The Journal of International Advanced Otology

J Int Adv Otol 2025; 21(5): 1-6 • DOI: 10.5152/iao.2025.241715

Original Article

Longitudinal Evaluation of Hearing Function in Hyperbaric Oxygen Therapy Inside Attendants

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Cite this article as: Avci AU, Demir KC, Abayli SY, Konyalioğlu FS, Turgut B. Longitudinal evaluation of hearing function in hyperbaric oxygen therapy inside attendants. *J Int Adv Otol.* 2025, 21(5), 1715, doi:10.5152/iao.2025.241715.

BACKGROUND: Inside attendant personnel (IAP) working in hyperbaric oxygen therapy (HBO_2) chambers face unique risks due to their exposure to pressurized environments, similar to those encountered by divers. During sessions, IAP breathe only compressed air, making them susceptible to potential adverse effects on hearing function. Previous studies have almost exclusively focused on divers, leaving a gap in understanding how these conditions might affect the hearing function of IAP.

METHODS: A retrospective analysis was conducted on the audiometry results of 15 IAP who worked at the Akyurt HBO_2 Center between 2012 and 2023. Hearing function was assessed through pure tone audiometry at frequencies ranging from 0.5 to 6 kHz. The data were analyzed by comparing baseline and final audiometry results, with subgroup analyses based on age, number of sessions, and working duration.

RESULTS: The study comprised a sample of 15 IAP, corresponding to 30 ears, who participated in a total of 2446 HBO_2 sessions. The analysis revealed no significant changes in hearing function, and no clinically significant hearing loss was detected. Three participants experienced mild middle ear barotrauma, and no cases of decompression sickness (DCS) were reported. Percent change values were computed to show the change more clearly; however, no clinically significant or consistent changes were identified in any subgroup analyses.

CONCLUSION: The findings suggest that with proper precautions, the risks associated with barotrauma and DCS do not pose significant threats to the hearing function of IAP. In this occupational setting, ongoing health screenings and preventive strategies appear to be beneficial for maintaining auditory health.

KEYWORDS: Barotrauma, decompression sickness, hearing function, hearing loss, hyperbaric oxygen treatment

INTRODUCTION

Hyperbaric oxygen therapy (HBO_2) chambers can be either monoplace or multiplace. A multiplace chamber is a pressurized medical vessel designed to accommodate multiple patients and an inside attendant personnel (IAP) during treatment. The chamber is pressurized with compressed air to therapeutic levels, typically 2.0 to 3.0 atmospheres absolute (ATA), while patients breathe 100% oxygen via masks or hoods. Inside attendant personnel play a critical role in assisting with pressure equalization, ensuring proper oxygen delivery, and responding to emergencies. Each treatment session lasts approximately 90 to 120 minutes, and IAPs are exposed to the pressurized chamber at most once per day, usually less frequently. They assist with pressure equalization techniques, ensure the appropriate use of masks, and promptly respond to any emergencies that may occur.

Working in a high-pressure environment comes with risks. Pougnet and colleagues conducted a literature review indicating that occupational accidents among hyperbaric chamber attendants are rare but can have severe consequences. Therefore, the associated risks should not be underestimated.[1] The primary risks include decompression illness (DCI) and barotrauma, both associated with repeated exposure to hyperbaric environments. Although DCI is rare, cases have been reported, particularly in individuals

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Received: September 3, 2024 • **Revision Requested:** February 4, 2025 • **Last Revision Received:** February 23, 2025 • **Accepted:** March 19, 2025 • **Publication Date:** September 8, 2025
Available online at www.advancedotology.org

with patent foramen ovale, and may lead to severe neurological complications.[2,3] Barotrauma, primarily affecting the ears and sinuses, was identified as the most common injury among attendants.[1] Additionally, handling-related injuries and accidental blood exposure were documented, posing risks similar to those encountered by other healthcare professionals.[4] In past years, fire-related fatalities have been reported, particularly in hyperbaric chambers with oxygen-enriched gas mixtures (O_2 > 28%).[5] These fires have generally been reported to be caused by prohibited items that should not be brought into the chambers.[1]

