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Frequency-Specific Loudness Discomfort Levels and Speech Discrimination in Noise in Patients with Chronic Tinnitus

Kronik Tinnituslu Hastaların Frekansa Özgü Rahatsız Edici Ses Seviyeleri ve Gürültüde Konuşmayı Ayırt Etme Becerileri

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This study was presented as a summary orally in 12th International Congress of Audiology&Speech Pathology in October 9-11, 2024, Ankara, Türkiye.

ABSTRACT Objective: This study aimed to evaluate the ability to discriminate speech in noise with frequency-specific loudness discomfort levels (LDL) in patients with chronic tinnitus and to show that noise affects speech perception. **Material and Methods:** The significance of the difference between the 2 study groups and correlation analysis was examined. Pure tone audiometry, speech discrimination (SD) test, LDL, SD in noise test (SDNT), Tinnitus Disability Questionnaire, and Weinstein Noise Sensitivity Scale (WNSS) were applied to each participant. Study sample: 40 patients with chronic tinnitus, aged between 40-55 years, and 40 healthy individuals without tinnitus complaints. **Results:** When the tinnitus group and the healthy control group were compared, statistically significant differences were found in the mean LDL and WNSS scores for both the right and left ears ($p<0.001$). Similarly, the mean SDNT scores for the right and left ears also differed significantly between the 2 groups ($p<0.05$). In addition, a significant positive correlation was observed between SDNT scores and SD scores ($p<0.001$), while a significant negative correlation was found between SDNT and WNSS scores ($p=0.01$). **Conclusion:** The findings show that patients with chronic tinnitus have decreased tolerance to sound, and their speech discrimination in noise is impaired.

Keywords: Tinnitus; speech perception; noise; hyperacusis; loudness discomfort level

ÖZET Amaç: Bu çalışmada, kronik tinnituslu hastalarda, frekansa özgü rahatsız edici ses seviyeleri ile gürültüde konuşmayı ayırt etme becerilerini değerlendirme ve gürültünün konuşma algısını etkileyeceğini gösterme amaçlanmıştır. **Gereç ve Yöntemler:** İki çalışma grubu arasındaki farkın anlamlılığı ve korelasyon analizi incelendi. Her katılımcıya sırasıyla saf ses odyometrisi, konuşma ayrımı [speech discrimination (SD)] testi, ses yüksekliği rahatsızlık seviyesi [loudness discomfort level (LDL)], gürültüde SD testi [SD in noise test (SDNT)], Tinnitus Engellilik Anketi ve Weinstein Gürültü Duyarlılık Ölçeği [Weinstein Noise Sensitivity Scale (WNSS)] uygulandı. Çalışma örneği: 40-55 yaş aralığında kronik tinnituslu 40 hasta ve tinnitus şikâyeti olmayan 40 sağlıklı birey. **Bulgular:** Tinnituslu bireylerden oluşan çalışma grubu ile sağlıklı bireylerden oluşan kontrol grubu karşılaştırıldığında hem sağ hem de sol kulak için LDL ve WNSS skor ortalamaları arasında istatistiksel olarak anlamlı fark bulunmuştur ($p<0,001$). Aynı şekilde SDNT testine ait sağ ve sol kulak skor ortalamaları da 2 grup arasında anlamlı düzeyde farklılık göstermiştir ($p<0,05$). Ayrıca SDNT skorları ile SD testi skorları arasında pozitif yönde anlamlı bir ilişki ($p<0,001$) ve SDNT ile WNSS skorları arasında negatif yönde anlamlı bir ilişki bulunmuştur ($p=0,01$). **Sonuç:** Bulgular, kronik tinnituslu hastaların sese karşı toleranslarının azaldığını ve gürültüde konuşma ayırt etme yeteneklerinin bozulduğunu göstermektedir.

