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Original Article

Official Journal of Erciyes University Faculty of Medicine

DOI: 10.14744/cpr.2024.69375
J Clin Pract Res 2024;46(2):122–129

Tinnitus and Hyperacusis May Affect Hearing Quality in Individuals with Sensorineural Hearing Loss: A Prospective Controlled Study

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Presented as an oral presentation at the 11th International Medicine and Health Sciences Researches Congress (UTSAK) held in Ankara on 24–25 December 2022.

Cite this article as:
Ozturk Ozdes N, Beton S. Tinnitus and Hyperacusis May Affect Hearing Quality in Individuals with Sensorineural Hearing Loss: A Prospective Controlled Study. J Clin Pract Res 2024; 46(2): 122–129.

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Submitted: 29.08.2023
Revised: 01.01.2024
Accepted: 19.02.2024
Available Online: 05.04.2024

Erciyes University Faculty of Medicine Publications -
Available online at www.jcpres.com

ABSTRACT

Objective: Assessing the impacts of tinnitus and hyperacusis on hearing quality is crucial. This study aimed to evaluate how tinnitus and hyperacusis affect the auditory abilities of individuals with sensorineural hearing loss.

Materials and Methods: The study included 60 adult individuals with bilateral sensorineural hearing loss, divided into three groups based on their reported symptoms of tinnitus and hyperacusis. A control group (CG) of 20 participants with normal hearing was also included. After undergoing audiological assessments, participants completed the Tinnitus Handicap Inventory (THI), the Khalfa Hyperacusis Questionnaire (HQ), and the Speech, Spatial, and Qualities of Hearing Scale (SSQ). The findings were then compared across the groups.

Results: It was observed that the hearing quality scores for the group experiencing both tinnitus and hyperacusis, in addition to hearing loss, were significantly lower than those of all other groups ($p<0.05$). Additionally, the speech perception score in the group with both tinnitus and hyperacusis was notably lower than in the group with only tinnitus ($p<0.05$). However, although the hearing quality scores were lower in the group with both tinnitus and hearing compared to the group with only hearing loss, this difference was not statistically significant ($p>0.05$).

Conclusion: The findings of this study demonstrate that both tinnitus and hyperacusis significantly impact the hearing quality of individuals with comparable levels of hearing impairment. Notably, the presence of hyperacusis further exacerbates the deterioration of hearing quality. In managing hearing loss, the potential impact of tinnitus and hyperacusis on hearing should be considered.

Keywords: Hearing loss, hyperacusis, speech perception, tinnitus, qualities of hearing.

INTRODUCTION

Hearing loss is an escalating health issue, primarily due to increasing noise levels from urbanization.[1] Sensorineural hearing loss (SNHL) leads to various problems, including decreased audibility, narrowing of the dynamic range, diminished frequency and temporal resolution, heightened listening effort, challenges in interpreting speech prosody, and difficulties in identifying sound directions. Moreover, these issues can adversely affect the psychological state, emotional well-being, and social life of individuals with hearing loss. It has also been reported that cognitive functions may be affected as the duration of hearing loss increases.[2,3] For this reason, determining the effects of factors frequently encountered in the management of hearing loss is crucial for maintaining accurate and early diagnosis, intervention, and rehabilitation stages.

Tinnitus is one of the most common problems associated with SNHL. It is often observed that tinnitus, particularly when severe, coexists with hyperacusis.[4] Although the effects of tinnitus and hyperacusis have been investigated in the literature, the emphasis is frequently placed on tinnitus. However, the often unrecognized association with hyperacusis may affect the neural correlates of tinnitus differently, potentially diversifying the effects on the patient.[5] It has been reported that tinnitus and hyperacusis can primarily affect hearing, emotional well-being, concentration, and sleep. Moreover, the literature discusses how tinnitus and hyperacusis may affect speech perception in noise.[6] Tinnitus and hyperacusis have also been linked to depression, anxiety, and social isolation. When combined with the negative effects of hearing loss, these issues manifest as problems in the communication skills and quality of life of individuals with hearing loss.

