METHODOLOGICAL APPROACHES TO ASSESSING BRIGHTNESS AND PULSATION OF SMALL-SIZED MOBILE ELECTRONIC DEVICE SCREENS

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Today, the existing regulatory and methodological documents provide no approved methodological approach to hygienic assessment of brightness and pulsation of mobile electronic devices (MEDs) with a small screen. The study was aimed to customize the current procedures used to assess brightness and pulsation of electronic devices with a large screen for hygienic assessment of brightness and pulsation of the small-sized MED screens. The design characteristics of 100 MEDs (smartphones and tablets) used by medical students in their leisure time and during training were estimated; pulsation and brightness of the MED screens were studied. The questionnaire survey of 173 medical students was performed that involved the use of the questionnaire developed by members of the Department of Hygiene, Faculty of Pediatrics, Pirogov Russian National Research Medical University; the students' visual acuity was assessed. Two thirds of medical students (67.5%) use MEDs with the screen size exceeding the average (5.5–6.8 inches). The average brightness of every second MED is less than 50.0% of the highest possible brightness. The decrease in the MED screen brightness results in the increase of pulsation coefficient (Spearman's rank correlation coefficient –0.462 ± 0.025, $p \leq 0.05$), which can worsen the conditions of visual work. Three quarters of students (76.0%) experience shortage of battery charge during the day; every second student (52.2%) uses the "dark" theme. The development of computer vision syndrome in students is influenced by the MED screen small size (Pearson's contingency coefficient 0.791 ± 0.026, $p \leq 0.05$) and its low brightness (Pearson's contingency coefficient 0.781 ± 0.027, $p \leq 0.05$), which confirms a sanitary legislation provision on prohibition of the use of smartphones in educational activities (for training). The use of the proposed methodological approach will make it possible to improve the efficiency of vision problem prevention in the population.

Keywords: mobile electronic devices, smartphones, tablets, screen brightness, screen pulsation, measurement technique, hygienic assessment

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Compliance with ethical standards: the study was approved by the Ethics Committee of the Pirogov Russian National Research Medical University (protocols № 203 of 20 December 2020 and № 209 of 28 June 2021). The study was in line with the principles of biomedical ethics and did not endanger the subjects; the informed consent was obtained for all study participants.

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МЕТОДИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ ЯРКОСТИ И ПУЛЬСАЦИИ ЭКРАНОВ МОБИЛЬНЫХ ЭЛЕКТРОННЫХ УСТРОЙСТВ, ИМЕЮЩИХ МАЛУЮ ДИАГОНАЛЬ ЭКРАНА

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В настоящее время в действующих нормативно-методических документах отсутствует апробированный методический подход к гигиенической оценке яркости и пульсации мобильных электронных устройств (МЭУ) с малой диагональю экрана. Целью работы было адаптировать действующие методики измерения яркости и пульсации экранов электронных устройств, имеющих большую диагональ экрана, для гигиенической оценки яркости и пульсации экранов МЭУ, имеющих малую диагональ. Изучены конструктивные характеристики 100 МЭУ (смартфонов и планшетов), используемых студентами-медиками во время досуга и обучения, изучены пульсация и яркость их экранов. Выполнено анкетирование 173 студентов-медиков с использованием опросников, разработанных сотрудниками кафедры гигиены педиатрического факультета РНИМУ имени Н. И. Пирогова, проведена оценка остроты их зрения. Две трети студентов-медиков (67,5%) используют МЭУ с диагональю экрана больше средней (5,5–6,8 дюймов). Средняя яркость экрана каждого второго МЭУ составляет менее 50,0% от максимально возможной. Снижение яркости экрана МЭУ повышает коэффициент его пульсации (коэффициент ранговой корреляции Спирмена –0,462 ± 0,025, $p \leq 0{,}05$), что может ухудшить условия зрительной работы. Три четверти студентов (76,0%) испытывают дефицит заряда аккумулятора в течение дня; каждый второй студент (52,2%) использует «темную» тему. На возникновение компьютерно-зрительного синдрома у студентов оказывают влияние малая диагональ экрана МЭУ (коэффициент сопряженности Пирсона 0,791 ± 0,026, $p \leq 0{,}05$) и его низкая яркость (коэффициент сопряженности Пирсона 0,781 ± 0,027, $p \leq 0{,}05$), что подтверждает положение санитарного законодательства о запрете использования смартфонов в образовательной деятельности для целей обучения. Использование предложенного методического подхода позволит повысить эффективность профилактики нарушения зрения у населения.