Anahtar Kelimeler: Kulak çınlaması; konuşma algısı; gürültü; hiperakuzi; rahatsız edici ses seviyeleri

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Tinnitus is the conscious awareness encompassing all types and forms of sound perception in the absence of an external sound source, regardless of the physical characteristics of the sound.[1,2] According to the American Tinnitus Association, tinnitus is one of the most common health problems in the country. However, in the United States, approximately 10% of the adult population (approximately 25 million) has tinnitus, and approximately 5 million people complain.[3] A recent review of tinnitus pathophysiology concluded that both the peripheral and central components of the auditory system work together with non-central auditory functions.[4] The peripheral component primarily consists of cochlear damage that triggers the central auditory system and causes tinnitus. The central component is located in and around the primary auditory cortex, as well as in many non-auditory higher-level processing centers such as attention, memory, and emotional systems.[4,5] The interaction between the peripheral and central components of tinnitus has been reported to affect sound processing, especially in complex acoustic conditions.[6] It has been observed that the ability to understand speech in tinnitus patients, especially in the presence of noise, is due to a central mechanism.[7]

A significant problem resulting from tinnitus is the difficulty in communicating, especially in noisy backgrounds. Tinnitus patients experience many problems like this. Therefore, it is important to investigate how tinnitus affects speech perception in noise.[8] Speech perception in noise refers to an individual's' ability to understand the language spoken in background noise. This complex process requires individuals to use their auditory and cognitive abilities.[9,10] Many studies on individuals with tinnitus have stated that they often have speech perception problems in noisy environments, whether they have normal hearing or not.[11,12] Contrary to the literature, tinnitus does not impair speech perception and there are also studies suggesting that it sometimes improves it.[12,13]

Hypersensitivity to sound and tinnitus often occur together.[14] The prevalence of tinnitus in people with hypersensitivity to sound is much higher than in the general population and is estimated to be 40%, 79%, and 86%.[15-17] Increased loudness (abnormal amplification of loudness perception) may be a separate condition in people with cochlear hearing loss or may accompany hyperacusis.[18] Increased loudness may affect emotional well-being, hearing, sleep and concentration, cause anxiety and affect speech perception in noise.[19] Hypersensitivity to external sounds may be important in the management of tinnitus. Therefore, it is important to measure the sensitivity to sound accurately. There is no standard protocol for assessing the hypersensitivity to sound. The most common approach involves anamnesis and measuring loudness discomfort levels (LDL) as the first step for diagnosis.[20]

This study aimed to evaluate the ability to distinguish frequency-specific disturbing sound levels and speech in noise in patients with chronic tinnitus. It was also aimed to show the relationship between the frequency-specific LDL test, speech in noise discrimination test, and noise sensitivity scale.

MATERIAL AND METHODS

STUDY DESIGN AND PATIENTS

This study is a prospective case-control study. The case group consisted of 40 patients (23 males, 17 females) between the ages of 40-55, with normal hearing, very mild hearing loss, and very mild hearing loss who applied to the Audiology Clinic of the Ear, Nose, and Throat Department of Başkent University Başkent Hospital between September 2023-June 2024 with complaints of tinnitus and underwent ear, nose, and throat examination. The study group consisted of patients who were followed up with a diagnosis of chronic subjective non-pulsatile tinnitus. Among the participants, 28 had bilateral tinnitus, 6 reported tinnitus localized to the right ear, and 6 reported tinnitus localized to the left ear. The control group consisted of 40 healthy individuals (23 males, 17 females) between the ages of 40-55, with normal hearing, very mild and mild hearing loss, who did not complain of tinnitus. Participation in the study was voluntary, and a written "Informed Consent Form for Scientific Research" was obtained from all participants. The principles of the Helsinki Declaration of 2008 were followed throughout the study.

No priori power analysis was conducted before data collection. To assess the adequacy of our sample, we performed "post hoc" effect size calculations using the observed means and standard deviations. Cohen's d values were very large for LDL (right ear d=1.76, left ear d=1.42) and Weinstein Noise Sensitivity Scale (WNSS) (d=1.44), indicating that the current sample size (n=40 per group) was more than sufficient. For speech discrimination in noise test (SDNT), the effect sizes were moderate (right ear d=0.63, left ear d=0.58). Based on these values, approximately 40-46 participants per group would be required to achieve 80% power, and 54-62 participants per group would be required to achieve 90% power (2-sided α=0.05). Thus, while this sample provided adequate power for the LDL and WNSS outcomes, the statistical power for the SDNT outcomes was somewhat limited.