Research has documented that the concurrent presence of tinnitus and hyperacusis leads to heightened psychological distress and social challenges compared to experiencing either condition individually.[7,8] In the literature, it is stated that the effects of tinnitus, hyperacusis, and hearing loss should be evaluated together, and the treatment process should start by focusing primarily on the most problematic area.[9] Although patients can benefit from hearing aids, it has been reported that the rate of those who do not use these devices is quite high. Furthermore, it is estimated that only 40% of hearing aid users continue to use the device after 10 years.[10] This finding is particularly surprising and alarming, given that the severity of hearing loss increases with age. It is believed that overlooking different combinations of hearing disorders affects the usage of hearing aids. Based on this premise, the aim of this study was to evaluate the impact of tinnitus and hyperacusis on hearing quality. Furthermore, the hearing quality of the three study groups was compared with that of a control group (CG), whose hearing thresholds were considered normal.

MATERIALS AND METHODS

Participants were recruited from an audiology clinic between January 2021 and April 2021, with their ages ranging from 18 to 60 years. Based on audiological evaluations, individuals with normal hearing were categorized into the CG. Those diagnosed with bilateral SNHL were divided into three study groups, resulting in four groups in total. The sample size was calculated using the statistical software G Power 3.1.0.[11] For the one-way Analysis of Variance (ANOVA), which compared the Speech, Spatial, and Qualities of Hearing Scale (SSQ) scores among the four groups, a large effect size of 0.40[12] was assumed, with a power of 0.80 and an acceptable Type I error rate of 0.05. It was determined that each group needed a minimum of 19 participants. Consequently, four groups were established, each comprising 20 participants, totaling 80 participants for the research.

Consent forms were collected from all volunteer participants. Audiological evaluations were conducted to determine their hearing thresholds. The Tinnitus Handicap Inventory (THI) and the Hyperacusis Questionnaire (HQ) were administered to assess the severity of tinnitus and to organize the study groups. The THI was only applied to individuals with tinnitus, whereas the HQ was administered to all participants. The study and control groups (CG) were formed based on the scores from these two questionnaires, the audiological evaluation results, and the participants' complaints. The data collected through the SSQ were then compared across the groups.

Inclusion and Exclusion Criteria

In the audiological evaluations, all study group participants exhibited at least mild bilateral sensorineural hearing loss. The inclusion criteria for Study Group One (SG1) were the absence of tinnitus and hyperacusis, with an HQ score of less than 16. For Study Group Two (SG2), the criteria included a THI score of 18 or higher, tinnitus complaints for at least three months, an HQ score of less than 16, and the absence of conditions capable of causing objective tinnitus. Study Group Three (SG3) required a THI score of 18 or higher, tinnitus complaints for at least three months, an HQ score of greater than 16, and the absence of conditions capable of causing objective tinnitus. The exclusion criteria for all study groups encompassed conductive or mixed hearing loss, severe or profound hearing loss, suspicion or diagnosis of central auditory processing disorder, and a history of an acoustic tumor. The CG inclusion criteria were normal hearing as per audiological evaluation, no complaints of tinnitus or hyperacusis, and an HQ score of less than 16. CG exclusion criteria included a history of an acoustic tumor, suspicion or diagnosis of a central auditory processing disorder, or a history of long-term noise exposure. Figure 1 details the participant selection process. Ethics committee approval (number I1-18-21, dated 14. 01. 2021) was obtained from Ankara University's Human Research Ethics Committee. This study adhered to the principles outlined in the Declaration of Helsinki.

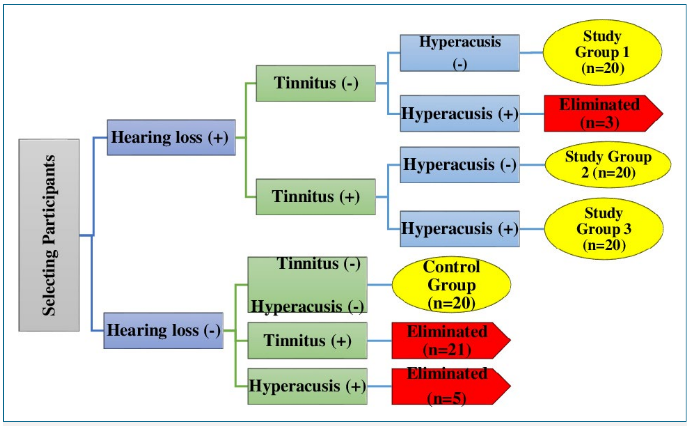

Figure 1. Illustration depicting participant inclusion process for the study.

