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The effects of music listening time with headphones on hearing thresholds among the young population

Hülya Osmanoğlu¹ , Handan Turan Dizdar² and Azize Arzu Koçyiğit^{1*}

Abstract

Background Today, young people who listen to loud music, especially through headphones, are at an extremely high risk of noise-induced hearing loss. The aim of this study was to investigate how young people's listening habits affect their hearing thresholds. A total of 88 young adults between the ages of 18 and 25 took part in the study, 44 of whom listened to music through headphones while the others did not. The control group was exposed to white noise at 55–65 dB with the Interacoustic AC 40 Hybrid Audiometer, and people who did not use headphones and said they were not exposed to higher levels of sound than the given sample were included in the study. Participants were given a survey to assess their music listening preferences. One hundred twenty-five to 18,000 Hz air conduction hearing thresholds were assessed for all participants.

Results When the pure tone thresholds of the groups were compared, the independent t-test showed that the thresholds of the study group were significantly worse than those of the control group. Bilaterally in the 4000 Hz band and for the left ear in the 6000 Hz band ($p < 0.05$). There were also significant differences between the groups in the 14,000 Hz and 16,000 Hz bands in the right ear and the 14,000 Hz, 16,000 Hz, and 18,000 Hz bands in the left ear ($p < 0.05$). Twenty-two participants reported listening to music at a high level, 16 participants at a moderate level, and 6 participants at a very high level.

Conclusion Although the hearing thresholds of the study group were worse than those of the control group in the 4000 Hz, 6000 Hz, 14,000 Hz, 16,000 Hz, and 18,000 Hz bands, the hearing thresholds of both groups were still within the hearing range and could be classified as normal. It should be remembered that hearing will deteriorate if a person listens to loud or very loud music continuously through headphones. The public, especially young people, should be made aware of this.

Keywords Headphones, Noise-induced hearing loss, High frequency, Music, Young population

Background

Long-term exposure to noise for various reasons adversely affects hearing health and causes permanent changes in hearing thresholds [1]. Prolonged exposure to loud noise damages the hearing system and permanent hearing loss may occur. This is called noise-induced hearing loss (NIHL) [2]. Although noise-induced hearing loss is the second most common cause of acquired sensorineural hearing loss, exposure to recreational noise poses a greater risk for the young population. Many situations have emerged that damage hearing, one of which

*Correspondence:

Azize Arzu Koçyiğit
azizekocyiğit@stu.aydin.edu.tr

¹ Audiology Department, İstanbul Aydın University, İstanbul, Türkiye

² Audiology Department, Ondokuz Mayıs University, Samsun, Türkiye



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is listening to loud music through personal music players [3]. Loud sound passes through the outer and middle ear and reaches the cochlea. Hair cells in the cochlea can be damaged by loud noise. When hair cells are damaged by loud noise, the incoming signals cannot be interpreted correctly by the brain, and there is no current treatment to repair hair cells once they are damaged. The resulting hearing loss is permanent [2]. Studies have shown that continuous exposure to sounds exceeding the intensity level of 89 dB for 5 h or longer in a week leads to hearing difficulties over time [3]. The harmful effect of noise on hearing physiology increases in direct proportion depending on the intensity level of the sound and the exposure time [4]. In the findings recorded on the audiogram showing the hearing thresholds of the individual exposed to noise, hearing threshold shifts, mostly bilateral [5]. On the audiogram, especially in the 4000 Hz frequency band, there is a notch-like sensorineural hearing loss, which is defined as “acoustic notch”, or a decrease in hearing thresholds at high frequencies. While hearing loss initially occurs at high frequencies, it has been reported that as the exposure time to noise increases, noise causes permanent hearing threshold changes in speech frequencies [6]. This is an indication that unwanted, disturbing loud sounds cause irreversible permanent damage to the hair cells and synapse connections in the inner ear.

Nowadays, the frequent use of mobile phones both while talking and listening to music, especially in young people, and the increase in the use of personal music players constitute an extremely important risk factor for noise-induced hearing loss. It is stated that individuals who use personal music players with in-ear headphones to listen to music hear a sound level 5.5 dB higher than those who listen to music in the ear and in free space [6]. In addition, those who listen to music with in-ear headphones in noisy environments prefer to listen to music at a higher volume, which causes negative effects on hearing health [7].

The aim of this study is to determine the effects of young people’s music listening habits on both speech frequencies and hearing threshold levels at high frequencies.

