AUDIOLOGY

Cite as: Archiv EuroMedica. 2022. 12; 6: e1. DOI 10.35630/2022/12/6.22

Received 19 September 2022;
Published 12 December 2022

AUTOMATED HEARING ASSESSMENT: OUR EXPERIENCE

***Valentin Popadyuk*[1], *Irina Zelenkova* [1,2], *Alexander Pashkov*[2,3], *Polina Mikhalskaia*[1]**

[1]*Peoples' Friendship University of Russia, Moscow;*
[2]*Research Institute of Pediatrics and Children's Health, Petrovsky National Research Centre of Surgery, Moscow;*
[3]*Central State Medical Academy of Department of Presidential Affairs, Moscow, Russia*

download article (pdf)

Polinamikhalskaia@gmail.com

ABSTRACT

The possibilities of hardware complex and its application to test the auditory function in children and adolescents were studied. We also determined the diagnostic value of various solutions for hearing testing (relationship with the results of the clinical test of pure tone audiometry). Examined group of children and adolescents included 70 people. A comparison of the results of hearing testing using via software and hardware complex and the Hearing Test application were carried out.

The studied screening methods have been focused on the possibility of audiological evaluation without visiting hearing health care services.

Keywords: analysis of auditory function, students, children, adolescents, hearing disorders

INTRODUCTION

The growing trend of digital medical services enables receiving certain types of prompt assistance. Automatic audiometry can be an example of such a service, underlying the use of software products or devices to record sound thresholds, which is one of the indicators of hearing status. The review on the automation of audiometry [1] describes the principle of such a study, when the patient signals via the device button or application screen area if he hears a sound signal. In this case, the research algorithm has a trend of increasing or decreasing signal intensity when changing the frequency of the sound tone. An important condition is the use of full-size ear pads ("headphones") with full ear shell coverage for a refined level of ambient noise, which makes it possible to perform a test in a quiet room, rather than in a soundproof environment.

Manufacturers of such equipment have proposed developments that are not a medical product. Hence, they can be used outside a medical institution, for example, in schools, increasing the availability of the service. Further development of the availability of such technology has led to the development of online platforms and applications for smartphones or tablets, making possible to test your hearing yourself [2-5].

MATERIALS AND METHODS

To assess the accuracy of the test methods under study, we compared the results of an automated test, a specialized application, and tone threshold audiometry, where the clinical method of audiometry was chosen as the gold standard.

The study involved 70 school children (n=140 ears) aged 7 to 17 years (mean =12.3±3.46); among them

girls - 42.9% (n=30), boys - 57.1% (n=40). The main cohort of subjects consisted of 50 normally hearing students (n=100 ears). The study identified 20 patients (n=40 ears) with various forms of hearing loss. Conductive hearing loss was detected in 17 children (n=35 ears), of which bilateral hearing loss was noted in 14 people (n=28 ears), unilateral hearing loss was observed in 3 patients (n=3 ears). Three students (n=5 ears) were diagnosed with sensorineural hearing loss, two of them (n=4 ears) had bilateral sound perception impairment. It should be noted that patients with hearing loss did not have active complaints of hearing loss or impairment of speech intelligibility prior to the test. They were diagnosed during the examination.

Participation in the study required the mandatory presence of signed informed consent from the legal representatives of all subjects and children over 14 years old.

Behavioral thresholds were determined in the speech frequency range using tone threshold audiometry using an AC 40 Interacoustics clinical audiometer (Denmark) in an anechoic chamber. The background noise level was less than 60 decibels (dB).

Automated audiometry was performed using the Hummingbird hardware and software complex. The complex includes a two-way active speaker system (reproducible frequency range from 43 to 24,000 hertz (Hz), maximum output power 82 watts (W), sound card with built-in induction loop, USB radio receiver (connection frequency - 2.4 megahertz (MHz) , range - 10 meters (m) and a wireless remote button Acoustic stimulation at frequencies of 500, 1000, 2000, 4000 Hz was performed using headphones on the headband HD205 frequency range from 14 to 20,000 Hz, sound pressure level - 112 dB .

To assess the feasibility of a mobile solution for determining hearing thresholds, the Hearing Test-Audiologist, Ears, ENT hearing test application, developed by IT For You CORP, version 2.1.5, installed on the iPad, on the iOS 11.0 platform, in Russian. The acoustic stimulus was delivered using Sennheiser HD 206 wired headphones (reproducible frequency range from 21 to 18,000 Hz; sound pressure level, 108 dB).

