Mann–Whitney test was used. Qualitative data was represented as a frequency number (%). χ^2 test was taken to finish the comparison between groups. $P < 0.05$ indicated statistical importance.

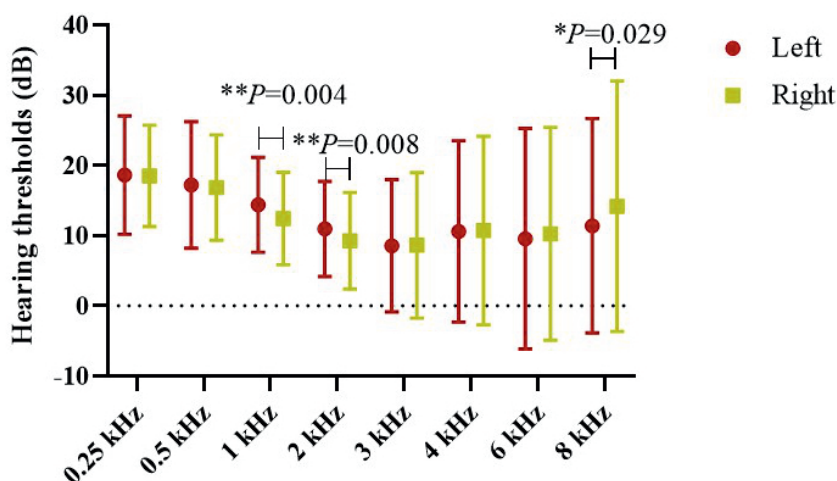


Fig. 1. Comparative analysis of hearing thresholds between the two ears (* $P < 0.05$, ** $P < 0.01$)

Results. Comparison of hearing thresholds between both ears. There were no significant differences in the thresholds for hearing among the right and left ears at 0.25 kHz, 0.5 kHz, 3 kHz, 4 kHz, and 6 kHz frequencies. However, a significant difference was noted at 1 kHz, 2 kHz, and 8 kHz. At 1 kHz and 2 kHz, the hearing thresholds were considerably lower in the right ear than in the left ($P < 0.01$). Conversely, at 8 kHz, the right ear exhibited a higher threshold than the left ear ($P < 0.05$) (Fig. 1).

Hearing threshold comparison among different age categories. The participants were divided into three age categories: the < 30 -years-old group with 81 participants (162 ears), the 30–39-years-old group with 38 participants (76 ears), and the ≥ 40 -years-old group with five participants (10 ears). Across frequencies of 0.5, 1, 3, 4, 6, and 8 kHz, the 30–39 age group's hearing thresholds were noticeably greater than those in the < 30 -year-old group ($P < 0.05/0.01$). Additionally, the hearing thresholds in the ≥ 40 -years-age range were significantly greater than those in the 30–39-years-age range ($P < 0.05/0.01$). At 6 kHz, the hearing thresholds were significantly greater in the group aged ≥ 40 than in the 30–39-age-range ($P < 0.01$) (Fig. 2).

The hearing loss cases, including single or both ears, in the ≥ 40 -years-old group were 4 cases (80%), significantly more than that of the < 30 -years-old group (12 cases and 15.14%) or 30–39-years-old group (16 cases and 42.10%) ($P < 0.001$) (Fig. 3).

Tinnitus occurrence rate. The tinnitus rate, including single or both ears, in the ≥ 40 -years-old group was 0 cases, significantly lower than that of the < 30 -years-old group (10 cases and 12.34%) or 30–39-years-old group (13 cases and 34.21%) ($P < 0.05$) (Fig. 4).

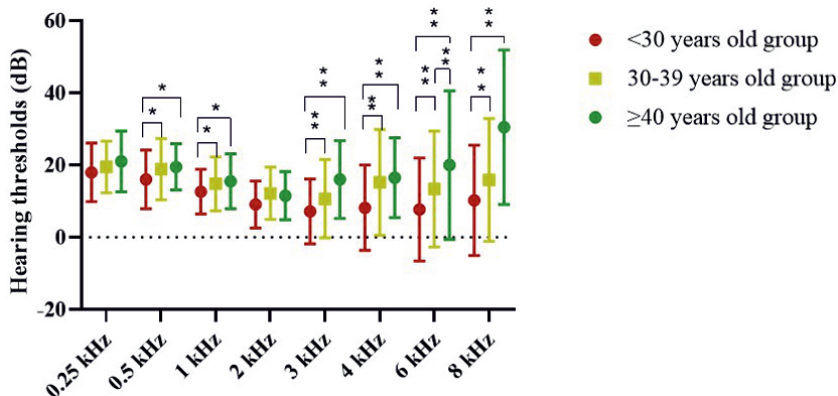


Fig. 2. Comparison of hearing thresholds across age groups
(* $P < 0.05$, ** $P < 0.01$)