Methods

Eighty-eight young adults between the ages of 18–25 participated in the study. The participants were divided into two groups according to their use of headphones while listening to music, 44 participants who listened to music with headphones and 44 participants who did not listen to music with headphones were included in the study voluntarily and the study and control groups were formed. Torre [8], in his study examining the output level settings of personal music systems in young adults,

reported that the average values of listening to music at low, medium, high, and very high levels were 62.0, 71.6, 87.7, and 97.8 dB SPL, respectively. Based on the values in this study, in our study, sounds of 54 dB and below were considered very low, 55–64 dB were considered low, 65–74 dB was considered medium, 75–84 dB was considered high, and 85–100 dB was considered very high. Both the control and study groups listened to 55–65 dB white noise using supra-aural headphones from the audiometer in our clinic. The possibility of the control group being exposed to acoustic trauma due to listening to music from devices such as radio, tape recorder, and TV, other than personal headphones was taken into consideration. For this reason, those who listened to white noise at 55–65 dB from the Interacoustic AC 40 Hybrid audiometer and stated that they listened to music with a higher intensity than this were not included in the control group. Those who stated that they listened to music at a level higher than 55–65 dB using personal headphones were included in the study group. In order to determine at what level of music the study group participants were listening to, white noises at 65–74 dB, 75–84 dB, and 85–100 dB were played through the audiometer with supraaural headphones for five seconds, and the level they indicated was recorded. Then, to confirm the answer given by the participants, the sounds were played again five minutes later, and the level at which they gave the same answer was determined as the level at which they listened to music. Individuals with a family history of permanent hearing loss, vestibular complaints, a history of acoustic trauma, any otoneurological disorder, conductive hearing loss, and those without bilateral type A tympanometry tests were not included in the study.

A questionnaire was applied to the participants first, and then audiological tests were performed in a single-walled, double-chambered silent cabin. The survey form used in the research was created by taking the survey form of Başkent University as a reference, and the survey questions of the studies published in international periodicals were used [6]. Permission to use the questionnaire was obtained from the author via e-mail. There are 12 questions in the questionnaire about demographic information and music listening habits. With these questions, data were collected on whether there is a relationship between young adults’ music listening habits, preferred sound levels, weekly-daily music listening times, music listening attitudes, and hearing complaints.

In the pure tone audiometry (Interacoustic AC 40 hybrid) test, the frequency range of 125–8 kHz was evaluated with TDH-39 supraaural headphones. In addition, air conduction hearing thresholds were evaluated using DD450 circumaural headphones in the high-frequency bands of 10,000, 12,400, 14,000, 16,000, and 18,000 Hz.

The findings were analyzed in the SPSS 22.0 package program. In descriptive statistics, mean and standard deviations ($X \pm SD$), minimum and maximum values of continuous quantitative variables are given. Frequency and percentage values are given for qualitative variables. The conformity of the quantitative data to the normal distribution was determined by the Shapiro–Wilk test. While evaluating the differences between groups in the evaluation of quantitative variables, an independent t -test was used for comparisons since the data showed normal distribution. In the evaluation of quantitative variables, the data were evaluated with the ANOVA test as they showed normal distribution. Since the variances were equally distributed in the post hoc evaluations after the ANOVA evaluation, the LSD test was used. The statistical significance level in the evaluations was accepted as $p \leq 0.05$.

Results

The gender and age distributions of the participants are shown in Table 1. In the control group, 30 women and 14 men who did not use headphones to listen to music;

36 women and 8 men who used headphones to listen to music were included in the study group. The mean age of the study group was 21.80 ± 0.90 and that of the control group was 21.97 ± 1.22 . There was no significant difference in gender and age distribution between the groups ($p > 0.05$).

Figure 1 shows the averages of pure tone thresholds of the groups by performing the Independent t -test. There was a significant difference between the groups in bilateral 4000 Hz ($p = 0.00$) and left ear 6000 Hz ($p = 0.00$) frequency bands ($p < 0.05$). Bilateral 14,000 Hz and 16,000 Hz ($p = 0.00$) and 18,000 Hz in the left ear ($p = 0.05$), there were statistically significant differences between the groups ($p \leq 0.05$). It was observed that the hearing thresholds of the study group were significantly worse than the hearing thresholds of the control group at these frequencies where the difference was obtained. There was no significant difference between the groups at other frequencies ($p > 0.05$).

Figure 2 shows which devices the study group used while listening to music. Twenty-six participants reported using the telephone, 17 participants both computer and telephone, and 1 participant reported using IPOD. It was observed that other devices were not used by the participants.

Figure 3 shows the distribution of earphone types used by the study group while listening to music. Thirty-six participants reported using in-ear headphones (small headphones that fit snugly into the ear canal and resemble earplugs), 3 participants using both ear-covering (headphones that cover the ear with a pillow and cover the ear from above) and in-ear headphones, 2 participants using in-canal headphones

Table 1 Gender and age distribution of the participants

Groups	Gender		Age
	Female	Male	
Study group ($X \pm SD$ - n (%))	36 (81.81%)	8 (18.19%)	21.80 ± 0.90
Control group ($X \pm SD$ - n (%))	30 (68.18%)	14 (31.42%)	21.97 ± 1.22
P	0.221		0.440