An analysis was made of a sample of 30 patients (n=30), obtained using a random number generator from a total sample of 70 children (n=140 ears) who did not complain of hearing loss (n=140). The age of the subjects varied from 7 to 17 years old (Mean=12.27±3.27). In the distribution by gender in the study sample (n=30), girls accounted for 53.3% (n=16), boys - 46.7% (n=14).

Statistical analysis was performed using the IBM program © SPSS Statistics New Seas Subscription © version 25.0.0. The mixing method algorithm was used as a random number generator. Samples were tested for normality of distribution by calculating the one-sample Smirnov-Kolmogorov test p value ≤0.05, which confirmed the normality of the tested distribution. To test for differences between samples, the calculation of Student's t-test for paired samples was used.

RESULTS AND DISCUSSION

The results of the comparison of pure-tone threshold audiometry and the automated method in the group of normally hearing students and in students with hearing impairment are shown in Tables 1-2.

Table 1 Mean behavioral thresholds at frequencies 500-4000 Hz in normal hearing children: results of pure-tone audiometry and automated audiometry.

Method	Behavioral Thresholds			
	500 Hz	**1000** Hz	**2000** Hz	**4000** Hz
Tone threshold audiometry, dB nPC	10.4±5,4	6.5±4.6	10.11±4.6	7.82±11.3
Automated audiometry, dB NPC	41.7±10.1	24.1±6.9	22.3±6.8	25.6±4.6
Mean Difference	31.3	17.6	12.2	17.7

Table 2. Mean behavioral thresholds at frequencies of 500-4000 Hz in patients with hearing loss: results of pure-tone audiometry and automated audiometry

Method	Behavioral Thresholds**, ±**			
	500 Hz	**1000**Hz	**2000**Hz	**4000**Hz

Tone threshold audiometry, dB nPC	11.4±4.23	8.17±3.6	7.5±3.1	7.7±3.4
Automated audiometry, dB NPC	43.5±8.9	23.8±6.1	15.1±7.1	19.1±8.9
Mean Difference	32.5±9.3	15.7±6,8	7.7±8.3	11.5±9.4

The assessment of hearing thresholds obtained using pure-tone threshold audiometry and the results of automatic audiometry showed a significant discrepancy in the data in the frequency region of 500 Hz, where the mean difference was 32.5±9.3 dB above the normal hearing threshold (nHL). The smallest discrepancy between the results was obtained at a frequency of 2000 Hz – 7.7±8.3.

Comparison of the data obtained using the mobile application "Test-x-Audiologist, Ears, ENT" and the results of pure-tone threshold audiometry is shown in Table 3. An almost complete coincidence of the results in terms of frequency was revealed. At frequencies of 1000 frequency, there was a slightly insignificant increase in the frequency of the results - 2.0 ± 2.8 dB nPC, which was not statistically significant.

Table 3. Mean behavioral thresholds at frequencies of 500-4000 Hz in normal hearing children: results of pure-tone threshold audiometry and the mobile application "Test-hearing-Audiologist, ears, ENT"

Method	Behavioral Thresholds			
	500 Hz	**1000** Hz	**2000** Hz	**4000** Hz
Tone threshold audiometry, dB nPC	11.4±4.23	8.17±3.6	7.5±3.1	7.7±3.4
MP "Test-hearing-Audiologist, ears, ENT", dB NPS	11.83±3.07	10.1±4.3	7.5±2.9	8.0±3.9
Mean Difference	0.83±3.9	2.0±2.8	00.0±2.6	0.33±3.7

Table 4 shows a comparison of the hearing thresholds obtained with the two screening methods studied in the study. The discrepancy between the results over the entire frequency range is noted. The largest difference in the average was found at a frequency of 500 Hz and amounted to 31.7 ± 9.1 dB fs.