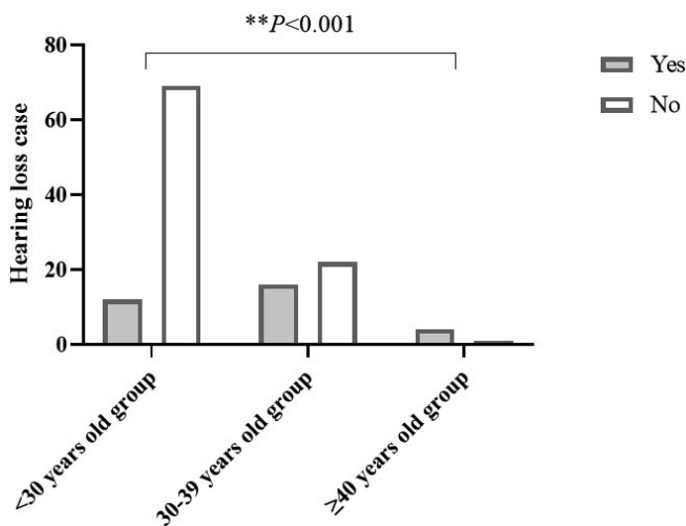


Fig. 3. Hearing loss occurrence cases among the three groups

Discussion. This study identified significant differences in thresholds for hearing between ears at specific frequencies. The right ear exhibited lower thresholds than the left ear at 1 kHz and 2 kHz ($P < 0.01$), but at 8 kHz, the right ear displayed higher thresholds ($P < 0.05$). Age significantly influenced thresholds of hearing at 0.5, 1, 3, 4, 6, and 8 kHz, with the highest prevalence of hearing loss in individuals aged ≥ 40 years compared to younger groups (< 30 and 30–39 years) [7,8]. Interestingly, tinnitus was more common in younger age groups, with no cases observed in participants over 40, suggesting that noise exposure, rather than age, was the primary factor [9].

Comparative research has reported similar findings. For example, DEJONCKERE and LEBACQ [10] noted elevated left ear thresholds in workers exposed to

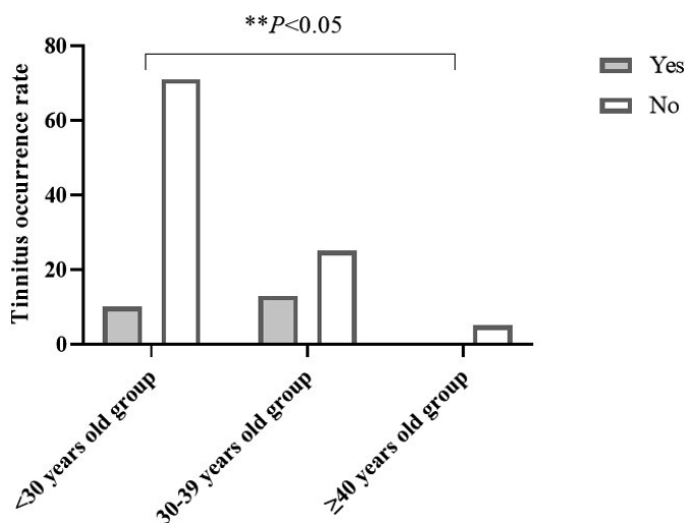


Fig. 4. Tinnitus occurrence cases among the three groups

occupational noise, particularly at 3 and 4 kHz. However, this study found differences only at 8 kHz, indicating individual variability in noise susceptibility due to factors such as ethnicity, exposure duration, and noise characteristics. Consistent with prior studies, unilateral hearing loss was more prevalent than bilateral loss, affecting 16.13% and 9.68% of participants, respectively, emphasizing the asymmetrical impact of noise [11, 12].

Extended noise exposure remains the most critical factor in NIHL progression [13]. Research indicates that preventive measures, such as regular audiometric screening and the use of protective equipment, can effectively reduce the incidence of hearing loss [14]. However, while pharmacological interventions, including antioxidants and anti-inflammatory agents, are being explored, their clinical effectiveness remains uncertain [15].

Tinnitus, closely associated with NIHL, often presents as high-pitched ringing due to high-frequency hearing loss. In this study, 18.55% of participants reported tinnitus, with 25.2% of them experiencing concurrent hearing impairment [16]. The absence of a distinct relationship between age and tinnitus or hearing loss aligns with recent studies that emphasize the complex neural mechanisms underlying tinnitus [17]. Sensorineural hearing loss, primarily due to cochlear hair cell damage, often progresses from high to low-frequency ranges, eventually becoming irreversible with continued exposure [18].

The implementation of effective prevention programmes, such as those utilized in the U.S., involving education, audiograms, and hearing protection devices, is essential to safeguard the auditory health of noise-exposed workers [19]. For aircraft maintenance personnel, additional strategies, such as scheduling adjustments, vitamin supplementation, and minimizing the use of ototoxic drugs,

can further mitigate NIHL risks [20]. Future research should focus on identifying genetic susceptibility factors and exploring molecular mechanisms to enhance prevention strategies and targeted interventions.

Conclusion. This study found that at 1 kHz and 2 kHz, the thresholds were substantially lower in the right ear than in the left ($P < 0.01$). At 8 kHz, the right ear exhibited higher thresholds than the left ear ($P < 0.05$). Age significantly affected thresholds for hearing at 0.5, 1, 3, 4, 6, and 8 kHz frequencies. Hearing loss was more prevalent in the ≥ 40 -year-old group compared to younger groups (< 30 and 30–39 years). However, the incidence of tinnitus followed an inverse trend across the groups.

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Data and material availability. The corresponding author will provide the data upon request.

Contributions of the Authors. The study was designed by Yingge Zhang. The first draft was written by Lin Liu. Raw data was gathered by Hua Guo, Qin Yao, and Fei Yu. Shan Chen conducted bioinformatics and statistical analysis. Yingge Zhang oversaw the research.

Ethical Approval. The Air Force Military Medical University's Ethics Committee gave its approval to this study protocol (afm20201008s).

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