Individuals with any ear, nose, and throat pathology, anatomical problems or diseases related to the outer ear and middle ear, history of otosclerosis, history of chronic otitis media, history of acoustic tumors, history of Meniere's disease, active ear discharge, history of ear surgery, uncontrolled hypertension and diabetes, pregnancy or breastfeeding, neuropsychiatric problems, exposure to acoustic trauma, and history of head trauma were excluded from the study. In addition, participants whose tinnitus was not diagnosed and who were not followed up due to tinnitus were not included in the study.

Test and Procedure

The same testing procedures were applied to all participants in the case and control groups. All tests and scales were performed in a single session (40 minutes) for each participant. Pure tone audiometry, speech tests, LDL, SDNT, impedancemetric assessment, Tinnitus Disability Questionnaire (TDQ) and WNSS were applied to each participant. If participants complained of fatigue, the tests were stopped, and a rest break (~10 minutes) was given.

Pure Tone Audiometry Test

Audiometric evaluations of the participants in the study were performed in an Industrial Acoustics Company (IAC) silent booth using an Interacoustics AC 40 clinical audiometer (Interacoustics A/S, Assens, Denmark) TDH-39 headphones (Telephonics Corporation, Farmingdale, NY, USA). headphones. All participants in the study had air conduction hearing thresholds in the frequency range of 250-8,000 Hz and bone conduction hearing thresholds in the frequency range of 250-4,000 Hz. According to the pure tone average, only individuals with normal hearing, very mild hearing, and mild hearing loss were included in the study.

Speech Audiometry Test

The speech audiometry test determined the minimum sound level at which individuals could correctly repeat 50% of the 3-syllable Turkish words presented in live sound, namely the Speech Reception Threshold (SRT), through TDH-39 headphones. Another step of the speech audiometry test is to measure the speech discrimination (SD) score. For this purpose, live voice and 25 monosyllabic word lists were used with the individuals' SRTs at +40 decibel (dB) sensation level (SL). Participants were asked to repeat the 25 monosyllabic phonemically balanced words presented, and each word they could repeat correctly was multiplied by 4 to calculate the SD score as a percentage.

Loudness Discomfort Level

The LDL varies according to the instructions given to the patient. The instructions recommended by the British Society of Audiology, which are frequently used in the literature, were used.[21] The maximum stimulus intensity was made at 0.5, 1, 2, 4, and 8 kHz for each participant, not exceeding 110 dB hearing level (HL). The participants were instructed, "the sound coming to your ear will slowly increase". Press the button when it reaches a disturbing level. This test is not a test to find the loudest sound you can stand; it only determines the level at which the sound is disturbing. The study measured hypersensitivity to sound by looking only at frequency-specific disturbing sound levels in patients with and without chronic tinnitus. No hyperacusis scale was used, and no distinction was made between hyperacusis.

Speech Discrimination in Noise Test

This test was performed using monosyllabic word lists. To increase the complexity of the stimulus, nar-

row-band, white noise, speech noise, and fluent speech were used ipsilaterally. With these features, it is a monotonic test. In practice, noise and speech are given to the same ear with a 0 dB or +10 dB signal/noise ratio. This study performed white noise with a +10 dB S/N ratio and 25-word monosyllabic word lists at 40 dB SL (re: Pure Sound Average (PSA).

Impedancemetric Evaluation

The test was applied to both groups using the AZ-26 impedance device (Interacoustics A/S, Assens, Denmark) TDH-39 headphones (Telephonics Corporation, Farmingdale, NY, USA) and 226 Hz probe tone. For the stapes reflex, acoustic reflexes were examined at 500, 1,000, 2,000, and 4,000 Hz frequencies. Individuals with acoustic reflexes and only Type A in the tympanogram were included in the study.

