ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA DOI: 10.5336/healthsci.2024-105957

Smartphone-Based Audiometric Test Results on Different Mobile Phones: A Cross-Sectional Study

Akıllı Telefon Tabanlı İşitme Testlerinin Farklı Telefonlardaki Sonuçları: Bir Kesitsel Çalışma

Nidanur ÇELİK[a], Zeynep BOZALİ[a], Elif KURU[a], Özge GEDİK TOKER[a]

[a]Bezmialem Vakıf University, Faculty of Health Sciences, Department of Audiology, İstanbul, Türkiye

This study was presented as an oral presentation at the 9th International Participation Audiology Student Congress, May 6-7, 2024, Ankara, Türkiye

ABSTRACT Objective: Mobile hearing test applications allow users to assess their hearing thresholds directly on their personal phones. While numerous studies have evaluated the validity and reliability of these applications, the impact of different mobile phones on test results has not been thoroughly investigated. This study aims to investigate how mobile hearing test results vary based on the mobile phone used. **Material and Methods:** Air conduction hearing thresholds of 78 participants with normal hearing, aged 18-25 years (20.96±1.13) were determined with Hearing Test (e-audiologia.pl) and uHear applications in a quiet environment (<30 dBA), on both Android and iOS-based reference phones, as well as the participants' personal mobile phones. The results of the applications on the reference phone and the participants' phones and the results of both applications on the reference phone were compared. **Results:** The Hearing Test (e-audiologia.pl) thresholds were significantly lower than the uHear at all frequencies bilaterally ($p<0.05$). 4000-6000 Hz in the right ear and 1000, 4000, and 6000 Hz in the left ear thresholds in the Hearing Test (e-audiologia.pl) were significantly better on the reference phone ($p<0.05$). Also, in the uHear, hearing thresholds were significantly better on the reference phone at 500, 1000, and 2000 Hz bilaterally and on the participants' phones at 4000 Hz in the left ear ($p<0.05$). **Conclusion:** Mobile hearing test applications may yield varying results across different mobile phones. Manufacturers and researchers should account for these device-related variations when designing and evaluating such tests.

Keywords: Mobile applications; hearing tests; telemedicine

ÖZET Amaç: Mobil işitme testi uygulamaları, kullanıcıların kendi cihazlarını kullanarak işitme eşiklerini belirlemelerini sağlar. Çok sayıda çalışma bu uygulamaların geçerlilik ve güvenilirliğini değerlendirmiş olsa da farklı cep telefonlarının test sonuçları üzerindeki etkisi kapsamlı bir şekilde araştırılmamıştır. Bu çalışma, mobil işitme testi sonuçlarının kullanılan cep telefonuna bağlı olarak nasıl değiştiğini incelemeyi amaçlamaktadır. **Gereç ve Yöntemler:** 18-25 yaş arası normal işitmeye sahip 78 katılımcının (20,96±1,13) hava yolu işitme eşikleri, sessiz bir ortamda (<30dBA), Android ve iOS tabanlı referans telefonlarda ve katılımcıların kendi cep telefonlarında Hearing Test (e-audiologia.pl) ve uHear uygulamaları ile belirlenmiştir. Uygulamaların referans telefon ve katılımcıların telefonlarındaki sonuçları ile her iki uygulamanın referans telefondaki sonuçları karşılaştırılmıştır. **Bulgular:** İşitme Testi (e-audiologia.pl) eşikleri bilateral tüm frekanslarda uHear uygulamasından anlamlı derecede daha düşük elde edilmiştir ($p<0,05$). İşitme Testi (e-audiologia.pl) uygulamasında sağ kulakta 4000-6000 Hz ve sol kulakta 1000, 4000 ve 6000 Hz eşikleri referans telefonda anlamlı derecede daha iyi elde edilmiştir ($p<0,05$). Ek olarak, uHear uygulamasında bilateral 500, 1000 ve 2000 Hz'de referans telefonda ve sol kulakta 4000 Hz'de katılımcıların kendi telefonlarında işitme eşikleri anlamlı derecede daha iyi elde edilmiştir ($p<0,05$). **Sonuç:** Mobil işitme testi uygulamaları farklı mobil telefonlarda uygulandığında farklı sonuçlar verebilmektedir. Üreticiler ve araştırmacılar bu testleri tasarlarken ve değerlendirirken bu cihazla ilgili farklılıkları hesaba katmalıdır.