Lastly, despite the implementation of preventive measures, fire-related fatalities remain a rare but significant occupational hazard. Sheffield and Desautels reported 25 clinical hyperbaric chamber fires between 1923 and 1996.[5] They noted that no fire-related fatalities were recorded in clinical hyperbaric chambers in North America, and the incidents have primarily occurred in hyperbaric chambers with oxygen-enriched gas mixtures (O_2 > 28%). Studies have shown that these fires were often caused by prohibited items brought into the chamber, highlighting the critical need for strict safety protocols and compliance.[1]

Like divers, IAP also work in pressurized environments for varying periods. During sessions, IAP don't receive 100% oxygen regularly in the chamber, unlike patients. As a result, they are at risk for decompression sickness (DCS) and the negative effects of pressure changes on different body systems and organs. This could potentially impact their hearing functions. Different results have been obtained from studies examining the hearing function of divers. Several studies have documented increased hearing thresholds in professional and military divers.[6-9] Conversely, there are studies reporting no hearing loss in recreational divers.[10,11]

Previous studies have almost exclusively focused on divers. In terms of surroundings and operational circumstances, divers and IAP differ in a number of ways. Although divers can work in environments with higher pressures, IAP typically operate at pressures below 2.8 ATA. Divers breathe different mixtures of gases as needed, while internal assistants breathe only air (and oxygen during the decompression phase of the session). Because of the paucity of studies, it is unknown whether or not these changes have an impact on hearing function in IAP.

Every year, the staff at HBO_2 centers undergo routine screenings and examinations. These routine screenings include audiological assessments. The aim of this study was to evaluate any longitudinal alterations in the hearing function of inside attendants employed at the Akyurt HBO_2 Center since the beginning of their work.

MAIN POINTS

- Inside attendants working in hyperbaric oxygen therapy (HBO_2) are exposed to pressurized environments similar to those experienced by divers, potentially posing risks to hearing function due to noise, barotrauma, and decompression sickness (DCS). Previous research has primarily focused on divers, leaving a gap in understanding the specific risks for HBO_2 inside attendant personnel.
- This study provides a comprehensive longitudinal evaluation of hearing function in HBO_2 inside attendants, showing no significant changes in hearing thresholds over time despite their occupational exposure. The findings suggest that, with appropriate preventive measures, the risks of hearing loss due to noise, barotrauma, or DCS are avoidable in this population.
- The results emphasize the importance of continued routine screenings and the implementation of preventive strategies to protect the auditory health of HBO_2 inside attendants. This study may inform guidelines and policies regarding occupational health and safety standards in HBO_2 centers, potentially influencing future research and preventive practices in similar high-pressure environments.

METHODS

A retrospective evaluation of the audiometry results of IAP, who worked at the Akyurt HBO_2 Center between 2012 and 2023, was performed. Inside attendant personnel with incomplete medical records or those who had stopped working without undergoing periodic examinations were excluded.

Hearing function was evaluated using otolaryngological examination records and pure tone audiometry data (air and bone conduction) at the frequencies 0.5, 1, 2, 3, 4, and 6 kHz. Medical history, age, smoking history, history of barotrauma and DCS, history of underwater activities (including recreational and professional diving), sports history, and pure tone audiometry data were all collected from IAP annual routine examinations. The session records were used to calculate the total number of sessions and the length of time that an IAP worked.

Features of the Center and Sessions

The Akyurt HBO_2 Center (closed in December 2023 due to relocation) was located in the district of Ankara with the same name as the center, at an altitude of 960 meters (3150 feet).

At the center, routine HBO_2 sessions were performed 5 days a week at 2.4 ATA for 2 hours (15 minutes of compression, 85 minutes of treatment pressure, and 20 minutes of decompression). The treatment consisted of 3 distinct 25-minute, 100% oxygen periods. To prevent DCS, it was mandatory for all IAP to breathe 100% oxygen during the final 10 minutes of the last oxygen period.