The Tinnitus Disability Questionnaire

The TDQ was applied to the case group. The TDQ was developed by Aksoy et al.[22] This questionnaire consists of a total of 25 questions, each of which has 3 answer options: "yes", "sometimes", and "no", and the answers were scored using the scores "4", "2", and "0", respectively. A total TDQ score was obtained for each participant.

Weinstein Noise Sensitivity Scale

The Turkish Tr-WNSS was created by Keskin Yildiz.[23] This 21-item survey was given to the participants and filled out after they were informed. The forms were filled out independently by the participants. The 21 items in the Tr-WNSS are subject to a Likert-type scaling from 1 (agree/very much) to 6 (disagree/not at all). The participant completes the survey by marking the value closest to him/her in each item. The scores are then added to determine each individual's' noise sensitivity score.

ETHICAL APPROVAL

This study was approved by the Karabük University Non-Interventional Ethics Committee (date: March 28, 2023; no: 2023/1329).

DATA ANALYSIS

Data analysis was performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA) Number, percentage, mean, standard deviation, and minimum and maximum values were used for descriptive variables. The normality of the data was assessed using visual (histograms) and analytical (Kolmogorov-Smirnov) analyses. A chi-square test was used to evaluate the difference between the qualitative variables between the groups. Similarly, the Student's t-test was used to evaluate the difference between the normally distributed quantitative variables between the 2 groups, and the Mann-Whitney U test was used for non-normally distributed data. The Spearman correlation test was used to evaluate the relationship between various quantitative variables. Statistical significance was taken as $p<0.05$ in all analyses.

RESULTS

CHARACTERISTICS OF THE STUDY

The descriptive characteristics of the participants are shown in Table 1. 57.40% of the males (n=23/40) in the study group and 42.6% of the females (n=17/40). The mean age of the individuals in the study group was 48.32±5.68 years, while the mean age of the control group was 48.52±4.97 years. The gender and age distributions of the individuals in the study and control groups were not statistically significant, which indicates that a homogenized group was taken. A statistically significant difference was found between the study and control groups in terms of educational background, with the majority of participants being university graduates in both groups 44.8% (n=18) in the study group and 62.5% (n=25) in the control group) ($p<0.001$). A significant difference was found in the right ear hearing status of the study and control groups ($p=0.027$), while no significant difference was found in the left ear hearing status ($p=0.196$). In addition, most patients in the study group had normal hearing. When the SD scores of the individuals were examined, the right ear SD score averages of the study and control groups were 94.90±9.01, 94.10±5.72, respectively. The study and control groups left ear SD score averages were 95.00±6.05 and 94.50±5.17, respectively. It was observed that this difference between the 2 groups was not significant (right $p=0.387$, left $p=0.587$). In addition, when

TABLE 1: Descriptive characteristics of participants and p values between groups

	Study group		Control group		
Variables	**n**	**%**	**n**	**%**	**p value**
Gender					
Female	17	42.6	17	42.6	0.589
Male	23	57.4	23	57.4	
Education					
Primary school	1	2.6	-	-	<0.001**
Middle school	8	20	-	-	
High school	9	22.6	15	37.5	
University	18	44.8	25	62.5	
Postgraduate	4	10	-	-	
Hearing status (right)					
Normal hearing	25	62.4	13	32.6	0.027*
Very mild hearing loss	9	22.6	17	42.6	
Mild hearing loss	6	15	10	25	
Hearing status (left)					
Normal hearing	24	60	16	40	0.196
Very mild hearing loss	8	20	13	32.5	
Mild hearing loss	8	20	11	27.5	
TDQ					
Very light	4	10	-	-	-
Light	10	25	-	-	
Middle	13	32.6	-	-	
Severe	10	25	-	-	
Very severe	3	7.4	-	-	
	X̄±SD	**Minimum-maximum**	**X̄±SD**	**Minimum-maximum**	**p value**
Age (year)	48.32±5.68	40-55	48.52±4.97	40-55	0.867
SD score					
Right ear	94.90±9.01	80-100	94.10±5.72	76-100	0.387
Left ear	95.00±6.05	80-100	94.50±5.17	84-100	0.587

*p<0.05; **p<0.001; Student's-t test and chi-square test were used. TDQ: Tinnitus Disability Questionnaire; SD: Standard deviation; SD: Speech discrimination

the TDQ classification of the study group was examined, it was determined that 32.6% (n=13) were moderate and 7.4% were very severe.