Anahtar Kelimeler: Mobil uygulamalar; işitme testleri; teletıp

According to the World Health Organization, 430 million live with a hearing loss "disability". By 2050, the number of people living with a hearing loss disability is expected to be more than 700 million.[1] In underdeveloped and developing countries, lack of awareness, limited availability of trained profession-

TO CITE THIS ARTICLE:
Çelik N, Bozali Z, Kuru E, Gedik Toker Ö. Smartphone-based audiometric test results on different mobile phones: A cross-sectional study. Turkiye Klinikleri J Health Sci. 2025;10(2):476-84.

Correspondence: Elif KURU
Bezmialem Vakıf University, Faculty of Health Sciences, Department of Audiology, İstanbul, Türkiye
E-mail: ekuru@bezmialem.edu.tr

Peer review under responsibility of Turkiye Klinikleri Journal of Health Sciences.

Received: 03 Oct 2024 ***Received in revised form:*** 25 Dec 2024 ***Accepted:*** 08 Jan 2025 ***Available online***: 16 Apr 2025

als, and expensive professional resources are barriers to early diagnosis and rehabilitation of hearing loss.[2,3]

With the increasing use of smartphones, smartphone-based applications such as smartphone-based audiometric tests are attracting more attention in healthcare services.[4] Self-administered hearing tests can be useful for individuals who do not have access to audiological services.[5] They can be used as a hearing screening tool in critical situations, including developing countries, rural areas, medically underserved areas, and situations where physical presence in health services is restricted, such as coronavirus disease-2019 health precautions.[6] It was recommended that mobile hearing tests be used as a screening tool, especially in critical populations such as the elderly and school-age children.[7,8]

More than 100 hearing test applications are available on smartphones for individuals interested in assessing their hearing status.[9] These tests are quick to perform, require no specialized expertise, and many are available free of charge.[10] In the literature, validity and reliability studies of different Android (Google LLC, Mountain View, CA, USA) and iOS (Apple Inc., Cupertino, CA, USA)-based applications have been conducted and analyzed regarding ease of use. In terms of being free, not requiring the purchase of accessories beyond the recommendation of a supported/calibrated headphone, having validity compared to clinical audiometry, having an ambient noise reduction strategy and a headphone selection strategy, allowing self-administration, and providing a qualitative description of the results with an audiogram printout, only 2 apps meet these criteria: uHearTM (Unitron, Victoria, Canada) available on iOS and Hearing Test™ (e-audiologia.pl, Radwanice, Poland) available on Android.[6,11]

Despite the established validity of these applications, the impact of different mobile phones on their results has not been investigated. Given that these hearing test applications are designed to be used on users' personal phones, it is likely that device features influence test outcomes. Since smartphones vary widely in brand and model, understanding whether hearing test results differ across devices will enhance the effectiveness of these applications as a pre-assessment tool.

It was hypothesized that the mobile phone used would affect the thresholds obtained from mobile hearing test applications. Our study aims to investigate whether iOS and Android-based hearing test applications (uHear™-Hearing Test™ e-audiologia.pl) cause changes in the results depending on the phone used in normal hearing adults determined with audiometry and the Hearing Handicap Inventory for Adults (HHIA). The secondary aim of our study is to compare the two mobile hearing test applications with each other.

MATERIAL AND METHODS

ETHICAL APPROVAL AND INFORMED CONSENT STATEMENTS

This study was conducted at Bezmialem Vakıf University, Department of Audiology, and approved by Bezmialem Vakıf University Non-Interventional Research Ethics Committee on February 21, 2023 with the decision numbered 2023/58. Individuals who volunteered to participate in the study were included, and the study was prepared following the principles of the Declaration of Helsinki. An informed consent form was obtained from each participant.

PARTICIPANTS

The study included 78 normal hearing participants aged 18-25 (20.96±1.13). Individuals with difficulties accessing and using online systems were excluded from the study. Participants were selected from the relatives of the researchers and the patients. Individuals who volunteered to participate in the study were included, and the study was prepared following the principles of the Declaration of Helsinki. An informed consent form was obtained from each participant.