X Mean, SD Standard deviation, n Number, % Percentage

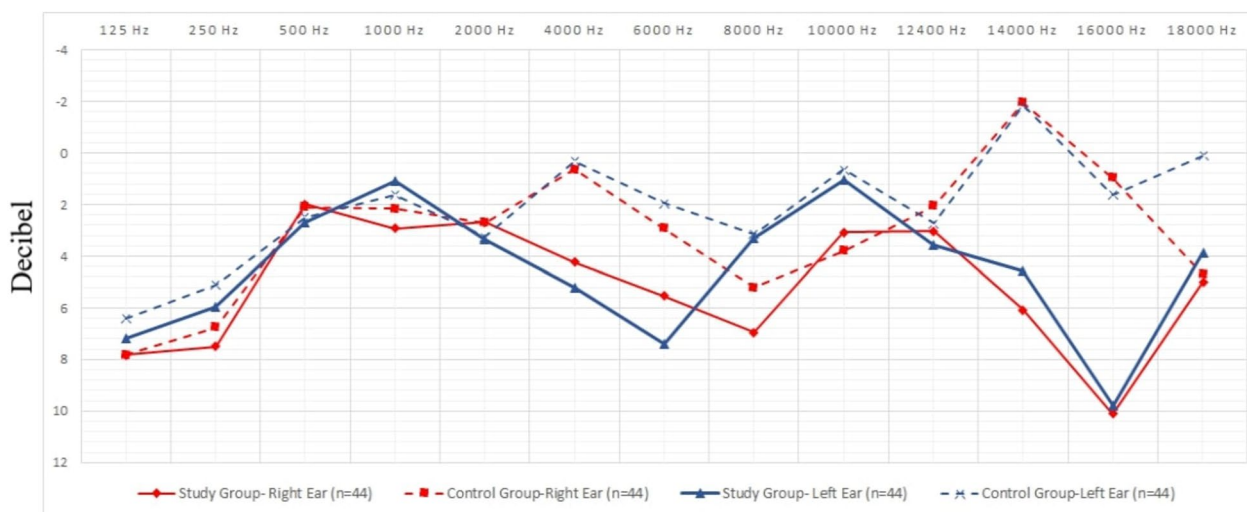


Fig. 1 Averages of 125–18,000 Hz air conduction hearing thresholds of the study and control groups

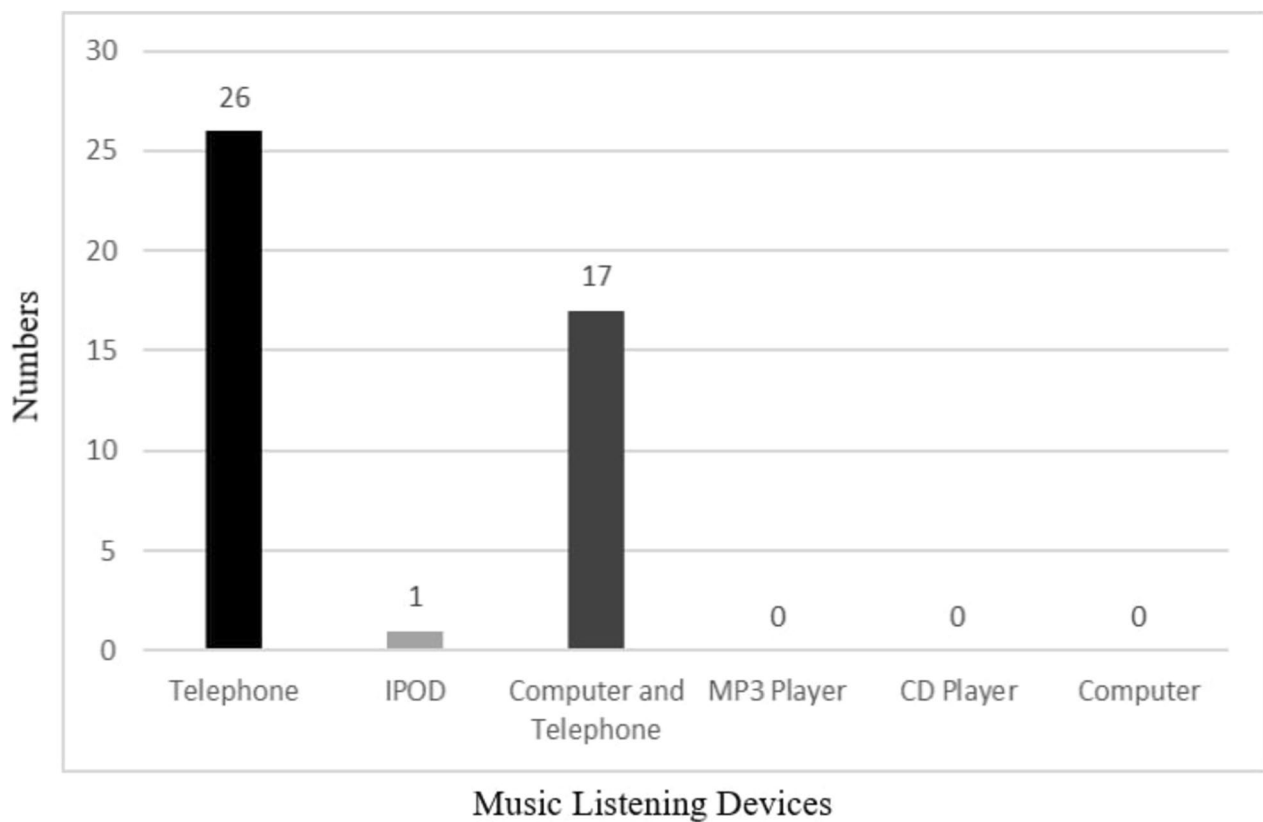


Fig. 2 Distribution of the devices used by the study group while listening to music