Table 4. Mean behavioral thresholds at frequencies of 500–4000 Hz in normal hearing children: results of automated audiometry and the Test-Hearing-Audiologist, Ears, ENT mobile application

Method	Behavioral Thresholds			
	500 Hz	**1000** Hz	**2000** Hz	**4000** Hz
Automated audiometry, dB NPC	43.5±8.9	23.8±6.1	19.1±8.9	19.2±8.9
MP "Test-hearing-Audiologist, ears, ENT", dB NPS	11.8±3.07	10.2±4.3	10.17±4.2	8.0±3.9
Mean Difference	31.7±9.1	13.7±7.1	9.0±9.9	11.2±3.7

DISCUSSION

The automated auditory function test is a promising screening method. However, the full realization of its potential is possible only if a number of conditions are met: the equipment for automated hearing diagnostics must be reliable for conducting multiple studies, the place for installing the screening complex must be chosen taking into account the ambient background noise, which will not affect the results obtained.

Cloud technologies in screening diagnostics (based on applications for smartphone and tablet platforms) are not only highly promising, but also cost-effective, as they reduce the cost of purchasing equipment. However, they require ongoing technical support and harmonization of the collected data to ensure

continuity with clinical trials.

In general, conducting automated audiometry outside the isolation chamber imposes additional requirements on headphones; in this case, the most effective technical solution is closed-type headphones, which can provide maximum isolation from ambient noise. The application of the protocol for recording bone conduction thresholds requires additional study, since air conduction examination is sufficient to detect hearing impairment, and if a pathology is detected, further examination is carried out in a specialized department of audiology.

The developed technology can complement the arsenal of screening methods for detecting possible hearing impairments; such tests are based on the registration of electrophysiological responses of various parts of the auditory analyzer and do not depend on the age (degree of participation) of the patient in the study [7]. At the same time, hearing screening studies are not carried out at a later age, which creates the risk of sensory deprivation and delayed cognitive development of the child, even with a slight hearing loss [8]. The introduction of automated audiometry technology outside specialized medical institutions, for example, as part of a school medicine program, will contribute to the early identification of persons with possible hearing impairments and their referral for diagnosis with subsequent treatment and / or rehabilitation, which in turn minimizes medical and social losses. due to the development of deafness.

CONCLUSION

Thus, the possibility of introducing screening tests for assessing auditory function has a high potential and will ensure the earliest possible identification of persons with possible hearing loss in the target groups of children, adolescents and students directly on the territory of educational institutions, without a mandatory visit to a specialized clinic (medical organization).

CONFLICTS OF INTEREST

The authors declare no conflicts of interest

REFERENCES

1. Pashkov A.V., Naumova I.V., Zelenkova I.V., Namazova-Baranova L.S., Vishneva E.A., Voevodina K.I. Automated Audiometry as the Screening of Hearing in Schoolchildren: Literature Review and Own Experience. Current Pediatrics. 2021;20(3):245-250. https://doi.org/10.15690/vsp.v20i3/2277
2. Wasmann JW, Pragt L, Eikelboom R, Swanepoel W. Digital Approaches to Automated and Machine Learning Assessments of Hearing: Scoping Review. J Med Internet Res. 2022 Feb 2;24(2):e32581. DOI: 10.2196/32581
3. Swanepoel de W, Biagio L. Validity of diagnostic computer-based air and forehead bone conduction audiometry. J Occup Environ Hyg. 2011 Apr;8(4):210-4. DOI: 10.1080/15459624.2011.559417
4. Masalski M. et al. Self-test web-based pure-tone audiometry: validity evaluation and measurement error analysis //Journal of Medical Internet Research. – 2013. – T. 15. – No 4. – C. e2222. DOI: 10.2196/jmir.2222
5. Yao JJ, Yao D, Givens G. A Browser-Server-Based Tele-audiology System That Supports Multiple Hearing Test Modalities. Telemed J E Health. 2015 Sep;21(9):697-704. DOI: 10.1089/tmj.2014.0171
6. Govender SM, Mars M. The use of telehealth services to facilitate audiological management for children: A scoping review and content analysis. J Telemed Telecare. 2017 Apr;23(3):392-401. https://doi.org/10.1177/1357633X166457
7. Daihes N. A., Pashkov A. V., Yablonsky S. V. Methods for the study of hearing. – 2009.
8. Pashkov Aleksandr V., Namazova-Baranova Leyla S., Vishneva Elena A., Naumova Irina V., Zelenkova Irina V. Hearing Loss Effect on the Educational Process in Children and Adolescents. Voprosy sovremennoi pediatrii — Current Pediatrics. 2020; 19 (4): 272–278. DOI:10.15690/vsp.v19i4.2134

back