PURE TONE AUDIOMETRY

Hearing thresholds were assessed in all individuals using a calibrated Madsen Astera 2 audiometer (Otometrics©, Denmark) in the sound booth. Air conduction hearing thresholds at 125-8000 Hz frequencies were assessed using Telephonics® (Telephonics, Farmingdale, NY, USA) TDH-39 headphones and bone conduction hearing thresholds at 250-4000 Hz frequencies were assessed using RadioEar B71 (RadioEar, New Eagle, Pennsylvania) bone vibrator. Pure tone averages (PTA) were calculated by averaging air conduction hearing thresholds at 0.5, 1, 2, and 4 kHz. Individuals with PTA≤15 dB HL were included in the study.

HEARING HANDICAP INVENTORY FOR ADULTS

HHIA is a form developed by Newman et al. to determine the effects of hearing loss on the daily lives of individuals between the ages of 18 and 64.[12] There are 2 Turkish versions, a long-form and a screening version. Both forms are valid and reliable tools for clinical practice and research.[13]

The long form of HHIA used in our study consists of 24 items based on a 3-point Likert-type self-assessment. For each item, a total score was calculated by giving "no" 0 points, "sometimes" 2 points, and "yes" four points. The total score on the scale varies between 0-100. According to the scale, the higher the score of the participants, the higher the level of disability they perceive depending on the level of hearing loss. When evaluating the results, 0-16 is considered as no disability, 18-42 as mild to moderate disability, and >44 as significant disability.[13]

HHIA was converted into an online form and presented to the participants with PTA≤15 dB HL to obtain information about self-reported hearing health status. Individuals who scored 0-16 points (no disability) were included in the study.

MOBILE HEARING TESTS

Hearing Test™ (e-audiologia.pl)

The Hearing Test™ (e-audiologia.pl) application, which can be downloaded from the Google Play Store (Google LLC, Mountain View, CA, USA), evaluates at 250-500-1000-2000-4000-6000-8000 Hz hearing thresholds. The test can be performed with the bundled headphones that come with the smartphone or with external headphones. If the user uses the bundled headphones, a calibration coefficient is applied. However, which database the developers used is not disclosed or publicly available. If the user uses 3rd-party headphones, the calibration must be performed by a person with "normal hearing". Since external headphones were used in our study, biological calibration was performed on a researcher who was confirmed to have normal hearing by clinical audiometry.

The test has 3 buttons: "I can hear, I cannot hear, barely audible". Depending on the hearing status, the application changes the sound intensity in 5 dB steps when the person presses the relevant button. In this application, the stimulus is sent continuously for a few seconds. Hearing thresholds are displayed on the audiogram in dB at the end of the test. On the results screen of the application, hearing loss is graded as normal hearing=0-20 dB, mild hearing loss=21-40 dB, moderate hearing loss=41-60 dB, severe hearing loss=61-80 dB, and deafness=80 dB.[14]

uHear (Unitron)

The uHear™ application, which can be downloaded from the Apple Store or iTunes Store (Apple Inc., Cupertino, CA, USA) for Apple iOS (Apple Inc., Cupertino, CA, USA) devices [iPad or iPhone (Apple Inc., Cupertino, CA, USA)], evaluates at 500-1000-2000-4000-6000 Hz using the ten down and 5 up methods. A 267-msn pulse duration stimulus is used. For hearing loss grading, normal hearing=0 -25 dB, mild hearing loss=26-40 dB, moderate hearing loss=41-55 dB, moderate to profound hearing loss=56-70 dB, profound hearing loss=71-90 dB and profound hearing loss=90 dB.