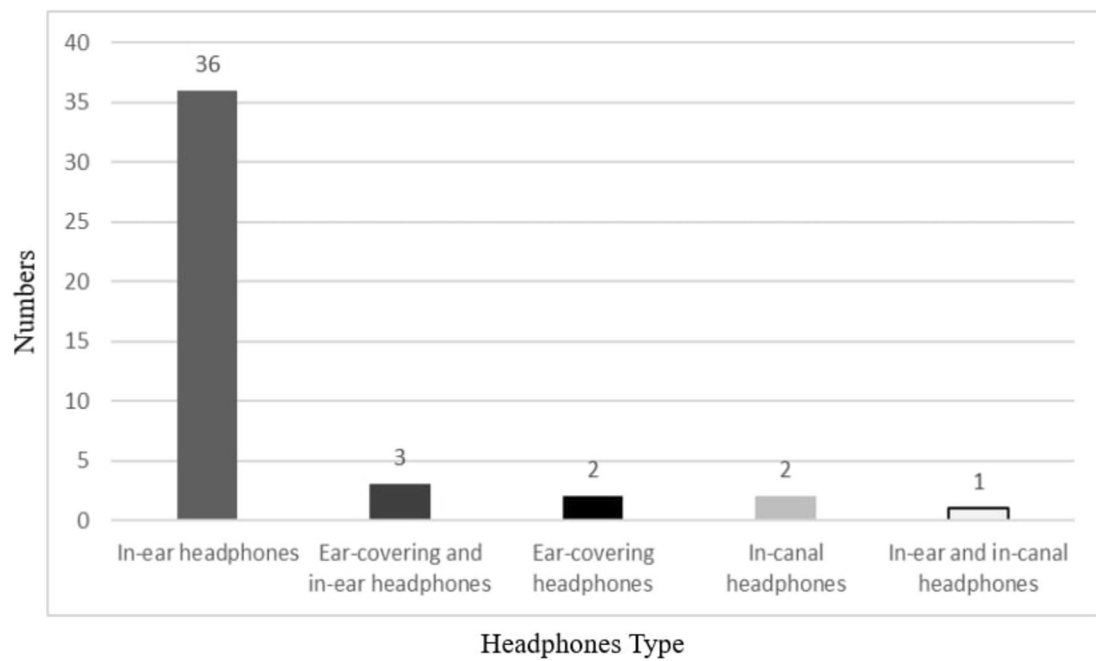


Fig. 3 Distribution of headphone types used by the working group

(headphones that fit into the ear canal at a certain depth), 2 participants using ear-covering headphones, and 1 participant using both in-ear and in-canal headphones.

Figure 4 shows the music listening levels of the study group. Twenty-two participants reported listening to music at a high level (75–84 dB), 16 participants at a medium level (65–74 dB), and 6 participants at a very high level (85–100 dB). It was observed that none of the participants listened to music at very low and low volume levels.

Table 2 shows the music-listening status of the study group. When it was examined at which times they listened to music during the day, it was observed that there were 16 participants (36.4%) during the study, 36 participants (81.8%) when traveling in and out of the city, 20 participants (45.5%) when playing sports, 28 participants (63.6%) when relaxing at home, 1 participant (2.3%) at other times. Two participants (6.8%) listen to metal, 20 participants (45.5%) rock, 39 participants (88.6%) pop, 18 participants (40.9%) classical music, 12 participants (27.3%) Turkish folk music, 10 participants (22.7%) Turkish art music, 12 participants (27.3%) hip hop, and 3 participants (6.8%) listen to music in other music types. While 23 (52.3%) participants had no problems after listening to music with headphones, it was determined that ear congestion occurred in 5 (11.4%) participants, tinnitus occurred in 8 (18.2%) participants, headache occurred in 5 (11.4%) participants, feeling fullness occurred in 7

(15.9%) participants, loud noise intolerance problems occurred in 5 (11.4%) participants. There were 7 (15.9%) participants who stated that they had difficulty hearing when someone from outside called out, and 4 (9.1%) participants who stated that they had difficulty listening to the teacher in the classroom. It was observed that there were 18 (40.9%) participants who increased the volume of devices such as TV and radio, and 4 (9.1%) participants who were disturbed by high-pitched sounds. In the study group, there are 34 (77.3%) participants who turn up the volume of music when they encounter a noisy environment, and 6 (13.6%) participants think that they have had a hearing problem in the last 1 year.

In Table 3, the listening status of the study group with headphones is given on a weekly, hourly, and annual basis. According to the results obtained, it was seen that the study group listened to music for an average of 7.67 ± 3.13 years, 5.14 ± 2.16 days a week, 2.18 ± 1.42 h a day.

The analysis of the music listening levels of the study group according to the daily, hourly, and annual music listening times was made with the ANOVA test and is shown in Table 4. In the findings, a significant difference was observed on an annual basis according to music listening levels ($p < 0.05$). There was no significant difference in listening to music based on day and hour ($p > 0.05$).