RELATIONSHIP BETWEEN SDNT SCORES AND SD SCORES AND THE WNSS

Table 2 shows the Spearman's correlation' test results for the relationship between the participants' SDNT right-left scores and SD right-left WNSS scores. A highly positive (r=0.731, p<0.001) significant relationship was found between the participants' SDNT right score and SD right score, and a moderately positive (r=0.611, p<0.001) significant relationship was found between the SDNT left score and SD right score. A moderately positive (r=0.688, p<0.001) significant relationship was found between the SDNT right score and SD left score, and a highly positive (r=0.749, p<0.001) significant relationship was found between the SDNT left score and SD left score. In addition, a low-level negative correlation

TABLE 2: Relationship between speech discrimination in noise test scores and speech discrimination scores and the WNSS

		SDNT right	SDNT left
SD right	r value	0.731	0.611
	p value	<0.001**	<0.001**
SD left	r value	0.688	0.749
	p value	<0.001**	<0.001**
WNSS score	r value	-0.296	-0.355
	p value	0.008*	0.001*

*p=0.01, **p<0.001; Spearman's correlation test was used. WNSS: Weinstein Noise Sensitivity Scale; SDNT: Speech discrimination in noise test; SD: Speech discrimination

was found between the SDNT right score and WNSS scores (r=-0.296, p=0.008), and a moderate-level negative correlation was found between the SDNT left score and WNSS scores (r=-0.355, p=0.001).

DECREASED SOUND LEVEL TOLERANCE; LDL LEVELS

The means and SDs of LDLs for the participants in the study and control groups for each ear and each measured frequency are shown in Table 3. Accordingly, the mean LDL right ear score at 1 kHz was 100.25 (SD 7.15), and the mean LDL left ear score was 101.25 (SD 7.22) for the individuals in the study group. In addition, the mean LDL left ear score at 2 kHz was 100.37 (SD 7.10). The mean LDL values in other frequency measurements in the study group were below 100 dB HL. The mean LDL values for the right and left ears of the individuals in the control group were above 100 dB HL at all frequencies.

LDL AND SDNT SCORES AND WNSS SCORES CASE-CONTROL

Table 4 shows the differences between the LDL, SDNT, and WNSS scores of the study and control groups evaluated by the Mann-Whitney U test. The mean LDL at 0.5, 1, 2, 4, and 8 kHz of the individuals in the study group was 98.02 dB HL (SD±6.48) for the right ears (n=40). The mean LDL at 0.5, 1, 2, 4, and 8 kHz for the left ears in the same group was 99.55 dB HL (SD±6.99) (n=40). The mean LDL right-left scores between the groups created a statistically significant difference (p<0.001). When the control group was examined, the mean LDL at 0.5, 1, 2, 4, and 8 kHz was 107.57 dB HL (SD±4.08) for the right ears (n=40). The mean LDL at 0.5, 1, 2, 4, and 8 kHz for the left ears in the same group was 107.62 dB HL (SD±4.02) (n=40). The mean SDNT right score of the individuals in the study group was 85.80±12.04 and 92.10±7.44 in the control group, and this difference was statistically significant (p=0.012). The mean SDNT left score of the individuals in the study group was 86.80±10.95 and 92.40±7.98 in the control group, and this difference was statistically significant (p=0.018). In addition, the mean WNSS scores of the individuals in the study group (97.95±17.25) were higher than those in the control group (69.65±21.80) and were statistically significant (p<0.001).