Audiological Evaluation and Scales

Audiological evaluations were conducted in quiet rooms with a noise level below 35 dB A, in accordance with Industrial Acoustic Company standards, using an Interacoustics AC40 clinical audiometer and a GSI Tympstar Pro. Evaluations included pure tone audiometry, speech audiometry, and immittance measurements. Hearing status was determined by integrating these data. In pure tone audiometry, air conduction (AC) hearing thresholds were assessed across frequencies ranging from 125 to 8000 Hz with insert earphones. Bone conduction (BC) hearing thresholds were measured at frequencies between 500 and 4000 Hz using a bone vibrator. A difference of 10 dB or less between AC and BC hearing thresholds has been used as a reference for determining the presence of SNHL. Pure tone averages (PTA) were calculated by averaging the thresholds at 500, 1000, 2000, and 4000 Hz. In our study, the degree of hearing loss was determined based on the AC PTA using Goodman's classification from 1965.

The THI serves to assess how individuals perceive their tinnitus and the extent of discomfort it causes.[13] Higher scores on the THI indicate greater severity of tinnitus.

The HQ was designed for diagnosing and treating individuals with hyperacusis.[14] HQ scores below 15 suggest the absence of hyperacusis; scores from 16 to 28 indicate suspected hyperacusis, and scores above 28 are considered indicative of definitive hyperacusis. While it is possible to diagnose complete hyperacusis with a score of 29 or higher, previous studies have suggested that this threshold is too stringent.[15,16] Consequently, participants identified with suspected hyperacusis were also classified as having hyperacusis and were included in SG3.

Table 1. Age comparison across groups

	Group	Mean rank	Kruskal-Wallis H	df	p
Age	SG1 (n=20)	33.55			
	SG2 (n=20)	23.25	5.23	2	0.059
	SG3 (n=20)	34.70			
	CG (n=20)	28.38			

CG: Control group; SG1: Study group 1; SG2: Study group 2; SG3: Study group 3.

In the SSQ, a specific situation in daily life is provided as an example in each question. Participants are asked to self-evaluate on a scale from zero to ten points.[17] This scale measures the quality of skills in hearing complex sounds in daily life, distinguishing them from each other, and determining their origin, direction, and movement. It includes subsections on speech perception (SPEP), spatial perception (SPAP), and other aspects of hearing quality (QH). Evaluations are based on three subcomponent scores and an overall scale score.

Statistical Method

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics included the mean, standard deviation, median, and both number and percentage values. Suitability for normal distribution was assessed through analytical and visual methods. A one-way ANOVA was conducted to compare SSQ scores among groups. The Tukey's Honest Significant Difference (HSD) test was used for pairwise post hoc comparisons due to homogeneously distributed variances. Pearson correlation analysis was applied to explore the relationship between THI and SSQ scores, with correlation coefficients categorized as weak (≤0.3), moderate (0.3–0.7), and strong (≥0.8). The confidence interval was set at 95%, and the significance threshold was 0.05.

RESULTS

The gender distribution of participants included 28 females (35%) and 52 males (65%). Among 60 participants with hearing loss, the right ear's PTA and standard deviation were 38.9±10.9, while the left ear's PTA and standard deviation were 38.5±12.4. For the 20 participants in the CG, the right ear's PTA was 8.9±4.7, and the left ear's was 9.2±4.6. The overall mean age and standard deviation of participants were 47.7±10.5. The results of the analyses pertaining to the comparison of the ages of the groups are presented in Table 1. There were no statistically significant differences between the study groups regarding age, gender, and pure-tone average (PTA) for both the right and left ears (p=0.073; p=0.091; p=0.821; p=0.844). In this respect, it can said that the study groups have similar ages, genders, and PTAs.