Ключевые слова: мобильные электронные устройства, смартфоны, планшеты, яркость экрана, пульсация экрана, методика измерения, гигиеническая оценка

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Соблюдение этических стандартов: исследование одобрено этическим комитетом РНИМУ имени Н. И. Пирогова (протоколы № 203 от 20 декабря 2020 г. и № 209 от 28 июня 2021 г.). Исследование соответствовало требованиям биомедицинской этики и не подвергало опасности участников, для каждого участника было получено добровольное информированное согласие.

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The literature provides data on the impact of physical factors associated with technical characteristics of electronic devices (EDs) on the human body [1, 2].

The researchers have proven that the irrationally arranged information displayed on the ED screen and other ED technical characteristics contribute to the visual analyzer rapid fatigue [3–7].

Mobile electronic devices (MEDs — smartphones, tablets) that show considerable technical and audiovisual differences from the stationary EDs are the most common and affordable information and communication technology (ICT) tools; the features of their effects on the body are poorly understood.

Preventive measures considering the diversity of technical characteristics of various EDs are needed to reduce the ED adverse effects on health [8, 9].

The existing regulatory and methodological documents provide no methodological approaches to recording and assessment of brightness and pulsation of small-sized MED screens.

The development of methodological approach to safety assessment of brightness and pulsation of the MED screens will make it possible to ensure safe conditions for visual work and reduce the prevalence of functional impairments and chronic eye disorders in the population.

The study was aimed to customize the current procedures used to assess brightness and pulsation of EDs with a large screen for hygienic assessment of brightness and pulsation of the small-sized MED screens.

METHODS

In 2020–2021, a questionnaire survey of 173 students of the Faculty of General Medicine and Faculty of Pediatrics, Pirogov Russian National Research Medical University, was conducted that involved the use of the questionnaire developed by members of the Department of Hygiene, Faculty of Pediatrics, Pirogov Russian National Research Medical University, having the following board certificates: “General Hygiene”, “Hygiene of Children and Adolescents”, “Epidemiology”.

The design characteristics of 100 MEDs (smartphones and tablets) used by students in their leisure time and during training were studied, and technical characteristics of these MEDs provided by the manufacturers were assessed. Instrumental assessment of brightness (100 measurements) and pulsation (100 measurements) of their screens was performed. Pulsation and brightness of the MED screens were studied in the dark or with the screened windows, with the general artificial lightning turned on.

The MED screen brightness was measured according to the method [10] customized in accordance with the goals and objectives of the study. Assessment was performed using the Argus-02 luminance meter (VNIIOFI; Russia) equipped with radiation transducers, the maximum permissible error of which did not exceed 10%. The meter had a state-recognized calibration certificate.

The MED screen pulsation was measured using the TKA-PKM-08 luxmeter + pulsemeter (“TKA” Scientific Instruments; Russia) equipped with radiation transducers, the maximum permissible error of which did not exceed 10%, according to the method provided in the TKA-PKM-08 user manual and customized in accordance with the goals and objectives of our study. The device had a state-recognized calibration certificate.

When measuring the MED screen pulsation, the MED was on the tabletop. The user took a comfortable position and set the screen brightness to a comfortable level. The study was performed in the mode of working with the text document opened in conventional word processor. Furthermore, the absence of shadows from the surrounding objects, meter, and a person conducting the measurement was controlled. The color of the text processor background was also recorded in the protocol. The meter was placed at a distance of 1–5 cm from the center of the screen. The parameter was recorded for 1 min. The results were documented in the protocol.

When measuring the MED screen brightness, the luminance meter lens was screened to prevent stray light from entering. The MED was on the tabletop during measurement. Brightness of the working surface of the table was tested for compliance with the established safety requirements before measurement [11]. When performing measurement, the user set the MED screen brightness to the comfortable level considering comfortable body position and the distance from the eyes to the screen. The luminance meter lens was positioned at the eye level of the user in such a way that the optical axis matched the line of sight. The user opened the text in conventional text processor. The color of the text processor background was also recorded. The resulting average screen brightness was calculated as the mean of three direct measurements.

Assessment was performed in the classroom at the Department of Hygiene, Faculty of Pediatrics, Pirogov Russian National Research Medical University, where medical students used MEDs for work. To adjust the study conditions to standard conditions, the measurements were performed in the room reserved for the use of MEDs for work, the luminance level of which complied with the hygienic requirements established for this type of activity.