TABLE 3: LDL mean and standard deviation values of the groups in dB HL

	LDL-Frekans, Hz				
Groups	**500**	**1,000**	**2,000**	**4,000**	**8,000**
Study group					
LDL right ear	97.37 (9.20)	100.25 (7.15)	99 (6.81)	97.50 (7.92)	96 (9.48)
LDL left ear	98.75 (9.59)	101.25 (7.22)	100.37 (7.10)	99.25 (8.36)	98.12 (9.58)
Control group					
LDL right ear	107.12 (4.92)	107.87 (4.21)	107.50 (4.66)	107.87 (4.65)	107.50 (4.38)
LDL left ear	107.12 (4.92)	108 (4.20)	107.50 (4.66)	107.87 (4.65)	107.62 (4.08)

LDL: Loudness discomfort level; dB HL: Decibel hearing level

TABLE 4: Mean, standard deviation and p values of LDL, SDNT and WNSS scores in the groups

	Study group		Control group		
	X̄±SD	**Minimum-maximum**	**X̄±SD**	**Minimum-maximum**	**p value**
LDL right	98.02±6.48	81-110	107.57±4.08	94-110	<0.001**
LDL left	99.55±6.99	81-110	107.62±4.02	94-110	<0.001**
SDNT right	85.80±12.04	52-100	92.10±7.44	68-100	0.012*
SDNT left	86.80±10.95	60-100	92.40±7.98	60-100	0.018*
WNSS score	97.95±17.25	52-138	69.65±21.80	30-99	<0.001**

*p<0.05; **p<0.001; Mann-Whitney U test was used. LDL: Loudness discomfort level; SDNT: Speech discrimination in noise test; WNSS: Weinstein Noise Sensitivity Scale; SD: Standard deviation

DISCUSSION

Individuals with tinnitus state that they are extremely sensitive to sounds and cannot tolerate loud noises. The most disturbing situation for these patients is the noisy environment. So, are these patients really as sensitive to loud noises as they claim to be, and is their ability to distinguish speech impaired in the presence of noise? This study, which started with the question, compared patients who had been experiencing tinnitus for at least 6 months, who were diagnosed and came to the clinic for treatment, with patients who did not have tinnitus using behavioral tests and questionnaires.

CHARACTERISTICS OF THE STUDY AND TDQ

The increase in the number of epidemiological studies has shown that there is a strong relationship between tinnitus and hearing loss. Some studies have shown that especially high-frequency sensorineural hearing loss can be an important factor in the development of tinnitus.[24,25] In contrast to these studies, a study using the TDQ has proven that hearing loss and tinnitus discomfort levels are unrelated.[26] Since the effect of hearing loss on tinnitus is a controversial issue, a more homogenized group was preferred in the study, and the impact of hearing loss was not examined. In addition, TDQ was applied to the case group, and a highly significant difference was obtained in the LDL test in individuals with moderate, severe, and very severe tinnitus compared with individuals with very mild and mild tinnitus. In this study, the clinical importance of the LDL test in patients with tinnitus and its relationship with pure tone audiometry tests and questionnaires were investigated. Tinnitus intensity was found to have a weak negative correlation with LDL at most frequencies except 8 kHz. As a result, a significant relationship was shown between LDL levels and emotional factors in tinnitus patients.[27]

DECREASED SOUND LEVEL TOLERANCE; LDL LEVELS

To assess the effect of tinnitus on sound level tolerance, disturbing sound levels were examined at 0.5-1-2-4-8 kHz. Consistent with previous studies, it was found that patients with tinnitus showed significantly lower LDLs compared with controls. This has been argued by putting forward different hypotheses. The 1st hypothesis is that the reduced sound level discomfort levels in patients with tinnitus with normal and symmetrical hearing thresholds may be related to hidden cochlear damage that causes tinnitus development, especially on one side. The 2nd hypothesis is that hyperacusis and tinnitus result from the exact mechanism: an increase in central gain and hyperactivity triggered by reduced sensory input. The 3rd hypothesis is that tinnitus may cause increased sensitivity to sound in these patients.[26-28] The 1st hypothesis argued that unilateral tinnitus was associated with cochlear synaptopathy, but bilateral tinnitus was observed in 70% of this study group.