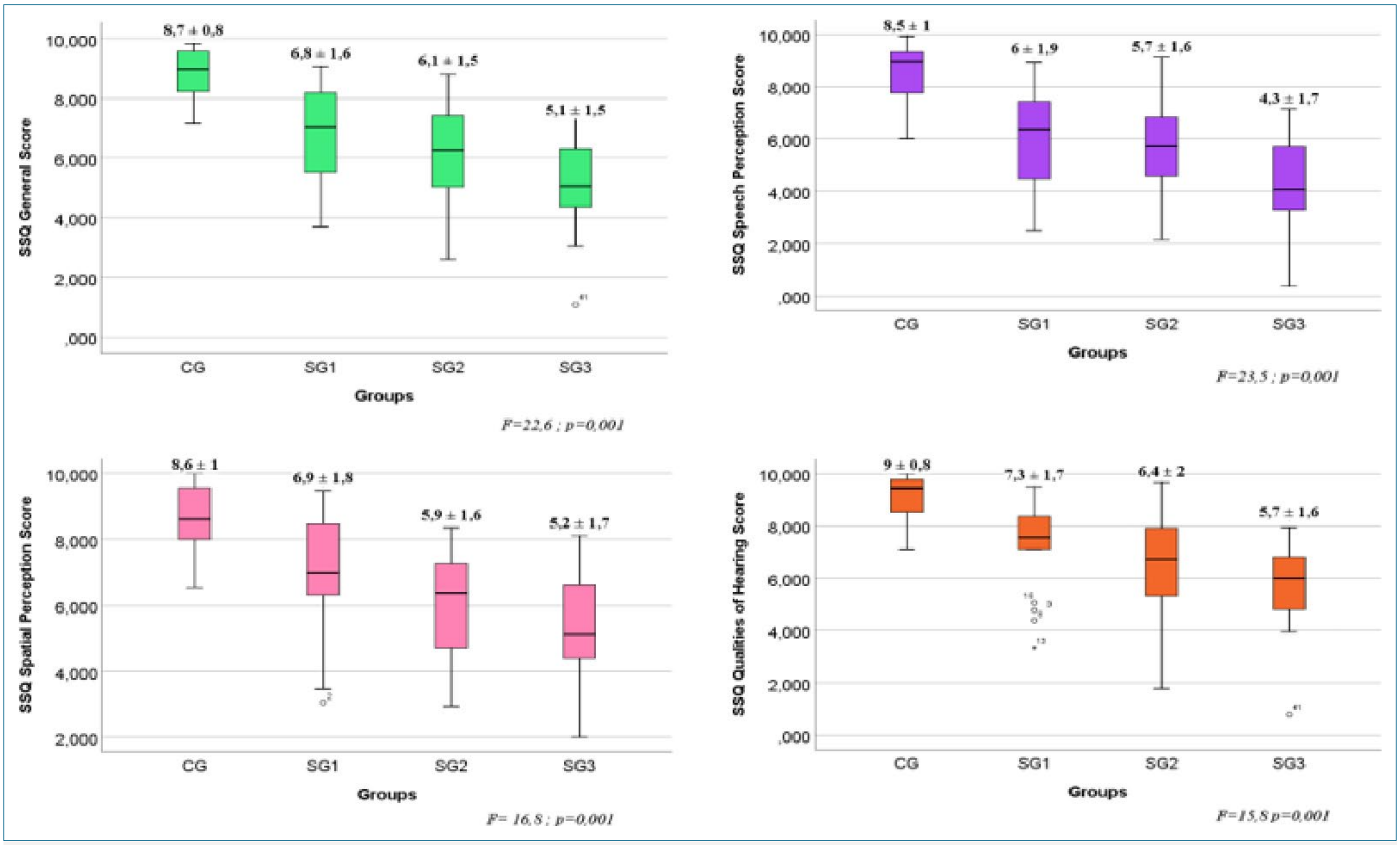

Figure 2. Comparison of overall and subgroup scores on the SSQ scale among the four groups included in the study, highlighting the differences between the mean scores.

