REGIME OF USING MOBILE ELECTRONIC DEVICES BY STUDENTS AS A RISK FACTOR OF VISION IMPAIRMENT

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The adverse impact of electronic devices, including mobile ones (smartphones, tablets), on the organism of children, adolescents and youth has been highlighted by many studies. The study was aimed to assess the regime of using mobile electronic devices and its impact on the students' vision. The data on the use of mobile electronic devices in educational and recreational activities by 1218 schoolchildren and students were acquired; their work-rest schedule when engaged with mobile electronic devices was characterized. A total of 943 schoolchildren and students were examined by ophthalmologist and with the use of the Armis hardware-software complex (Russia). A significant decrease in visual acuity (measured in diopters) and the increase in the rate of functional vision problems and chronic eye disorders in first-graders ($p \leq 0.05$) compared to their age-mates of the past decade were observed. During the learning process, a significant decrease in visual acuity ($p \leq 0.05$) in both eyes was observed starting from middle school, which persisted both in high school and during first years of the university. Students, who adhered to the work-rest schedule when engaged with mobile electronic devices, significantly less often ($p \leq 0.05$) complained of health problems. A regression model ($p \leq 0.05$) was constructed for the relationship between the students' visual acuity (OD, OS, diopters) and their work-rest schedule when engaged with mobile electronic devices. When assessing the regime of using electronic devices, medical stidents found that the time of use in both educational and recreational activities should be strictly regulated. To prevent functional vision problems and chronic eye disorders, it is necessary to limit the time of using mobile electronic devices by students. According to scientific research, this would have a beneficial effect on the finctional state of the organism and prevent fatigue.

Keywords: schoolchildren, students, visual acuity, mobile electronic devices, work-rest regime

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Compliance with ethical standards: the study was approved by the Ethics Commitee of Pirogov Russian National Research Medical University (protocol № 159 of 21 November 2016), did not endanger the subjects, and was consistent with the principles of biomedical ethics; the informed consent was submitted by all study participants.

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РЕЖИМ ИСПОЛЬЗОВАНИЯ МОБИЛЬНЫХ ЭЛЕКТРОННЫХ УСТРОЙСТВ ОБУЧАЮЩИМИСЯ КАК ФАКТОР РИСКА РАЗВИТИЯ ОТКЛОНЕНИЙ СО СТОРОНЫ ОРГАНА ЗРЕНИЯ

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Отрицательное воздействие электронных устройств (ЭУ), в том числе и мобильных (смартфон, планшет), на организм детей, подростков и молодежи отмечено во многих научных исследованиях. Целью работы явилось изучение режима использования мобильных электронных устройств и его влияния на состояние органа зрения обучающихся. Были получены данные об использовании мобильных электронных устройств в учебной и досуговой деятельности 1218 школьниками и студентами и дана характеристика их режима труда и отдыха при работе с мобильными электронными устройствами. Врачом-офтальмологом и с помощью АПК «Армис» (Россия) было осмотрено 943 школьника и студента. Было обнаружено достоверное снижение остроты зрения в дптр, а также увеличение частоты функциональных отклонений и хронических заболеваний глаза у первоклассников ($p \leq 0,05$), в сравнении со сверстниками предыдущего десятилетия. В динамике обучения отмечено достоверное снижение ($p \leq 0,05$) остроты зрения на оба глаза начиная со средней школы, которое и далее сохранялось на этом уровне и в старшей школе, и на первых курсах университета. У обучающихся, соблюдающих режим труда и отдыха при работе с мобильными электронными устройствами, достоверно реже ($p \leq 0,05$) встречались жалобы на нарушение здоровья. Получена регрессионная модель ($p \leq 0,05$), описывающая связь остроты зрения (OD, OS, дптр) обучающихся с режимом их труда и отдыха при работе с мобильными электронными устройствами. При оценке режима использования ЭУ студентами-медиками установлено, что как в учебной, так и в досуговой деятельности, время использования должно быть строго регламентировано. Для профилактики функциональных отклонений и хронических заболеваний органа зрения необходимо ограничить во времени использование мобильных электронных устройств обучающимися, что, согласно научным исследованиям, как благоприятно влияет на функциональное состояние организма в целом, так и предотвращает развитие переутомления.

Ключевые слова: школьники, студенты, острота зрения, мобильные электронные устройства, режим труда и отдыха

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Early 21st century was marked by booming development of digital environment. In 2000, the telecom company *Ericsson* used the term "smartphone" for a mobile electronic device for the first time. Smartphones became available in the general market after 2008. The UNISEF report "The State of the World's Children 2017: Children in a Digital World", published 10 years after the release of the first iPhone, showed the increasing role of Internet in education and socialization of children, adolescents and youth. Children and adolescents under the age of 18 make up about a third of Internet users worldwide. The age of first use of Internet is constantly decreasing: more and more 3–5-year-old children in European countries become Internet users, which involves the use of mobile electronic devices [1].