When the person responds correctly to 2 out of three stimuli for the same intensity level, the app sets that intensity level as the threshold. The app randomizes the signal durations to avoid prediction. It automatically assesses the environmental noise before the test and allows the test to start when the appropriate condition is met. The application automatically repeats the measurement steps if the noise exceeds the defined level during the test. The uHear application does not provide hearing thresholds in dB, but the results show hearing grades for each frequency shown on the audiogram. For this reason, a scoring table was prepared and the hearing ratings for each frequency were determined in dB.[15]

Procedure

Pure Tone Audiometry and HHIA were administered to each participant, and individuals with a PTA≥16 dB and an HHIA score>16 were excluded from the study. For comparison, the reference mobile phones were Xiaomi Mi 11 Lite (Xiaomi Inc., Beijing, China) for the Android-based Hearing Test™ (e-audiologia.pl) application and iPhone 11 (Apple Inc., Cupertino, CA, USA) for the iOS-based uHear™ application. In a quiet room, mobile hearing tests were performed on both reference phones for each participant. Afterward, the Hearing Test™ (e-audiologia.pl) application was downloaded if the participant's phone was Android-based, or the uHear™ application if the participant's phone was iOS-based, and the relevant test was repeated on the participant's phone (Figure 1). All hearing tests were administered in the same room under the same conditions. Tests were performed when the ambient noise was <30 dBA.[16]

JBL Tune 510BT Multi Connect Wireless Headphone (JBL Inc., Northridge, CA, USA) with wireless connection was used in all tests to eliminate the possibility of a type of headphones affecting the test results. While choosing the headphones, it was paid attention that they were in the accessible price range and were among the most preferred headphones. Air conduction hearing thresholds were determined in both applications.[10,17] Since the Android-based application allows biological calibration before the test, biological calibration was performed by the same person with normal hearing on all Android phones to make the results more reliable. Biological calibration was performed with the Békésy audiometry specified by the application and took an average of 7 minutes.

Before the test, the participants were informed about how to use the applications and were instructed to press the relevant button on the screen every time they heard the sounds.

STATISTICAL ANALYSIS

Statistical analysis of the results was performed with IBM SPSS Statistics version 22.0 (SPSS Inc., Chicago, IL, USA) program. Mean, standard deviation, minimum and maximum values were obtained with descriptive statistics. The distribution between the groups was analyzed by Kolmogorov-Smirnov (n>50) and Shapiro-Wilk (n<50) tests and it was observed that the groups were not normally distributed. The Mann-Whitney U test was used to analyze the difference between the hearing thresholds. All analyses were performed at a 95% confidence interval and the significance level was p<0.05.

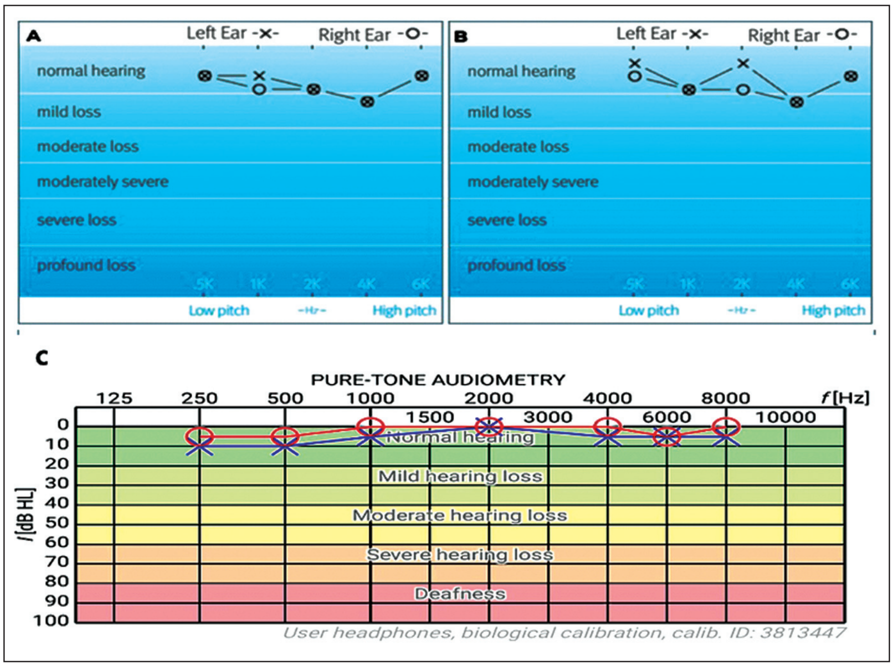

FIGURE 1: Test results of a participant obtained from iOS reference phone **(A)**, personal iOS phone **(B)**, and Android reference phone **(C)**

RESULTS

Three participants included in the reference phone comparison could not be evaluated with their phones because the application froze and did not display the results. All participants were tested with an Android reference phone and an iOS reference phone; 51 participants were tested with their personal iOS phone, and 24 were tested with their personal Android phone.

