# KEY HEARING LOSS RISK FACTORS FOR CHILDREN, ADOLESCENTS AND YOUTH ASSOCIATED WITH USE OF MOBILE ELECTRONIC DEVICES WITH HEADPHONES

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The number of research papers about the impact electronic devices produce on the younger generation that uses them is constantly growing. This study aimed to identify the leading hearing loss risk factors for children, adolescents and youth associated with use of mobile electronic devices with headphones In the 2017–2021 academic years, we surveyed 518 students in Moscow and 1000 schoolchildren and students in the towns of Izhevsk and Tchaikovsky. The survey was designed to collect data on the conditions in which the respondents use mobile electronic devices with headphones, design features of the headphones used and their hearing health status. The inclusion criteria were: status of a schoolchild, student, signed and submitted informed consent form, questionnaire correctly completed by the respondent or his/her legal representative, one or more years of using mobile electronic devices. The conducted study does not endanger the participants and complies with the biomedical ethics requirements. Statistica 13 PL software was used for statistical processing of the data collected. Fourteen percent of the respondents reported hearing deterioration in the course of the last year. Prolonged use of mobile electronic devices with headphones increases the risk of hearing loss by 10.4 times, listening to audio files at maximum volume — by 3.2 times, listening to audio files while in a moving vehicle — by 7.1 times. Most schoolchildren and students with hearing impairments have been using headphones for at least a year, preferred in-ear headphones with silicone tips, used them at maximum volume daily, for more than two hours a day, including while in a moving vehicle. The recommendations for students and schoolchildren is to limit the time of use of their electronic devices with headphones and use them at a lower volume; complying with the recommendations can improve the functional state of their health. It is also recommended not to use headphones while in a moving vehicle. If hearing begins deteriorating, it is necessary to cease using mobile electronic devices with headphones. Today, schoolchildren and students are exposed to the hearing impairment risks associated with use of mobile electronic devices with headphones, which makes the search for the most efficient ways of forming healthy lifestyle habits among them even more urgent.

**Keywords:** schoolchildren, students, mobile electronic devices

**Author contribution:** Pavlova GV — research supervisor, article authoring; Markelova SV, Martiusheva VI — collection of material, statistical processing, literature analysis.

**Compliance with ethical standards:** this study was approved by the Ethics Committee of Pirogov Russian National Research Medical University (Minutes #203 of 20.12.2020) and Ethics Committee of Izhevsk State Medical Academy of the Ministry of Health of Russia (Minutes #655 of 23.04.2019). Each participant signed a voluntary informed consent form. The conducted study does not endanger the participants and complies with the biomedical ethics requirements.

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# ВЕДУЩИЕ ФАКТОРЫ РИСКА НАРУШЕНИЙ ОРГАНА СЛУХА ПРИ ИСПОЛЬЗОВАНИИ ДЕТЬМИ, ПОДРОСТКАМИ И МОЛОДЕЖЬЮ МОБИЛЬНЫХ ЭЛЕКТРОННЫХ УСТРОЙСТВ С НАУШНИКАМИ

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В научной литературе появляется все больше публикаций о влиянии использования мобильных электронных устройств на подрастающее поколение. Целью данного исследования являлось выявление ведущих факторов риска нарушений органа слуха при использовании детьми, подростками и молодежью мобильных электронных устройств с наушниками. В 2017–2021 учебных годах было проведено анкетирование 518 студентов Москвы и 1000 школьников и студентов Ижевска и Чайковского. С помощью опроса получены данные об условиях использования мобильных электронных устройств с наушниками и конструктивных особенностях наушников, состоянии органа слуха. Критерии включения — школьник, студент, наличие подписанного информированного согласия, корректно заполненный респондентом или его законным представителем опросник, стаж использования мобильных электронных устройств — год и более. Проведенное исследование не подвергает опасности участников и соответствует требованиям биомедицинской этики. Статистическая обработка проведена с использованием Statistica 13 PL. 14,0% респондентов отметили ухудшение слуха в течение последнего года. Риск снижения слуха повышается при длительном использовании мобильных электронных устройств с наушниками в 10,4 раза, прослушивании аудиофайлов на максимальной громкости — в 3,2 раза, прослушивание аудиофайлов в транспорте — в 7,1 раз. Большинство школьников и студентов, которые имели нарушения слуха, имели стаж использования наушников не меньше года, использовали внутриканальные наушники на максимальной громкости ежедневно, длительностью более двух часов в день, в том числе и в транспорте. Учащимся рекомендуется ограничение времени и снижение громкости использования электронных устройств с наушниками, что благоприятно влияет на их функциональное состояние здоровья. Рекомендуется не использовать аудионаушники в транспорте. При появлении жалоб со стороны органа слуха необходимо прекращение использования мобильных электронных устройств с наушниками. В современных условиях у школьников и студентов существует риск нарушения слуха, связанный с использованием мобильных электронных устройств с наушниками, что делает особенно актуальным поиск наиболее эффективных форм формирования установок ЗОЖ у молодежи.