Statistical Analysis

Statistical analyses were conducted based on the number of ears rather than the number of individuals due to the absence of a side-specific effect. The final audiometry results were compared to the baseline audiometry results obtained before beginning work as an IAP. The analyses were grouped by age, number of sessions, and working duration as an IAP. Age (≤35, >35), study duration (≤15 months, >15 months), and number of sessions (≤103, >103) were divided into 2 categories each in the analyses based on the median values. Furthermore, a percentage change variable was produced by using the baseline and final audiometry results. The formula applied for calculating the percentage change was "(last value—first value)/first value."

Statistical analyses were performed using SPSS software, version 25 (IBM SPSS Corp.; Armonk, NY, USA). Descriptive statistics for categorical variables were expressed as frequencies and percentages, while continuous variables were summarized as means and standard deviations (mean ± SD). The normality of the distribution of continuous variables was assessed using the Shapiro–Wilk test and visual inspection of histograms and probability plots. For comparisons of 2 related groups not meeting the normality assumption, the Wilcoxon signed-rank test was applied. In cases where 2 independent groups did not follow a normal distribution, the Mann–Whitney *U* test was utilized. Statistical significance was set at $P < .05$.

Ethics

This study was performed in compliance with the ethical standards of the Declaration of Helsinki. Written informed consent was obtained from all subjects involved in the study. The study received ethical approval from the Gülhane Ethics Board of the University of Health Sciences (approval number: 4/24: 2024-201, date: April 24, 2024).

RESULTS

Between 2012 and 2023, 36 healthcare professionals worked as IAP in the center. Prior to their initial periodic examination, 14 IAP stopped working at the center for non-health-related reasons. Six IAP were excluded due to a lack of audiometry measurements, and 1 IAP was excluded due to a neurological disease unrelated to HBO_2.

The study comprised a sample of 15 IAP, corresponding to 30 ears, who participated in a total of 2446 HBO_2 sessions. Fourteen of the participants were female, and 1 was male. The average age of the participants was 35.2 years (min-max: 22-48). The average total duration of personnel employment, regardless of their involvement in sessions, was 23.7 months, with an average of 163.1 attended sessions and 97.5 sessions per year (Table 1). None of the IAP had any comorbidities. Their initial or periodic examinations revealed no otolaryngologic findings.

There was no occurrence of DCS. At different times, 3 IAP experienced 5 middle ear barotrauma episodes: 1 bilaterally, 2 in the left ear, and 2 in the right ear, involving a total of 6 ears, each affected only once. The incidence of middle ear barotrauma was 204 per 100,000 sessions. As per the modified Teed classification, all incidents were classified as less than grade 2. Two IAP were active smokers, 1 with 5 pack-years and 1 with 2 pack-years. There were no other active or ex-smokers among the IAP.

A direct comparison of the baseline and final audiometry results revealed that all values were similar ($P > .05$ for all) (Table 2).

Table 3 shows the percentage changes in the audiometric values between the IAP who experienced barotrauma and the IAP who did not. All percentage change values were similar for both groups ($P > .05$ for all).

The pure tone average (air conduction) increased by 20% in the final measurements in those with a working duration of 15 months or less, while there was no change over time in those with a working period of more than 15 months ($P = .022$). The 500 Hz (air conduction) value increased by 30% in those with a working duration of 15 months or less, while there was no change in those with a working duration of more than 15 months ($P = .040$). A 2 kHz

Table 1. Characteristics of Hyperbaric Oxygen Therapy Inside Attendant Personnel

Variable	n (%)/Mean ± SD
Gender	
Female	14 (93.3)
Male	1 (6.7)
Age	35.2 ± 7.8
Working duration (month)	23.7 ± 22.0
Number of sessions	163.1 ± 144.4
Number of sessions per year	97.5 ± 51.1

Table 2. Direct Comparison of Baseline and Final Audiometric Results (n = 30)