LSD posthoc analysis was performed because there was a significant difference between the music

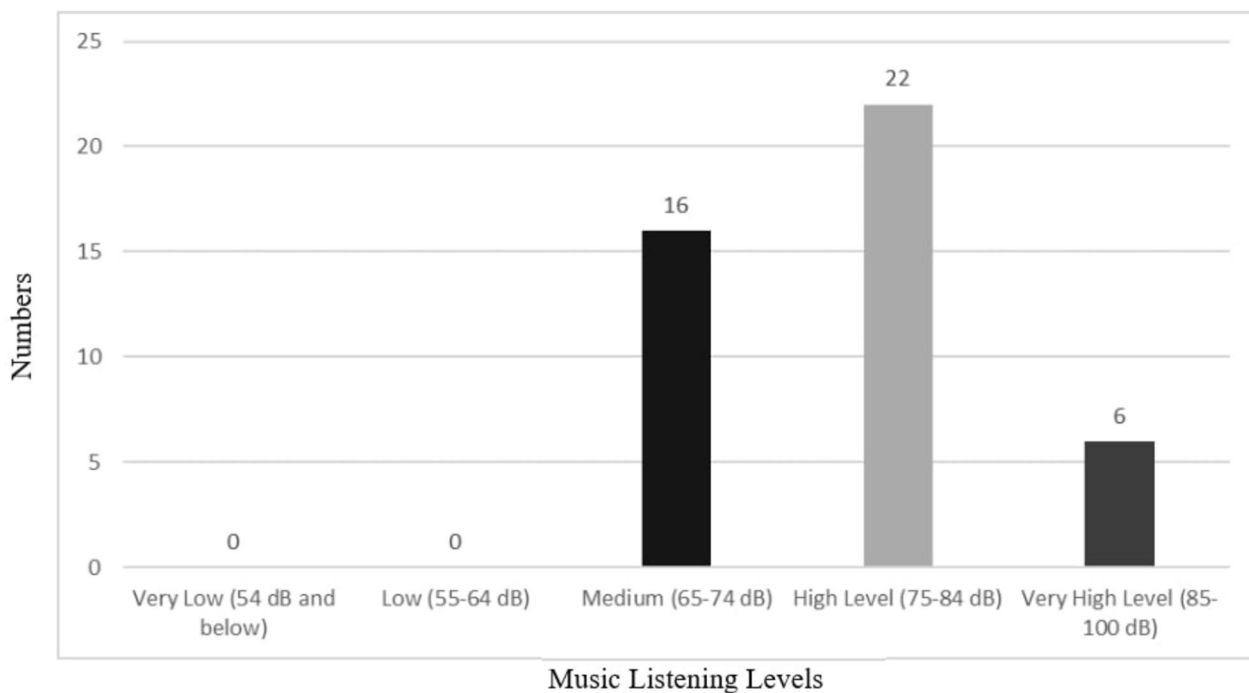


Fig. 4 Music listening levels of the study group

Table 2 Music listening situations of the study group

	Yes (n-%)	No (n-%)
What time of day do you use headphones to listen to music?		
Working (lecture, office)	16 (36.4%)	28 (63.6%)
Traveling in and out of the city	36 (81.8%)	8 (18.2%)
Doing sports	20 (45.5%)	24 (54.5%)
While relaxing at home	28 (63.6%)	16 (36.4%)
Other	1 (2.3%)	43 (97.7%)
What type of music do you usually listen to?		
Metal	2 (6.8%)	42 (93.2%)
Rock	20 (45.5%)	24 (54.5%)
Pop	39 (88.6%)	5 (11.4%)
Classical music	18 (40.9%)	26 (59.1%)
Turkish folk music	12 (27.3%)	32 (72.7%)
Turkish art music	10 (22.7%)	34 (77.3%)
Hip Hop	12 (27.3%)	32 (72.7%)
Other	3 (6.8%)	41 (93.2%)
Do you feel any problems while listening to or after listening to music with headphones?		
Ear congestion	5 (11.4%)	39 (88.6%)
Tinnitus	8 (18.2%)	36 (81.8%)
Headache	5 (11.4%)	39 (88.6%)
Feeling of fullness	7 (15.9%)	37 (84.1%)
Intolerance to loud noise	5 (11.4%)	39 (88.6%)
No problem	23 (52.3%)	21 (47.7%)
Have you experienced any of the following problems in the last 1 year?		
Did you find it difficult to hear what is calling out to you?	7 (15.9%)	37 (84.1%)
Did you have difficulty hearing the teacher in class?	4 (9.1%)	40 (90.9%)
Does it happen when you turn up the volume while listening to devices such as TV or radio?	18 (40.9%)	26 (59.1%)
Do you have trouble hearing high-pitched sounds such as the TV, doorbell, and child and female voices?	4 (9.1%)	40 (90.9%)
Do you turn up the volume of the music when you encounter a noisy environment?	34 (77.3%)	10 (22.7%)
Do you think there is a problem with your hearing in the last 1 year compared to the past?	6 (13.6%)	38 (86.4%)

n Number, % Percentage

Table 3 Duration of listening to music with headphones of the study group

	Min-max	$\bar{X} \pm SD$
How many days a week do you listen to music with a music player? (day)	0-7	5.14 ± 2.16
How many hours a day do you listen to music with headphones on average? (hour)	0-7	2.18 ± 1.42
How many years have you been listening to music with headphones? (year)	0-15	7.67 ± 3.13

\bar{X} Mean, *SD* Standard deviation, *Min* Minimum, *Max* Maximum

listening levels of the study group in year-based music listening times and the variances were homogeneously distributed (Table 5). According to the results, the year-based music listening time of those who listen to

very high-level music is significantly longer than the year-based music listening time of those who listen to medium-level music ($p < 0.05$). There was no significant difference between other findings ($p > 0.05$).