**Ключевые слова:** школьники, студенты, мобильные электронные устройства

**Вклад авторов:** Павлова Г. В. — научное руководство, написание статьи; Маркелова С. В., Мартюшева В. И. — сбор материала, статистическая обработка, анализ литературы.

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Modern mobile electronic devices — smartphones — are small but powerful computers that can continuously receive audio and video data, and the potential harm they can do is increasingly associated with the duration of use of such devices [1–5].

According to WHO, 1.1 billion young people worldwide are at risk of hearing loss because of the exposure to noise in recreational and entertainment settings. Nearly 50% of all adolescents and young adults aged 12 to 35 use their personal audio devices with sound volume hazardously high. About 15% of schoolchildren have hearing impairments [6–8].

However, current scientific literature does not have a sufficient number of publications investigating hearing hazard risk factors the younger generation is exposed to, including those related to the conditions of use of mobile electronic devices with headphones and their design features.

This study aimed to identify the leading hearing loss risk factors for children, adolescents and youth associated with use of mobile electronic devices with headphones

## MATERIALS AND METHODS

In the 2017–2021 academic years (September through May), we surveyed 518 students in Moscow and 1000 schoolchildren and students in the towns of Izhevsk and Tchaikovsky. Using a standardized questionnaire we collected data on the conditions in which the respondents use mobile electronic devices with headphones, design features of the headphones used and their hearing health status.

The inclusion criteria were: status of a schoolchild, student, signed and submitted informed consent form, questionnaire correctly completed by the respondent or his/her legal representative, one or more years of using mobile electronic devices. The exclusion criteria were: different age, lack of signed informed consent form, lack of the correctly completed questionnaire, using mobile electronic device for less than a year. The study did not endanger participants; it meets the biomedical ethics requirements and conforms to the provisions of the Declaration of Helsinki (1983).

Statistical processing of the data was enabled by Statistica 13.0 (StatSoft Inc.; USA).

## RESULTS

With the help of the questionnaire, we established the pattern of use of mobile electronic devices with headphones habitual for schoolchildren and students, as well as design features of the headphones.

By design, there are basically four types of headphones. Over-ear headphones with good noise isolation, good sound quality at a lower volume level; such headphones deliver sound into the auricle and not the ear canal, which reduces the impact on the eardrum; ear cushions of over-ear headphones completely cover the auricles and fit snugly to the head. On-ear headphones fit well to the ear but do not wrap around it completely, do not create increased sound pressure on the acoustic apparatus and have average noise isolation. In-ear headphones (earphones) with silicone tips offer good sound isolation and good sound quality at a lower volume level, but they are put into the external auditory canal, which brings the sound source as close as possible to the inner ear and affects the eardrum. Plastic in-ear headphones (also called “classic earphones”) are put in the auricle in front of the ear canal; they offer poor sound isolation, which translates into higher sound volume levels associated with their use. A design feature of the headphones that should be mentioned is the Active Noise Cancellation (also known as Active Noise Control and Active Noise Reduction) technology, which eliminates unwanted noise by adding a specially generated sound to the audio stream. The drawback of this technology is the increased pressure on the eardrums: together with music and noise, we hear “anti-noise”, i. e., inverted ambient noise.

Among the surveyed schoolchildren and students of Izhevsk and Chaikovsky, 88.2% prefer in-ear headphones with silicone tips, 8.9% use plastic in-ear headphones and 2.9% use headphones of other types. In Moscow, 95.7% of students prefer in-ear headphones with silicone tips. Headphones of 72.3% of the surveyed schoolchildren and students of Izhevsk and Tchaikovsky are wired, the remaining part of the participants use wireless headphones. On the contrary, in Moscow 71.4% of students that participated in the study use wireless headphones and the rest use wired. Ninety percent of the respondents have been using headphones for no more than 3 years. As for the noise canceling technology, 15.7% of the headphones had it.