Frequencies (kHz)	Baseline Median (Min-Max)	Final Median (Min-Max)	P*
PTA	8.3 (1.7-18.3)	8.3 (3.3-18.3)	.437
B- PTA	5.0 (0.0-10.0)	5.0 (0.0-8.3)	.636
HiPTA	7.5 (0.0-27.5)	8.8 (2.5-25.0)	.133
0.25	10.0 (5.0-25.0)	10.0 (5.0-20.0)	.139
0.5	10.0 (5.0-20.0)	10.0 (5.0-20.0)	.469
1	10.0 (0.0-10.0)	10.0 (5.0-20.0)	.512
2	5.0 (0.0-15.0)	5.0 (0.0-15.0)	.527
4	5.0 (0.0-35.0)	5.0 (0.0-25.0)	.195
6	10.0 (0.0-30.0)	10,0 (5.0-30.0)	.452
B-500	5.0 (0.0-15.0)	5.0 (0.0-10.0)	.439
B-1	5.0 (0.0-10.0)	5.0 (0.0-10.0)	.593
B-2	5.0 (0.0-10.0)	5.0 (0.0-5.0)	.796
B-4	5.0 (0.0-35.0)	5.0 (0.0-15.0)	.953

B, refers to bone conduction; HiPTA, high-frequency pure tone average (4-6 kHz); kHz, kilohertz; PTA, pure tone average (0.5-1-2 kHz).
*Wilcoxon.

Table 3. Comparison of the Percentage Changes in the Audiometry Results by History of Barotrauma (n = 30)

Frequencies (kHz)	History of Barotrauma		P*
	No (n = 24) Median (Min-Max)	Yes (n = 6) Median (Min-Max)	
PTA	0.0 (−0.5-0.6)	0.2 (−0.7-2.0)	.509
B-PTA	0.0 (−1.0-5.0)	0.0 (−1.0-5.0)	.338
HiPTA	0.1 (−0.7-10.0)	0.3 (−0.3-0.6)	.754
0.25	0.0 (−0.5-1.5)	−0.3 (−0.5-0.0)	.332
0.5	0.0 (−0.5-1.0)	0.0 (−0.8-0.5)	.696
1	0.0 (−0.5-5.0)	0.0 (−0.8-10.0)	.843
2	0.0 (−1.0-5.0)	0.5 (−0.7-5.0)	.135
4	0.0 (−1.0-10.0)	0.5 (0.0-5.0)	.212
6	0.3 (−0.7-10.0)	0.3 (−0.7-1.0)	.433
B-500	0.0 (−1.0-5.0)	0.0 (−1.0-5.0)	.345
B-1	0.0 (−0.5-5.0)	0.0 (−1.0-5.0)	1.000
B-2	0.0 (−1.0-5.0)	2.5 −1.0-5.0)	.299
B-4	0.0 (−1.0-5.0)	0.0 (−1.0-5.0)	.697

B, refers to bone conduction; HiPTA, high-frequency pure tone average (4-6 kHz); kHz, kilohertz; PTA, pure tone average (0.5-1-2 kHz).
*Mann–Whitney *U*.

measurement (bone conduction) increased by 37% (mean value) in those with a working duration of 15 months or less, while this measurement increased by 204% (mean value) in those with more than 15 months of employment ($P=.027$). Other percentage change values were similar for both groups (Table 4).

The pure tone average (air conduction) increased by 30% in those aged 35 years and younger, while no change was observed between the baseline and final measurement in those over 35 years of age (Mann–Whitney *U*, $P=.016$). 1 kHz measurement (air conduction) increased by 30% in those aged 35 years and younger, while no change was observed between the baseline and final measurement in those over 35 years of age ($P=.036$). Other percentage change values were similar for both age groups (all $P > .05$).

In all frequencies the percent change values of audiometry results were similar in those with 103 or fewer sessions and those with more than 103 sessions (Mann–Whitney *U*, all $P > .05$).