Table 4 Comparison of the music listening levels of the study group according to the duration of listening to music

Questions about music listening times	Music listening levels			P
	Medium 65–74 dB (X±SD)	High (75–84 dB) (X±SD)	Very High (85–100 dB) (X±SD)	
How many days a week do you listen to music with a music player? (day)	4.31 ± 2.55	5.41 ± 1.92	6.33 ± 1.03	0.103
How many hours a day do you listen to music with headphones on average? (hour)	1.69 ± 1.08	2.36 ± 1.36	2.83 ± 2.14	0.169
How many years have you been listening to music with headphones? (year)	6.36 ± 3.43	8.27 ± 2.94	9.67 ± 1.63	0.050*

X Mean, SD Standard deviation

* P ≤ 0.05

Table 5 Examining the working group's listening time to music by year

	Mean differences	P
Medium (65–74 dB)		
High (75–84 dB)	–1.83	0.071
Very high (85–100 dB)	–3.35	0.023*
High (75–84 dB)		
Medium (65–74 dB)	1.83	0.071
Very high (85–100 dB)	–1.52	0.275
Very high (85–100 dB)		
Medium (65–74 dB)	3.35	0.023*
High (75–84 dB)	1.52	0.275

* P ≤ 0.05

Discussion

In our study, the effect of listening to music with headphones on hearing thresholds was investigated. It was observed that the study group's pure tone and high-frequency thresholds were worse than the control group, even though they were within normal hearing limits in certain frequencies. This may be an indication that listening to music with headphones will negatively affect hearing in the future. In a study where the hearing thresholds in the 250–8000 Hz frequency bands were evaluated by pure tone audiometry test in 122 students aged between 23–30, 61 of whom used a personal musical instrument with headphones and 61 of whom did not have headphones, a strong relationship was found between daily music listening times and hearing thresholds. It has been reported that 36.06% of students listening to music with headphones have hearing loss [9]. In a review study, it was reported that hearing loss, tinnitus, and hyperacusis occur as a result of listening to loud music and exposure to other noises in individuals with initially normal audiometric thresholds [10]. These results may support the results of our study. In another study, the music listening habits and preferred sound levels of the Swedish youth with normal hearing and those with severe-to-severe congenital hearing

loss who use hearing aids were evaluated by applying a questionnaire and comparisons were made by testing their hearing thresholds. The study results showed that the deaf group had been listening to music at a significantly higher level for a very long time. Although it is seen that the habit of listening to loudness causes a worsening of hearing function in both groups, it is stated that the findings are alarming, especially for the hearing loss group [11]. In a thesis study conducted at Örebro University (Sweden), 15 participants between the ages of 16–20 were included, and questionnaires were administered to participants with severe to profound congenital hearing loss, and their personal musical device usage habits, attitudes towards noise were determined, and hearing loss was determined by pure tone audiometry. Thresholds were evaluated. Hearing thresholds were evaluated in 2010, the tests were repeated in 2017, and the progression of hearing loss in the right and left ears of 10 participants was found to be statistically significant. This progression in hearing loss has been observed especially at high frequencies (3–8 kHz) [12]. This result supports our prediction that our participants, who do not currently have enough damage to cause hearing loss, may have hearing loss in the future.

Although it is stated in the literature that acoustic trauma is mostly seen in the 4 kHz region, permanent threshold shift can be seen in the 3000 and 6000 Hz frequency bands [13]. For this reason, it may be important for early diagnosis to include the 3000 and 6000 Hz frequency bands, which are not often evaluated in routine audiometric examination because they are intermediate frequencies, and also high frequencies in individuals with a history of acoustic trauma or noise exposure.

Considering the complaints that occurred during or after listening to music with headphones, 52.3% of the participants reported that they did not experience any problems, but tinnitus ($n=5$), ringing ($n=8$), headache ($n=5$), feeling of fullness ($n=7$), and intolerance to loud noise ($n=5$) are also present. A study

conducted with 216 young adults reported that 12.9% of the participants experienced tinnitus after listening to music [14]. In a survey study investigating the effects of mobile phones and musical instruments, 153 medical school students aged 19–25 were applied and as a result, 60 students (39.2%) reported loss of concentration, 42 students (27.4%) had discomfort, 22 students (14.4%) had tinnitus, 22 students (14.4%) had hearing loss, 7 students (4.6%) had negative symptoms and complaints such as a feeling of warmth in the ear [15]. A study of call center operators aged 18–40 reported headaches, otalgia, tinnitus, and other hearing-related symptoms. The literature and our study show that listening to music/using headphones causes a lot of discomfort in people [16].