Among the respondents, 14.1% usually listen to audio files in headphones at maximum volume.

Students have the longest experience of using mobile electronic devices with headphones: 10.2±1.5 years, while for schoolchildren this value is 7.4±0.9. It is typical for students to use mobile electronic devices with headphones in moving vehicles, while commuting; this setting adds its own specifics to the use case. Over half of the respondents (53.1%) often listen to music on electronic devices with headphones in places where the noise level is high, such as public transport and public spaces, and 49.2% of the participants underestimate the risk of doing so when in a moving transport, i. e. the risk the respective environment, with its insufficient lighting and loud noises, poses to eyes and hears. The degree of risk associated with high noise levels in transport settings is underestimated by 28.4% of students and schoolchildren. While in a moving public transport, 18% of young people listen to music on electronic devices with headphones at a volume of 8.6 ± 1.4 out of 10. The average time of using mobile electronic devices with headphones in transport settings is 17.2±1.2 minutes. Only 15.7% of respondents agree to refrain from listening to audio files in headphones when the level of ambient noise is high. Tinnitus, buzzing in ears that follows listening to audio files in headphones, is known to 22.9% of respondents.

Overall, 14.0% of the respondents mentioned hearing deterioration over the past year, and specifically among students this figure was 13.8% (Table).

Calculation of relative risk showed that the risk of hearing deterioration increases 10.4 times when mobile electronic devices with headphones are used for long periods of time, grows 3.2 times when audio files are played at maximum volume, goes up 7.1 times if listening happens in public transport settings.

There were no hearing deterioration cases registered among those who did not use mobile electronic devices with headphones. Most schoolchildren and students whose hearing was impaired have been using headphones for at least a year, preferred in-ear headphones with silicone tips and used them at maximum volume every day, for more than two hours a day, including while in transport.

## DISCUSSION

The study revealed that students and schoolchildren use mobile electronic devices with headphones in 95.0% of cases, which confirms the importance of prevention campaigns

**Table 1.** The impact of use of mobile electronic devices with headphones on the development of hearing impairment in schoolchildren and students during the last year

| Factors | Pearson coefficient | | |
|---|---|---|---|
| | Value | p | Strength of association |
| Length of use of ED with headphones | 0.89 | $p \leq 0.05$ | strong |
| Audio file listening volume | 0.83 | $p \leq 0.05$ | strong |
| Falling asleep with headphones on | 0.82 | $p \leq 0.05$ | strong |
| Use of ED with headphones in transport settings | 0.75 | $p \leq 0.05$ | strong |
| Type of headphones | 0.71 | $p \leq 0.05$ | strong |
| Weekly headphones use frequency | 0.71 | $p \leq 0.05$ | strong |
| Installed noise canceling technology | 0.70 | $p \leq 0.05$ | strong |

among children, adolescents and youth aimed at instilling a proper attitude towards using mobile electronic devices with headphones, with such campaigns, in particular, incorporating the necessary information into curricula [9,10].

Numerous research papers highlight the impact of mobile electronic devices on the body systems of children, adolescents and young people. In particular, such devices affect the organ of sight, neuropsychic systems, musculoskeletal system etc. [11,12,13].

However, the effects arising from the use of mobile electronic devices with headphones have not been investigated sufficiently. Russian research literature offers no evidence-based information on the safe level of volume and length of use of headphones, which disallows drawing a complete picture of preventive and protective measures designed to safeguard the hearing organ with the modern technological advancements factored in [6, 14].

The effect of sound is cumulative; adverse changes of the hearing organ accumulate gradually, during exposure to this harmful factor. The development of hearing loss is associated with gradual damage to the ear and its deteriorating adaptive capability: as a result of high sound pressure, the time it takes the hearing organ to recover between headphones use sessions increases. Prolonged exposure to excessive acoustic energy adversely affects hearing and can lead to its partial or significant loss [15].

Hearing disorders translate into gaps in received information and poor speech intelligibility, which, in turn, affect the psycho-emotional state of a person and lead to deterioration of the quality of life. More and more often, mobile electronic devices with headphones are used without restriction, and this trend will push up the number of people suffering from speech intelligibility and deteriorating hearing [16].

## CONCLUSIONS

Today, schoolchildren and students are exposed to the hearing impairment risks associated with use of mobile electronic devices with headphones, which makes the search for the most efficient ways of forming healthy lifestyle habits among them even more urgent.

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