DISCUSSION

In this study, no significant change in hearing function was found between the baseline and final audiometry results during the retrospective follow-up of HBO_2 IAP over a mean duration of 23 months. Analysis of longitudinal change according to age, working duration, number of sessions, and history of barotrauma did not reveal clinically significant results. Percent change values were computed to show the change more clearly; however, no clinically significant or consistent changes were identified in any of the analyses.

To the best of knowledge, there are no studies in the literature that investigate the change in hearing function in IAP. In contrast, numerous studies have examined how divers' hearing function varies over time. Ear barotrauma, DCS, and a noisy work environment are among the factors that increase the risk of hearing loss in divers.[12] Given the risk of barotrauma, DCS, and working in a relatively noisy environment, the impact of repeated hyperbaric environment exposure on the hearing functions of IAP was investigated, particularly in terms of occupational health and safety.

The literature presents varying findings regarding the correlation between diving and hearing loss. In a prospective study of 30 young professional divers followed for 12 years, Skogstad et al[6] found a significant decrease in auditory function at 0.25, 0.5, 2, 3, and 6 kHz for the right ear and at 3, 4, and 6 kHz for the left ear. However, they associated the decreases, especially at 4 kHz and 8 kHz, with diving. Similarly, other studies have found decreased hearing function at 4 kHz and 8 kHz in long-term audiometric follow-up of divers.[13,14] Recent research has found that, in contrast to earlier findings, diving has no negative effects on hearing. Sames et al[15] examined the change in audiology records of 227 professional divers between 10 and 25 years and found that diving had no significant effect on hearing function. In a study by Winglear et al[9] on 35 navy divers who had been diving for more than 15 years, it was found that hearing thresholds increased over time in divers, but this deterioration was less than the expected age-related deterioration. The authors concluded that military diving is not a risk factor for hearing loss. Another study by Canarslan-Demir et al[16] compared the hearing functions of 70 professional divers with those of a control group and found that diving did not adversely affect hearing.[11] According to the authors of both studies, factors such as increased awareness of safety at work, utilization of preventive measures, and adoption of more cautious diving profiles have the potential to effectively minimize the adverse consequences of diving.[9]

Noise-induced hearing loss is the second most prevalent type of sensorineural hearing impairment, following age-related hearing loss.[17] For an 8-hour time-weighted average, the recommended exposure limit is 85 decibels (A-weighted), while the exposure limit for impulsive or impact noise should not exceed a peak sound pressure of 140 dB. The National Institute for Occupational Safety and Health states that exposures at or above this level are potentially harmful.[18] Occupational noise exposure can exceed hazardous levels in hospitals. Some of the noise sources are medical devices, ventilation systems, portable vehicles, alarms, and communication systems.[19] Likewise, hyperbaric oxygen treatment centers have the potential to be high-noise environments. The European standard EN 14931 for pressure vessels for human occupancy states that the average sound level at treatment pressure with ventilation on should not be higher than 70 dB(A) and 90 dB(A) during compression and decompression.[20] However, noise levels in the hyperbaric chamber can easily exceed 85 decibels, especially during compression, decompression, or ventilation. Zaman et al[21] conducted a study in 41 HBO_2 centers across Türkiye and reported that the highest LAeq (equivalent continuous sound level) measured was 100.4 dB(A) at the treatment pressure during ventilation. During routine sessions, decompression and compression each lasted 15 minutes, totaling 30 minutes, while ventilation was performed during air breaks for a total of 10 minutes. Inside, attendant personnel performed their duties inside the chamber for a maximum of 1 session (2 hours) per day, after which they attended to other tasks in the clinic and were not exposed to device noise. The chamber in the center was manufactured in accordance

Table 4. Comparison of the Percentage Changes in the Audiometry Results by Working Duration (n = 30)