CG: Control group; SG1: Study group 1; SG2: Study group 2; SG3: Study group 3; The mean and standard deviation data of the SSQ scores of the groups and the one-way ANOVA results are given in the figure.

When examining the SSQ scores of 80 participants, the overall SSQ was found to be 6.7±1.9; speech perception was 6.1±2.2, spatial perception was 6.6±2, and the quality of hearing score was 7.1±2. Figure 2 displays the means and standard deviations of the overall SSQ scores and subcomponent scores of the three study groups, each consisting of 20 participants, as well as the CG, and compares the SSQ scores among the groups. The results of the one-way ANOVA are provided in Table 2. The Tukey HSD test was conducted for pairwise post hoc comparisons, revealing a significant difference between the CG and all study groups in terms of the general and subcomponent scores of the SSQ ($p<0.001$). Significant differences were identified between SG1 and SG3 in terms of the SSQ general, SPEP, SPAP, and QH scores ($p=0.003$; $p=0.009$; $p=0.008$; $p=0.015$). A statistically significant difference was observed between SG2 and SG3 regarding the SPEP subcomponent score of SSQ ($p=0.036$). Consequently, no statistically significant difference was found between SG1 and SG2 in terms of the SSQ general, SPEP, SPAP, and QH subcomponent scores ($p=0.418$; $p=0.956$; $p=0.258$; $p=0.363$). No statistically significant differences were observed between SG2 and SG3 regarding the SSQ general, SPAP, and QH subcomponent scores ($p=0.171$; $p=0.469$; $p=0.478$).

Upon examination of the participants' THI scores, the mean and standard deviation for SG2 were 51.6±18.9, whereas for SG3, they were 66.4±23.9. In SG3, a moderate and significant negative correlation was observed between the SSQ general score and the THI score ($r=-0.469$; $p=0.037$). In SG2, no significant correlation was observed between the SSQ general score and the THI score ($r=-0.414$; $p=0.07$). Table 3 shows the results of the Pearson correlation analysis between the participants' THI scores and SSQ scores.

DISCUSSION

Although recent advancements in hearing protection and amplification systems have been claimed to reduce the rates of hearing loss, conditions such as tinnitus and hyperacusis continue to pose significant public health challenges due to

Table 2. One-way ANOVA results for SSQ scores across groups

	Sum of squares	df	Mean square	F	p
SSQ general				22.690	0.001
Between groups	142.894	3	47.631		
Within groups	159.541	76	2.099		
Total	302.435	79			
SSQ SPEP				23.532	0.001
Between groups	185.927	3	61.976		
Within groups	200.159	76	2.634		
Total	386.086	79			
SSQ SPAP				16.888	0.001
Between groups	129.013	3	43.004		
Within groups	193.528	76	2.546		
Total	322.541	79			
SSQ QH				15.883	0.001
Between groups	126.300	3	42.100		
Within groups	201.452	76	2.651		
Total	327.752	79			

ANOVA: Analysis of variance; SSQ: Speech, Spatial, and Qualities of Hearing Scale; SPEP: Speech perception; SPAP: Spatial perception; QH: Hearing quality.

Table 3. Pearson correlation analysis between participants' THI scores and SSQ scores

	THI	p
SG2 (Mean: 51.6, SD: 18.9)		
SSQ general	-0.414	0.07
SSQ SPEP	-0.499*	0.025
SSQ SPAP	-0.383	0.095
SSQ QH	-0.267	0.255
SG3 (Mean: 66.4, SD: 23.9)		
SSQ general	-0.469*	0.037
SSQ SPEP	-0.579**	0.008
SSQ SPAP	-0.494*	0.027
SSQ QH	-0.258	0.271

*: P<0.05; **: P<0.01; THI: Tinnitus Handicap Inventory Score; SSQ: Speech, Spatial, and Qualities of Hearing Scale; SD: Standard deviation; SG2: Study group 2; SG3: Study group 3; SPEP: Speech perception; SPAP: Spatial perception; QH: Hearing quality.

increased noise exposure. In our study, which investigates the effects of tinnitus and hyperacusis complaints on individuals with bilateral sensorineural hearing loss, it was found that individuals experiencing both tinnitus and hyperacusis exhibited poorer speech perception compared to those with only tinnitus. Furthermore, a negative correlation was observed between hearing quality and the severity of tinnitus among participants with both tinnitus and hyperacusis. Based on these findings, we emphasize that the coexistence of tinnitus and hyperacusis significantly negatively affects hearing quality.