In the comparison of 78 participants and 156 ears, the hearing thresholds obtained with the Hearing Test (e-audiologia.pl) were significantly better bilaterally at all frequencies (500-1000-2000-4000-6000 Hz) than the hearing thresholds obtained with uHear (p<0.001). The means of the hearing thresholds obtained from the reference phones at all frequencies are given in Table 1.

When the results obtained from the Android reference phone and the Android users' phones were compared, a statistically significant difference was obtained at 4000-6000 Hz in the right ear and at 1000, 4000, and 6000 Hz in the left ear (p<0.05) (Table 2). At 4000-6000 Hz bilaterally, the hearing thresholds obtained on the reference phone were better than those obtained on the participant phones. Similarly, it was observed that the hearing thresholds obtained with the reference phone at 1000 Hz in the left ear

TABLE 1: Comparison of hearing thresholds from Hearing Test (e-audiologia.pl) and uHear on reference phones

		n	uHear-R	Hearing Test-R	p value
500 Hz	Right ear	78	15.96±4.19	8.14±7.43	**<0.001***
	Left ear	78	16.15±5.27	8.33±6.91	**<0.001***
1000 Hz	Right ear	78	19.74±2.40	5.44±6.98	**<0.001***
	Left ear	78	19.80±3.64	4.80±5.12	**<0.001***
2000 Hz	Right ear	78	20.12±5.09	4.80±7.22	**<0.001***
	Left ear	78	19.42±3.77	4.35±5.71	**<0.001***
4000 Hz	Right ear	78	30.12±4.69	2.30±6.72	**<0.001***
	Left ear	78	29.23±3.33	3.20±5.63	**<0.001***
6000 Hz	Right ear	78	15.00±0	4.42±6.59	**<0.001***
	Left ear	78	15.19±1.87	5.83±6.36	**<0.001***

*p<0.05; uHear-R: uHear Test results on reference phone; Hearing Test-R: Hearing Test (e-audiologia.pl) results on reference phone

TABLE 2: Comparison of hearing thresholds from Hearing Test (e-audiologia.pl) between the Android reference phone and participants' personal Android phones

		n	Hearing Test-R	Hearing Test-P	p value
250 Hz	Right ear	24	7.91±6.90	11.87±11.30	0.364
	Left ear	24	8.75±6.29	12.29±11.03	0.307
500 Hz	Right ear	24	8.54±7.58	11.87±11.68	0.375
	Left ear	24	8.33±7.01	12.29±8.59	0.079
1000 Hz	Right ear	24	6.04±6.91	8.54±10.05	0.381
	Left ear	24	5.00±5.31	8.95±8.33	**0.027***
2000 Hz	Right ear	24	6.04±6.75	8.75±9.80	0.155
	Left ear	24	4.16±6.19	7.08±9.43	0.093
4000 Hz	Right ear	24	2.50±4.66	9.37±9.00	**0.002***
	Left ear	24	4.58±5.69	9.79±8.78	**0.010***
6000 Hz	Right ear	24	4.16±4.34	11.87±10.81	**0.004***
	Left ear	24	6.45±5.61	14.37±10.96	**0.003***
8000 Hz	Right ear	24	11.25±6.95	15.00±12.06	0.547
	Left ear	24	11.87±7.19	17.50±12.42	0.089

*p<0.05; Hearing Test-R: Hearing Test results on reference phone; Hearing Test-P: Hearing Test (e-audiologia.pl) results on participants' personal phones

TABLE 3: Comparison of uHear hearing thresholds between the iOS reference phone and participants' personal iOS phones

		n	uHear-R	uHear-P	p value
500 Hz	Right ear	51	15.88±3.83	25.19±13.48	**<0.001***
	Left ear	51	16.76±6.46	24.31±13.71	**0.001***
1000 Hz	Right ear	51	19.50±2.50	25.19±10.03	**0.036***
	Left ear	51	19.70±4.05	23.33±7.56	**0.005***
2000 Hz	Right ear	51	19.60±1.68	23.13±7.99	**0.014***
	Left ear	51	19.70±3.60	23.52±7.70	**0.016***
4000 Hz	Right ear	51	29.70±2.10	30.29±6.11	0.098
	Left ear	51	28.82±3.60	23.52±7.96	**0.019***
6000 Hz	Right ear	51	15.00±0	16.17±4.19	0.052
	Left ear	51	15.00±0	15.98±4.24	0.094