Frequencies (kHz)	Working Duration		P^*
	≤15 months, (n = 16) Median (Min-Max)	>15 months (n = 14) Median (Min-Max)	
PTA	0.2 (−0.5-2.0)	0.0 (−0.7-0.6)	.022
B-PTA	−0.1 (−1.0-5.0)	0.0 (−1,0-5.0)	.114
HiPTA	0.1 (−0.7-5.0)	0.3 (−0.3-10.0)	.917
0.25	0.0 (−0.5-1.05)	−0.1 (−0.5-0.0)	.235
0.5	0.3 (−0.5-1.0)	0.0 (−0.8-0.5)	.040
1	0.0 (−0.5-10.0)	0.0 (−0.8-1.0)	.081
2	0.0 (−1.0-5.0)	0.0 (−0.7-5.0)	.735
4	0.0 (−1.0-5.0)	0.5 (−0.3-10.0)	.207
6	0.5 (−0.7-10.0)	0.3 (−0.7-10.0)	.722
B-500	0.0 (−1.0-5.0)	0.0 (−1.0-5.0)	.624
B-1	0.0 (−0.5-5.0)	0.0 (−1.0-5.0)	.856
B-2	0.0 (−1.0-5.0)	0.0 (−1.0-5.0)	.027
B-4	0.0 (−1.0-5.0)	0.0 (−1.0-5.0)	.181

B, refers to bone conduction; HiPTA, high-frequency pure tone average (4-6 kHz); kHz, kilohertz; PTA, pure tone average (0.5-1-2 kHz).
*Mann–Whitney *U*.

with EN 14931 and subjected to routine controls for compliance with these standards. The daily routines of IAP have been organized to reduce their exposure to noise, and no issues related to noise have been identified.

Middle ear barotrauma is another cause for concern that can cause hearing loss in IAP. The most frequently reported complication of HBO_2 is middle ear barotrauma, though the frequency varies with different studies.[22] In their analysis of 62,614 HBO_2 sessions and 2334 patients, Hadanny et al[23] discovered that middle ear barotrauma occurred in 9.2% of patients and in 0.04% of sessions. Another study on otological complications associated with HBO_2 showed that 14.8% of the patients experienced otological symptoms.[24] Previous studies at IAP have focused primarily on DCS, and in the few studies examining middle ear barotrauma, the frequency varies.[1] In their retrospective analysis of 8072 sessions from 73 IAP, Pougnet et al[2] reported a 0.173% barometric otitis. Cooper et al[25] conducted a retrospective analysis with 155 IAP and reported 15 episodes of middle ear barotrauma in 6062 sessions (0.247%), and all of these episodes were grade 2 and below according to the Teed scale. The incidence of middle ear barotrauma in the study was 0.16%, and all cases were classified below grade 2 on the Teed scale.

The slow compression method (descent rate 1.1 meters per minute) of HBO_2 proved to be safer than the standard method (descent rate 2.8 meters per minute) and reduced the incidence and severity of middle ear barotrauma.[26] Hyperbaric oxygen therapy centers have different approaches to middle ear barotrauma prophylaxis. Nasal decongestants are regarded as helpful.[22] Some precautions were taken in the center. If possible, IAP with upper respiratory tract infections were substituted for IAP with no symptoms; otherwise, nasal decongestants were administered prior to the sessions, and the compression rate was slower for those sessions. Pressurization was stopped if any symptoms developed. Depressurization and pressure equalization maneuvers could not provide relief, the IAP was taken out of the chamber. As a result, the incidence of middle ear barotraumas in IAP was low, and the severity was mild in the study. In the results, there was no deterioration in IAP hearing over the years and no difference in changes in hearing thresholds between those with and without barotrauma. Although these precautions prevented us from testing the hypothesis that HBO_2 may cause hearing loss due to the risk of barotrauma, the results showed that HBO_2 is safe for hearing function.