Previous studies have stated that hearing loss adversely impacts various aspects of hearing quality, including speech understanding, spatial perception, clarity, discrimination, listening effort, and concentration skills.[18,19] In our study, the hearing quality scores of the three study groups, composed of participants with SNHL, were lower than those of the CG.

While there are studies evaluating the impact of hyperacusis on an individual's quality of life, information on its effects on speech perception and hearing quality is limited. Individuals who experience hyperacusis in addition to tinnitus often consider hyperacusis to be more disturbing than tinnitus.[20] Oishi et al.[15] discovered that individuals with both tinnitus and hyperacusis, along with hearing loss, had higher HQ scores than those with only hyperacusis. Refat et al.[5] reported that in the group experiencing both tinnitus and hyperacusis, the overall severity of tinnitus was notably higher from the onset, and tinnitus intensity showed a significant increase over time. In our study, all SSQ scores of individuals with both tinnitus and hyperacusis with SNHL were worse than the scores of those with only SNHL. Accordingly, the addition of tinnitus and hyperacusis to bilateral SNHL further deteriorates hearing quality.

Factors such as attention and stress can influence tinnitus distress by altering the excitability of the central auditory system. This may, in turn, affect the sensory sensitivity to auditory input, including speech perception.[21] Hyperacusis is similarly influenced by factors like attention and stress.[9] However, the impact of hyperacusis on speech perception is unclear. In our study, we observed that individuals with both tinnitus and hyperacusis, alongside sensorineural hearing loss (SNHL), exhibited poorer speech perception compared to those with only tinnitus and SNHL. This finding could be attributed to the perception that hyperacusis is more disturbing and to the likelihood that participants with three concurrent disorders, rather than two, tend to report worse outcomes on subjective scales.[9,20] Additionally, this result may have been obtained indirectly, as the presence of hyperacusis exacerbates the perceived severity of tinnitus.[22] Refat et al.[5] discovered that, within the tinnitus group, the intensity of the tinnitus sound diminished over time, whereas it intensified in the group with both tinnitus and hyperacusis. This observation may explain the inferior hearing quality and speech perception in the group with both conditions. For individuals with both tinnitus and hyperacusis, even low-intensity noise exposure can aggravate tinnitus symptoms. This may have directly led to heightened general distress and, indirectly, to a deterioration in speech perception.[23] In our study, although the general SSQ scores, as well as the SPAP and QH scores of individuals with tinnitus, hyperacusis, and SNHL were lower than those with only tinnitus and SNHL, no significant difference was observed. We believe this may be due to the small sample size.

It has been reported that tinnitus and hyperacusis mainly affect hearing, sleep, concentration, and emotional well-being.[9,24] However, the specific aspects of hearing affected remain undefined. While some studies suggest that tinnitus may impact speech perception,[25] others report no significant effect of tinnitus on auditory perception or speech perception in general.[26] In our study, the hearing quality scores of all individuals with SNHL and tinnitus complaints were lower than those with only SNHL, though the difference was not statistically significant. Clinically, we observed that participants with tinnitus reported worse subjective speech perception. We anticipate that this difference could become significant in a study with a larger sample size.