*p<0.05; uHear-R: uHear test results on reference phone; uHear-P: uHear test results on participants' personal phones

were better than the thresholds obtained from the participant phones. The mean hearing thresholds obtained from the Android reference phone and the participant's phone are given in Table 2.

When the results obtained from the iOS reference phone and iOS users' phones were compared it was observed that bilateral reference phone thresholds were significantly better at 500, 1000, and 2000 Hz and the thresholds on the participants' phones were better at 4000 Hz in the left ear ($p<0.05$). The threshold averages and standard deviations of all frequencies on the iOS reference phone and participants' phones are given in Table 3.

DISCUSSION

This study evaluated the results of existing mobile hearing test applications with each other and with different mobile phone, regardless of their methods. It was observed that uHear or Hearing Test (e-audiologia.pl) applications applied to the same person from 2 different phones on the same operating system gave significantly different results at certain frequencies. In addition, comparing the thresholds obtained from the uHear and Hearing Test (e-audiologia.pl) on the same individuals, it was observed that the hearing thresholds obtained with the Hearing Test (e-audiologia.pl) application were significantly better than the uHear.

Since uHear and Hearing Test (e-audiologia.pl) are the most downloaded, widely used, valid, and free hearing test applications in the literature, these applications were preferred in our study.[6,18] Masalski et al. reported no significant difference according to traditional audiometry and Hearing Test (e-audiologia.pl).[14] The uHear test has also been confirmed by studies as a good hearing screening tool to exclude moderate hearing loss and measure the overall degree of hearing loss.[15,19]

The gold standard for audiological assessment is conducted by clinicians using calibrated equipment. In contrast, mobile hearing tests are performed on users' phones with their personal headphones. Due to the wide variety of phone models with differing speakers and the diversity of headphone types, ensuring that the tones presented in mobile tests match the accuracy of those in clinical manual audiometry is challenging.[6] Additionally, these differences may lead to variations in the results of hearing test applications across different phones or applications. This study compared the results obtained from the Android-based Hearing Test (e-audiologia.pl) and the iOS-based uHear applications. To the best of our knowledge, this is the first study to compare these 2 applications across different operating systems. In our study, the Hearing Test (e-audiologia.pl) application showed significantly better hearing thresholds than the uHear. This discrepancy may be attributed to differences in calibration methods. The Hearing Test (e-audiologia.pl) employs biological calibration when using external headphones, while uHear relies on user-defined settings, such as specifying headphone type and setting the volume level to 50% of the maximum. Calibration plays a critical role in determining accurate hearing thresholds. Failure to properly calibrate can lead to issues such as inconsistent volume scales across devices and incompatibilities between smart phone models and headphones.[6] Furthermore, several studies have reported poorer threshold values in individuals with normal hearing when using the uHear application.[20,21] One potential explanation is the 16-bit digital-to-analog converter in iPhones, which limits the dynamic range of the uHear app to approximately 85 dB (15-100 dB).[19] This limitation may also account for the higher thresholds observed in our study participants with normal hearing when using uHear.

As with traditional audiometry, the type of headphones used in smartphone-based hearing tests can also affect the results.[17,22] Barczik et al. evaluated the iPhone-based applications uHear (Unitron) and uHearingTest (WooFu Tech, LLC) with 3 different headphones (earbuds, supra-aural, circum-aural) in 22 participants. It was observed that earbuds gave the most accurate results for the uHear test, while supra-aural headphones gave the most accurate results for the uHearingTest. Accordingly, it has been suggested that manufacturers provide instructions tailored to specific earbud models for their devices. Selecting the appropriate transducer is essential for achieving accurate results.[17] In our study, all tests were conducted using the same headphones, eliminating any potential effects related to headphone variability.