In our study, it was observed that the study group listened to music for an average of 7.67 ± 3.13 years, 5.14 ± 2.16 days a week, 2.18 ± 1.42 h a day. Considering the age of the participants, it is seen that they have been listening to music with headphones since adolescence. When the levels of listening to music with headphones are examined, 16 participants (36.4%) listen to music at a medium level, 22 participants (50%) listen to music at a high level, and 6 participants (13.6%) listen to music at a very high level. It has been determined that they have been listening to music for more years than those who listen to music at a higher level. None of the participants listen to music at low or very low levels. The fact that those who listen to music at very high levels have been listening to music for more years also explains the significant decrease in high frequencies. Two hundred forty-five students (113 females and 132 males, aged 21.5 ± 2.18) from three universities participated in a study to raise awareness among young adults in Jordan about the impact of loud noises on hearing and effective ways to protect the ears. They completed a 19-question questionnaire targeting hearing health. Examining the weekly music listening times of the participants in terms of hours, it was found that 29% listened to music for 1–5 h, 16% for 6–10 h, 18% for 11–15 h, 19% for 16–20 h, and 18% for 20 and above hours [17]. As the exposure to noise increases, the likelihood of hearing loss also increases. In a study that included 40 adults with normal hearing between the ages of 18–31 and randomly divided them into four groups, the safe listening time of music on the iPod Touch, a personal music listening tool, was investigated. Nearly 90% of respondents reported listening to music via their devices for more than 5 years, and 82.5% reported listening to their devices three or more times a week. Most participants (85%) reported listening to music for ≥ 3 h per week, seven participants reported listening to music for ≥ 3 h continuously in an environment, and the remaining participants listened

to music for ≤ 2 h in an environment. More than 75% of participants reported experiencing a variety of auditory symptoms after listening to music, such as ringing, fullness in the ears, hearing loss or muffled hearing, pain in the ears, limited concentration, or decreased tolerance to certain environmental sounds. It has also been reported that listening to music on iPod Touch at 100% volume for as little as 30 min causes a temporary threshold shift and worsening of otoacoustic emissions, posing a risk of auditory damage [18]. In 2016, a systematic review study was conducted on the problems caused by the level and dose of listening to music that adolescents and young adults are exposed to with individual listening devices, and in 26 of them, it was reported that the pure tone audiometry and emission findings in individuals defined as normal hearing gradually worsened. It was reported that the preferred listening levels of 58.2% of the participants in the studies exceeded the recommended daily noise dose by 100%, and because the volume was increased when there was background noise, there was a positive correlation between the background noise and the preferred listening level, and the duration of listening to music and their attitudes affected hearing health [19].

There have been many audiological and non-audiological studies showing the negative effects of noise on human health [20]. In the literature, audiological problems due to acute exposure to loud noise or prolonged exposure to loud noise with personal musical instruments; temporary and permanent threshold shifts in hearing thresholds, as well as temporary or permanent tinnitus (ringing) have been reported [21, 22]. In another comparative study conducted on the young population who listen to music with their individual devices (58 participants between the ages of 16–26), the group of 29 participants who routinely listen to music for 3–4 h with their individual devices every day and the control group of 29 participants who do not listen regularly; SPL (sound pressure level), hearing thresholds, speech comprehension scores in noise and silence, otoacoustic emission findings were checked and they were asked to spend 15 days without listening to music, and test repetitions were made after this time. It has been evaluated whether the negative results caused by listening to loud music are temporary or permanent. The results of the study showed that the hearing of the group that routinely listens to music is weaker than the control group and this negative effect is permanent. It has been reported that routinely listening to music with headphones at high volume levels causes permanent damage to both the peripheral and central hearing systems [23].

An important limitation of our study is that emission tests were not included in the evaluation of hearing.

Conclusion

Although the pure tone averages of the study and control group members were within normal limits, the hearing thresholds of the study group were found to be worse than the control group in the frequency bands of 4000 Hz, 6000 Hz, 14,000 Hz, 16,000 Hz, 18,000 Hz. This supports the view that listening to loud music is a risk factor for hearing health. Considering the young age of the participants, it should be kept in mind that the hearing thresholds may worsen in the future, especially in the group that listens to loud and very loud music. It is important for early diagnosis to routinely evaluate the 3000 and 6000 Hz frequency bands, which are not often evaluated in routine audiometric examination because they are intermediate frequencies, as well as high frequencies in individuals with a history of acoustic trauma or noise exposure.

It may be helpful to educate and raise awareness among the youth by demonstrating concretely with test results that listening to loud music with headphones for a long time causes permanent damage to their hearing thresholds. For this purpose, it is recommended that awareness training be added to the curriculum of the National Education at regular intervals in order to protect the hearing health of children and young people. In addition, it is recommended to conduct studies examining the relationship between daily talk time and mobile phones in Bluetooth and wired headset users. An extensive evaluation on the basis of frequency can be conducted with otoacoustic emission tests, and the relationship between the sound intensity level and the length of listening to music with headphones can be investigated.