The luminance parameters of the classroom were measured using the TKA-PKM-43 luxmeter (NTM Ltd.; Russia) with the range of 10–200,000 lx and a maximum permissible error of 8.0%. The meter was calibrated and had a state-recognized calibration certificate. The values obtained during measurement were tested for compliance with the established safety requirements [11].

Statistical processing of the results was performed using the Statgraphics software package (Statpoint Technologies; USA), as well as Microsoft Office Excel (Microsoft; USA) and Statistica 13 PL (StatSoft; USA). Descriptive statistics was used: the mean (M), root-mean-square deviation (*m*), standard deviation (σ). The relationships between traits were assessed using the Pearson's contingency coefficient (*k*) and the Spearman's rank correlation coefficient (*r*). $P \leq 0.05$ was considered to be a critical significance level.

RESULTS

The average (M ± σ) MED screen size was 5.6 ± 0.1 inches. MEDs were divided into two groups based on the screen size: MEDs with smaller screen size of 4.7–5.4 inches (32.5%) and that with larger screen size of 5.5–6.8 inches (67.5%).

The MED screen small size made it difficult to measure its brightness and pulsation using the existing regulatory and methodological documents, which was the basis for customization of methodological approaches in accordance with the goals of the study.

Luminance of the working surface of the table was within the range of 300–500 lx, which was consistent with the existing safety requirements for this type of activity [11]. The pulsation coefficient of the general lightning sources did not exceed 5%.

The average screen brightness set by medical students on their MEDs was 145.2 ± 11.7 cd/m^2, which was less than 50.0% of 300–550 cd/m^2 (maximum possible brightness specified in technical characteristics). Such screen brightness was reported by every second medical student (59.0 ± 3.0%). The average pulsation coefficient was 8.2 ± 1.5%.

It was found that the decrease in the MED screen brightness increases its pulsation coefficient, which can worsen the conditions of visual work involving the use of MED (Spearman's rank correlation coefficient –0.462 ± 0.025, $p \leq 0.05$).

Just every fourth student (24.0%) has reported that the battery charge is enough for a whole day. This forces students to use power saving techniques for the MED battery. Every second student (52.2%) uses the "dark" theme, while others (47.8%) prefer using the "light" one.

It has been found that the development of computer vision syndrome in students is influenced by the MED screen small size (Pearson's contingency coefficient 0.791 ± 0.026, $p \leq 0.05$) and its low brightness (Pearson's contingency coefficient 0.781 ± 0.027, $p \leq 0.05$).

DISCUSSION

The MED user guides issued by manufacturers provide information about such design feature, as screen size measured in inches.

Two thirds of medical students (67.5%) use advanced models of MEDs, the most common screen size is 5.5–6.8 inches. Brightness is one more MED screen feature. The default brightness of smartphones is 100%, however, users often adjust it manually to reduce, since such brightness rapidly decreases the battery life. Thus, more than a half of medical students (59.0 ± 3.0%) use screen brightness that is below 50.0% of the maximum possible value declared by the manufacturer.

As is known from physical patterns, there is a relationship between the screen brightness and the pulsation coefficient. In our study the relationship was described using the Spearman's rank correlation coefficient (*r*), since the distribution of values was non-normal. The Spearman's rank correlation coefficient was –0.462 ± 0.025 ($p \leq 0.05$). This suggests that the screen brightness used (reduced to 50% or lower) increases the pulsation coefficient, thereby worsening the conditions of visual work involving the use of MED.

The design theme, "light" or "dark" is another smartphone screen feature. The "light" theme is based on positive contrast (dark text on light background); the "dark" theme is based on negative contrast (light text on dark background). The theme that can be manually set by the user affects the battery life, extending it. Furthermore, some users like the "dark" theme more. Our study has shown that every second medical student (52.2%) subjectively prefers the "dark" theme.

The findings are consistent with the data obtained by other researchers that suggest the relationship between the ED technical characteristics, the image displayed on the screen, and the user's health problems [4, 5].

The relationship between the development of computer vision syndrome and the MED screen small size (Pearson's contingency coefficient 0.791 ± 0.026, $p \leq 0.05$) together with its low brightness (Pearson's contingency coefficient 0.781 ± 0.027, $p \leq 0.05$) confirms validity of the sanitary legislation provision on prohibition of the use of smartphones in educational activities (for training).

CONCLUSIONS

Customization of the existing methods to measure brightness and pulsation of the EDs with a large screen size for hygienic assessment of the small-sized MED screens will make it possible to objectively estimate the risk of vision problems, effectively control brightness and pulsation of the small-sized MED screens, thereby contributing to prevention of vision problems in the population.

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