In the present study, the mean LDL values in the tinnitus group were approximately 98 dB HL, which are slightly higher than those reported in previous studies, where the average LDL thresholds typically ranged between 75-95 dB HL in tinnitus patients.[26-28] Since tinnitus is generally associated with decreased sound tolerance, lower LDL values would normally be expected. Notably, in our control group without tinnitus, the mean LDL values were much higher, around 107 dB HL, which is consistent with normative data and highlights the clear difference in sound tolerance between the 2 groups. Several factors may account for the relatively elevated LDL values observed in our tinnitus cohort. First, methodological variations such as the frequency range tested, the type of stimuli, and patient instructions can influence the measured LDL thresholds.[27] Second, individual differences in tinnitus severity and duration may alter responses; indeed, in our cohort, patients with more severe tinnitus tended to report lower LDL values, consistent with previous reports.[28] Finally, sociocultural and demographic factors, including the relatively higher educational level of the control group, may have indirectly influenced patient performance. Taken together, these findings suggest that although our results are broadly consistent with the literature in showing reduced tolerance to sound in tinnitus, methodological and sample-related factors may have contributed to the slightly elevated LDL thresholds in our study.

RELATIONSHIP BETWEEN SDNT SCORES SD SCORES AND WNSS SCORES

In the literature, speech in noise has been studied in patients with tinnitus using different materials such as digits, phonemes, words, and sentences. The cognitive resources required to process sentences or words vary significantly. Similarly, the type of background noise can affect speech in noise perception differently.[28] In this study, monosyllabic words were measured separately for both the right and left ears in noisy and noiseless environments. A significant relationship was found between the SDNT scores and SD scores. In this relationship, it was seen that speech understanding skills were impaired, especially when noise was introduced in the ears with tinnitus. It is also emphasized that participants with low SD scores had lower SDNT scores. The reviewed studies show that speech understanding is impaired in patients with tinnitus, especially in the presence of competing noise. This is true even in tinnitus patients with normal hearing thresholds.[7,11]

In studies conducted generally, the relationship between the hyperacusis scale and the Noise Sensitivity Scale in the tinnitus and healthy groups has been evaluated. As a result, a positive relationship was found between hyperacusis and noise sensitivity, especially in the tinnitus patient group.[29,30] However, this study did not use a scale related to hyperacusis because the aim here was not to detect hyperacusis. It was shown that speech discrimination in noise was impaired in people disturbed by noise (those who scored high on the WNSS). Although 4 people in the control group did not have tinnitus, their scale scores were high, and their SDNT scores were low. Here, it is emphasized that the relationship between the WNSS and the SDNT, an audiological test, is significant.

LDL AND SDNT SCORES AND WNSS SCORES CASE-CONTROL

The mean LDL value in patients with tinnitus is considered at or below the reference value of 100 dB. This limit is used to identify patients susceptible to moderate- and high-intensity sounds.[30] LDLs were significantly lower in our tinnitus patients compared with the control group compared with these normative values. However, the mean values in the case group were approximately 98 dB. In other studies, these mean values were between 75-95 dB.[20,28,31] This may be due to differences in the measured frequency value and tinnitus intensity. In addition, a relationship was observed between tinnitus intensity and LDL. Our 3 patients with severe tinnitus had significantly lower LDL thresholds than those with weak/mild tinnitus.