Another pressure-related condition that might affect hearing function is DCS. Klingmann et al[11] found no difference in divers compared to the control group in their study filtering for noise exposure and inner ear DCS and suggested that the hearing losses found in other studies may be due to inner ear accidents and noise. Consecutive diving days and multiple dives per day were the most prevalent predisposing factors for inner ear DCS.[27] In numerous studies on the health status of IAP, DCS has not been observed.[1] Cooper et al[25] reported no cases of DCS encountered during the 14-year period. Witucki et al[4] reported that in a span of 28 years, no IAP encountered DCS while utilizing the HBO_2 protocols that they created based on the US Navy Standard Air Tables. Pougnet et al[2] reported 2 cases of DCS in a 12-year period as a result of their survey, which covered 12 centers, 8072 sessions, and 73 IAP in France. According to Bell et al's[28] study, 1 of the 2 centers, which is located at an altitude of 4500 feet or higher, had 4 DCS in 26,900 sessions among inside attendants, while the other center had 1 DCS in 1847 sessions. They stated that the incidents occurred shortly after the centers began operating, and the risk of DCS at elevated altitudes is low when IAP use supplemental oxygen.

Only 1 case of inner ear DCS among IAP has been reported in the literature.[29] The authors stated that the patient experienced nausea, vertigo, and ataxia, and his audiological evaluation was in line with his prior history of minimal right-sided hearing loss. When the incident occurred, the HBO_2 protocol was described as follows: the duration was 90 minutes with a bottom pressure of 2.4 ATA (plus compression and decompression time), and IAP inhaled oxygen for 5 minutes before the session was completed. They reported that the patient was successfully treated with 7 HBO_2 sessions. The center has taken a variety of measures to prevent DCS. The protocols used in the center were consistent with the US Navy Standard Tables. Inside attendant personnel inhaled oxygen for the final 10 minutes of every session. Multiple exposures were avoided on the same day, and the interval between sessions was kept as long as possible. None of the participants in the study experienced DCS.

Some limitations must be addressed. First of all, since the center is located far from the seashore, there have been almost no cases of DCS. In cases such as gas embolism, which requires treatment at higher pressure, there may or may not be 1 case per year, mostly due to the center's remote location from the city center. For these reasons, the participants in the study have never experienced pressure exceeding 2.4 ATA. Secondly, even if it is a longitudinal study, the small sample size may lead to an inability to detect small changes and perform an effective subgroup analysis. Nevertheless, the clinical importance of small changes is doubtful. Lastly, it is important to emphasize that individuals selected to serve as inside attendants undergo comprehensive medical examinations and were chosen based on being in good health. A study with inside attendants who have underlying medical conditions or who are employed without medical examination might provide different findings.

CONCLUSION

During this retrospective follow-up of HBO_2 inside attendants, no significant change in hearing function was detected between the baseline and final audiometry results. If appropriate precautions are taken, it is believed that the potential risk factors of barotrauma and DCS will not pose a problem for hearing function for inside attendants. Future studies should involve larger, more diverse samples and extended follow-up periods to ensure generalizability. As a final point that should not be disregarded, it should be ensured that pressure chambers are manufactured in accordance with accepted standards and are regularly inspected to prevent noise from being a factor.

Data Availability Statement: The data from the analyses in this study (excluding personal identifiers) are available from the corresponding author upon reasonable request.

Ethics Committee Approval: The study received ethical approval from the Gülhane Ethics Board of the University of Health Sciences (approval number: 4/24: 2024-201; date: April 24, 2024).

Informed Consent: Written informed consent was obtained from the patient(s) who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – A.U.A., S.Y.A.; Design – A.U.A., S.Y.A.; Supervision – K.C.D., B.T.; Resources – A.U.A., S.Y.A.; Materials – A.U.A., K.C.D., S.Y.A.; Data Collection and/or Processing – A.U.A., K.C.D., S.Y.A.; Analysis and/or Interpretation – F.S.K., K.C.D., A.U.A.; Literature Search – A.U.A., K.C.D.; Writing Manuscript – A.U.A., K.C.D.; Critical Review – S.Y.A., K.C.D., B.T., F.S.K., A.U.A.

Acknowledgments: The authors would like to thank all the healthcare professionals are thanked for ensuring the sessions operated smoothly.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study received no financial support.

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