When analyzing the THI score, which indicates the severity of tinnitus, it was noteworthy that individuals with both tinnitus and hearing loss accompanied by hyperacusis had higher THI scores compared to those with just tinnitus and hearing loss. In one study, teachers with tinnitus and hearing loss had significantly lower scores on the Mini Tinnitus Questionnaire than teachers with both hyperacusis and tinnitus accompanied by hearing loss, a result that aligns with our findings.[27] It has been suggested that hyperacusis in patients with tinnitus exacerbates the emotional distress associated with tinnitus.[28] This has been attributed to nerve degeneration as well as to increased functional resting-state connectivity between the limbic system and the auditory cortex following hearing loss.[28,29] The elevated THI score in the group with hyperacusis in our study may be due to the same reasons.

The literature indicates that individuals with hearing impairments have worse auditory and speech perceptions compared to those with normal hearing.[19] Auditory and speech perception are influenced by cognitive factors and the degree of hearing loss. Tinnitus has also been associated with cognitive performance and is known to interact with the central auditory system.[21] Based on this, an analysis was conducted considering that, in addition to hearing loss, the severity of tinnitus may negatively affect the hearing quality score. A negative correlation was found between the general SSQ score and the THI score among participants with tinnitus, hyperacusis, and hearing loss. This correlation was not observed in participants with only tinnitus and hearing loss. The observed effect in SG3, but not in SG2, may be attributed to the higher THI scores in SG3 participants, which likely impact their hearing quality more significantly than in SG2.

Studies suggest that cognitive decline can be mitigated with appropriate diagnosis and treatment in individuals with hearing loss.[30] Therefore, it is crucial to address hearing loss, especially in middle-aged adults. In our study, we represented middle-aged adults, specifically those aged 40–50, with mild to moderate hearing loss. Currently, management of SNHL involves amplification systems. However, despite predictions that patients with SNHL could benefit from hearing aids, a significant number do not use them. This situation suggests that the issues frequently accompanying hearing loss may not have been thoroughly explored or integrated into the treatment process. The presence of different combinations of hearing impairments can lead to different effects.[22,27] Tyler et al.[24] stated that tinnitus, hyperacusis, and hearing loss should be considered together, with interventions targeting the most problematic area first. Drawing on this, our study concludes that the concurrent presence of both tinnitus and hyperacusis, especially when combined with sensorineural hearing loss (SNHL), significantly affects hearing quality.

The findings underscore the importance of assessing for hyperacusis in conjunction with tinnitus before initiating interventions such as hearing aid fitting and tinnitus rehabilitation, prioritizing the primary concern of the patient. Distinguishing hearing quality across different conditions is anticipated to aid in the planning and execution of treatment, rehabilitation, and counseling.

Limitations of the Study

The HQ score was employed to identify the presence of hyperacusis in determining study groups. Currently, there is no universally accepted method for definitively diagnosing hyperacusis. Given its complex nature, a single scale may not suffice for diagnosis.

Responses to the SSQ reflect individuals' self-perceptions. As all three conditions are associated with depression, anxiety, and psychological issues, participants experiencing more significant problems may tend to report lower scores.

Not all combinations of SNHL, tinnitus, and hyperacusis were explored in our study. Future research should address this gap.

CONCLUSION

Our observations suggest that tinnitus and hyperacusis can adversely affect hearing in individuals with bilateral SNHL. The presence of hyperacusis, in particular, complicates interventions and rehabilitation efforts. In clinical practice, it is crucial to consider comorbid conditions and employ suitable methodologies. The data from this study primarily reflect the experiences of individuals with mild to moderate SNHL. Future research could benefit from examining hearing quality across different severities and types of hearing loss, including severe and profound cases.

Ethics Committee Approval: The Ankara University Faculty of Medicine Human Research Ethics Committee granted approval for this study (date: 14.01.2021, number: I1-18-21).

Author Contributions: Concept – NOO, SB; Design – NOO, SB; Supervision – SB; Resource – NOO, SB; Materials – NOO, SB; Data Collection and/or Processing – NOO; Analysis and/or Interpretation – NOO; Literature Search – NOO; Writing – NOO, SB; Critical Reviews – SB.

Conflict of Interest: The authors have no conflict of interest to declare.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Use of AI for Writing Assistance: Not declared.

Financial Disclosure: The authors declared that this study has received no financial support.

Peer-review: Externally peer-reviewed.

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