Tinnitus may have a negative effect on speech perception. Contrary to the literature, some studies emphasize that tinnitus, hearing loss, and noise do not affect speech intelligibility.[13,32] It has been stated that tinnitus patients have poorer speech understanding skills against noise. In addition to tinnitus, hearing loss has also been found to impair speech intelligibility in noise.[7] In a study examining the effect of noise, the peech Reception Threshold (SRT) was compared in noisy and noiseless environments, and it was observed that participants with tinnitus had higher SRT in both environments.[11] Consistent with earlier studies, our findings demonstrate that patients with tinnitus have significantly lower SDNT scores compared with controls, confirming that speech understanding in noise is impaired in this population. In addition, it was found that SDNT scores worsened as tinnitus severity increased, regardless of hearing loss.[33] Tinnitus may act as a central masker, reducing audibility, sound level tolerance, and speech intelligibility in noise. This effect is thought to arise from increased central gain and dysfunctional neuroplasticity within the auditory system, consistent with previous reports.[27,28,33]

Various tools and scales have been developed to assess noise sensitivity in individuals with tinnitus. The WNSS is widely used to assess noise sensitivity levels, and studies have shown significant differences in WNSS scores between individuals with and without tinnitus.[29,30] This study supports the literature and found significant differences between the WNSS scores in our case and control groups. WNSS scores were high in the case group, especially in participants with moderate and severe tinnitus. Here, the grading of tinnitus is significant.

LIMITATIONS AND FUTURE DIRECTIONS

The state of hypersensitivity to sound was measured using a behavioral test, LDL, but the hyperacusis

scale was not used for the participants. Although the LDL averages created a significant difference between people with and without tinnitus, no distinction was made for hyperacusis. Similar studies should be conducted using hyperacusis scales on more people to generalize the statement that people with tinnitus are hypersensitive to sound. One limitation of this study concerns the difference in educational level between the tinnitus and control groups. Participants in the control group generally had a higher educational background, which may have influenced their performance on auditory tasks that require not only peripheral hearing ability but also cognitive resources such as attention and memory. Previous studies have shown that educational attainment is associated with enhanced cognitive reserve, which in turn can improve speech perception in challenging listening conditions.[34,35] Therefore, the observed group differences might partly reflect the influence of educational level, and future studies should aim to recruit groups with more homogeneous sociodemographic characteristics.

Another limitation of this study is related to the statistical power. "Post hoc" sample size estimations indicated that the current sample (n=40 per group) was more than sufficient for detecting the large effect sizes observed in the LDL and WNSS outcomes. However, for the SDNT measures, the observed effect sizes were moderate (d=0.58-0.63), and the statistical power was somewhat limited, particularly for achieving 90% power. Therefore, the results related to SDNT should be interpreted with caution and confirmed in future studies with larger samples.

Another limitation of our study is that we did not evaluate the impairment of speech intelligibility, especially in background noise. We believe that this situation is due to impaired selective attention. Future research should unravel the causal relationships between attention and speech understanding, as well as the various factors contributing to the impairment of speech perception in tinnitus.

CONCLUSION

According to the present results, patients with chronic innitus have decreased tolerance to sound and speech discrimination, especially in noisy environments. Increased noise sensitivity in individuals with tinnitus may affect daily functioning, including anxiety, depression, and speech understanding in noisy environments. Understanding these relationships is crucial for developing effective interventions for tinnitus and related symptoms.

Clinical assessment for individuals with speech anxiety in noise should address both hearing sensitivity and the presence of tinnitus. Future studies of speech in noise should include cognitive testing and neuroimaging to disentangle the contribution of cognitive factors, such as cognitive control, to speech in noise in tinnitus.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Tuğba Ural;* ***Design:*** *Tuğba Ural, Büşra Nehir Şahin, Işılay Öz;* ***Control/Supervision:*** *Işılay Öz;* ***Data Collection and/or Processing:*** *Tuğba Ural, Büşra Nehir Şahin, Işılay Öz;* ***Analysis and/or Interpretation:*** *Tuğba Ural;* ***Literature Review:*** *Tuğba Ural;* ***Writing the Article:*** *Tuğba Ural;* ***Critical Review:*** *Tuğba Ural, Büşra Nehir Şahin;* ***References and Fundings:*** *Tuğba Ural;* ***Materials:*** *Tuğba Ural, Büşra Nehir Şahin.*

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