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Authors' contributions

Conceptualization: HO. Data curation: HO and AAK. Formal analysis: AAK. Investigation: all authors. Methodology: HO, HTD. Project administration: HO. Resources: HO. Supervision: HO and HTD. Visualization: all authors. Writing—original draft: HO, HTD. Writing—review and editing: all authors. Approval of final manuscript: all authors.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was created in accordance with the principles of the Helsinki Declaration of Human Rights. It was examined in the ethics committee meeting held on 02.12.2021 in the Non-Interventional Clinical Research Ethics Committee of Biruni University and it was decided to be ethically appropriate (Decision No: 2021/63-08). A voluntary agreement form from the participants was collected before the research data collection process began, including the aims of the study as well as the time and location of the hearing tests.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

- Mülazımoğlu S, Büyükatalay ZÇ (2022) Gürültüye bağlı İşitme Kaybı ve Tanısı. In: Yılmaz O, Yılmaz N (eds) Gürültüye Bağlı İşitme Kayıpları, 1st edn. Us Akademi, Türkiye, pp 47–52
- American Speech-Language-Hearing Association (2019) Noise. <https://www.asha.org/siteassets/ais/ais-noise.pdf>. Accessed 16 Nov 2023
- Imam L, Hannan SA (2017) Noise-induced hearing loss: a modern epidemic? *Br J Hosp Med* 78(5):286–290
- Rabinowitz PM, Galusha D, Dixon-Ernst C, Slad MD, Cullen MR (2007) Do ambient noise exposure levels predict hearing loss in a modern industrial cohort? *OEM* 64(1):53–59
- Gan WQ, Moline J, Kim H, Mannino DM (2016) Exposure to loud noise, bilateral high-frequency hearing loss and coronary heart disease. *OEM* 73(1):34–41
- Tanrikulu N, Şenkal ÖA, Aydın E, Özlüoğlu L, Tekindal MA (2013) Üniversite Öğrencilerinin Kulaklıkla Müzik Dinleme Alışkanlıklarının İşitme Eşikleri Üzerine Etkisi: Başkent Üniversitesi Örneği. *KBB ve BBC Dergisi* 21(3):93–103
- Hodgetts WE, Rieger JM, Szarko RA (2007) The effects of listening environment and earphone style on preferred listening levels of normal hearing adults using an MP3 player. *Ear Hear* 28(3):290–297
- Torre PIII (2008) Young adults' use and output level settings of personal music systems. *Ear Hear* 29(5):791–799
- Manisha N, Mohammed NA, Somayaji G, Kallikkadan H, Mubeena D (2015) Effects of personal music players and mobiles with ear phones on hearing in students. *IOSR J Dent Med Sci* 14(2):31–35
- Pienkowski M (2021) Loud music and leisure noise is a common cause of chronic hearing loss, tinnitus and hyperacusis. *Int J Environ Res Public Health* 18(8):4236
- Widén SE, Möller C, Kähäri K (2018) Headphone listening habits, hearing thresholds and listening levels in Swedish adolescents with severe to profound HL and adolescents with normal hearing. *Int J Audiol* 27:1–7
- Magnusson V (2017) Headphone use, hearing and listening levels in young people with hearing loss a comparison between the ages of 17 and 24. Dissertation, University of Örebro, Sweden
- Golmohammadi R, Ziad M, Atari SG (2006) Assessment of noise pollution and its effects on stone cut industry workers of Malayer District. *Iran Occup Health* 3(1):23–27
- Torre PIII, Reed MB (2019) Risk factors for distortion product otoacoustic emissions in young adults. *Appl Sci* 9(8):1608
- Feroz Z, Kondeti A, Raju MRK, Murty M (2016) Effect of cell phones and music systems in medical students. *Int J Contemp Med* 3(11):3374–3375
- Olagbemi DOO, Asoegwu CN, Somefun AO, Nwawolo CC (2022) Otologic symptoms and hearing thresholds among a cohort of call center operators in Lagos. *Egypt J Otolaryngol* 38(1):1–6
- Alnuman N, Ghnimat T (2019) Awareness of noise-induced hearing loss and use of hearing protection among young adults in Jordan. *Int J Environ Res Public Health* 16(16):2961
- Gopal KV, Mills LE, Phillips BS, Nandy R (2019) Risk assessment of recreational noise-induced hearing loss from exposure through a personal audio system-iPod Touch. *J Am Acad Audiol* 30(7):619–633
- Jiang W, Zhao F, Guderley N, Manchaiah V (2016) Daily music exposure dose and hearing problems using personal listening devices in adolescents and young adults: a systematic review. *Int J Audiol* 55(4):197–205
- Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, Stansfeld S (2014) Auditory and non-auditory effects of noise on health. *Lancet* 383(9925):1325–1332
- Meyer-Bisch C (1996) Epidemiological evaluation of hearing damage related to strongly amplified music (personal cassette players,

discotheques, rock concerts)–high-definition audiometric survey on 1364 subjects. *Int J Audiol* 35(3):121–142

22. Kim MG, Hong SM, Shim HJ, Kim YD, Cha CI, Yeo SG (2009) Hearing threshold of Korean adolescents associated with the use of personal music players. *Yonsei Med J* 50(6):771–776
23. Hrudananda S (2016) Comparison of post exposure effect of music through personal listening device (PLD) on hearing in young adults. *Glob J Otolaryngol* 2(1):001–006

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