Hearing tests with mobile devices in the home environment require pre-calibration of the reference sound level. Masalski et al. evaluated approximately 8,630 people using 2,040 different models of phones and headphones to determine the reference sound level for sets of mobile devices and bundled headphones. They stated that reference sound levels are not the same for each device and that reference sound levels for different device groups should be evaluated separately. Reference sound level analysis was performed between models, and statistically significant differences were found.[23] However, since the same headphones are not used in every device in this process, it is unknown whether the difference is due to different model phones or headphones. Kim and Han showed that there was a significant difference of 8 dB in sound pressure levels in 6 different smartphone models [Galaxy S6 (Samsung Inc., Korea), Galaxy Note 3 (Samsung Inc., Korea), iPhone 5S (Apple Inc., USA), iPhone 6 (Apple Inc., USA), LG G2, and LG G3 (LG Electronics Inc., Korea)] at the first risk sound level in smartphones.[24] Our study observed that the same hearing test applied on different smartphones using the same headphones may give different results. This result may be due to the different sound level outputs that may be observed in different smartphone models. Further studies on this subject are needed.

We hypothesized that different mobile phones used may affect mobile hearing test results. Our results confirmed this hypothesis. The validity and reliability studies of mobile hearing test applications are carried out on a single device and in this way, device differences are ignored. However, these tests are produced to be applied on participants' phones. Our study draws attention to this gap in the literature. Mobile hearing test manufacturers and researchers should consider these device effects on test results.

This study was conducted with normal-hearing young adults aged 18-25 years. It was designed as a baseline study to minimize variables such as cognitive status and hearing loss, enabling a clearer comparison of mobile hearing test results across different devices. However, the target population for these tests will likely differ from our study sample. Future studies involving broader age ranges and participants with hearing loss will contribute valuable insights to the literature. Hearing Test (e-audiologia.pl) measures thresholds at 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 6 kHz, and 8 kHz, which includes 2 frequencies not assessed by uHear™ (250 Hz and 8 kHz). Consequently, differences between applications at these frequencies could not be evaluated in our study. Given the effects of presbycusis and noise-induced hearing loss on high frequencies, determining 8 kHz thresholds through mobile hearing tests will be crucial in future research. Another limitation of our study was the unequal number of participants using Android and iOS devices, which may impact the generalizability of the results. Additionally, the phones of three Android users froze during testing, and their results were excluded. Technical factors such as phone specifications, timeouts, or application glitches can affect the usability and efficiency of these tests. Users should conduct hearing tests only after resolving such issues. Participants in our study used a variety of phone models with differing usage histories, highlighting the potential influence of device characteristics -such as model, usage duration, and speaker quality- on test outcomes. This is the first study to explore this issue, and future research focusing on specific device features and usage durations would provide valuable contributions.

CONCLUSION

The same mobile hearing test performed on the same individual, using the same headphones, can yield different results across devices. Additionally, hearing thresholds may vary between different mobile hearing test applications. When mobile hearing tests are used for patient follow-up, it is important to consider that results can differ depending on the application and device. Overestimation of hearing thresholds due to device-related factors may cause unnecessary stress and lead to increased visits to healthcare facilities. Future studies comparing hearing test results across applications and devices, as well as establishing correction factors based on audiometric thresholds, will provide valuable contributions to the literature.

Source of Finance

This study was supported way Research Project Grants TÜBİTAK 2209-A (project number: 1919B012221738).

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:** Nidanur Çelik, Zeynep Bozali, Elif Kuru, Özge Gedik Toker; **Design:** Elif Kuru, Özge Gedik Toker; **Control/Supervision:** Elif Kuru, Özge Gedik Toker; **Data Collection and/or Processing:** Nidanur Çelik, Zeynep Bozali; **Analysis and/or Interpretation:** Elif Kuru, Özge Gedik Toker; **Writing the Article:** Nidanur Çelik, Zeynep Bozali, Elif Kuru, Özge Gedik Toker; **Critical Review:** Elif Kuru, Özge Gedik Toker; **References and Fundings:** Nidanur Çelik, Zeynep Bozali, Özge Gedik Toker; **Materials:** Nidanur Çelik, Zeynep Bozali, Özge Gedik Toker.*

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