At the current stage domestic education moves on to the "digital school" and implementation of technologies of distance education that also involves the use of mobile electronic devices to access the educational process and electronic educational resources and therefore shapes the usual mode of using such devices in educational activities by the students [2, 3].

The impact of mobile electronic devices on the organism of children, adolescents and youth has been highlighted by many studies. It should be noted that students, who use mobile electronic devices, often complain of asthenopia. They also experience eye problems, musculoskeletal disorders, become psychologically addicted, etc. [4–12].

Earlier, the potential dangers of using mobile electronic devices were associated with exposure to physical factors and positioning of a mobile phone close to the human head. Today, smartphones are small but powerful computers that continuously receive audio and video data. Potential dangers of using smartphones are increasingly associated with the temporal characteristics of the use of mobile electronic devices [13–16].

The above-mentioned demands the analysis of the impact of various modes of using mobile electronic devices on the health status (particularly on the students' vision) that would make it possible to develop preventive measures aimed at reducing health risks in the younger generation.

The study was aimed to assess the regime of using mobile electronic devices and its impact on the students' vision.

METHODS

In 2017–2021 academic years, a single examination and blank questioning of 1218 schoolchildren and students in Moscow and Moscow region (among them 150 primary-level schoolchildren, 225 middle schoolers, 200 high school students, 643 undergraduate students) were carried out. Information about the usual mode of using mobile electronic devices (MEDs) was obtained from students having the experience with MEDs of a year or more using the standardized questionnaire. We also applied questionnaires that contained information about the conditions of using MEDs (availability of the organized workplace, possibility of maintaining working posture, adequate level of illumination of the working surface), modes of using MEDs (work breaks, their frequency and length), characteristics of the applied preventive measures (frequency, timeliness of work breaks, filling of those with preventive activities), the amount of "screen time" when using MEDs. High school students and undergraduate students were offered to fill out an online questionnaire [17]. A total of 200 high school students and 518 undergraduate students were surveyed.

The data of the student's examination were copied by ophthalmologist. Visual acuity was assessed in 943 schoolchildren and students. The examination results were recorded in the following way: UCVA (OD =…, OS =…). We also studied archival data of the examination of schoolchildren, who attended the Dolgoprudny Gymnasium, performed by the Board Certified ophthalmologist in 2000–2005.

Inclusion criteria: student (schoolchild or undergraduate student); availability of written informed consent; availability of the ophthalmic examination results; questionnaire, completed correctly by the respondent or his/her legal representative (for primary-level schoolchildren); no chronic eye disorders; experience with MEDs of a year or more. Exclusion criteria: different age group; no informed consent; no ophthalmic examination results; chronic eye disorder that makes it possible to attribute the subject to the health groups 4 and 5; no correctly completed questionnaire; experience with MEDs of less than a year.

The study did not endanger the subjects, it was consistent with the principles of biomedical ethics and the Declaration of Helsinki (1983). The study was approved by the Ethics Committee of Pirogov Russian National Research Medical University (protocol № 159 of 21 November 2016).

Statistical processing of the results was performed using the Statistica 13 PL software package.

RESULTS

The research allows us to consider inadequate regime of the use of MEDs by students, the conditions of using MEDs, and no elements of healthy lifestyle in the students' daily routine the major risk factors of health problems.

When assessing the regime of using MEDs by students, it was found that only 6.0% of them did not use MEDs every day and had at least one "day free from using mobile electronic devices", for example on weekends. The day free from using MEDs was mostly reported by the primary-level schoolchildren and middle schoolers, other students reported they used MEDs every day. Almost all the surveyed students (91.5%) not only used MEDs for calls and sending messages, but also treated MEDs as personal computers that could be used for educational purposes and in leisure time. Half of the respondents (50.0%) mentioned the use of MEDs to complete educational tasks, both urgent and those that could be completed later using fixed electronic devices (computers, laptops). Every second student (65.0%) mentioned that he/she worked with MEDs during meals; almost all the respondents (85.0%) used MEDs in transport, and continued using MEDs in low light conditions with no organized workplace (75.0%). The mobile device battery life was an indirect proof of the intensity of using MEDs. Only one in four respondents (24.0%) reported that the battery was enough for one day use. Half of the respondents (50.0%) mentioned that they never did ocular gymnastics or any other type of gymnastics during breaks when working with MEDs.

The regime of using MEDs by students can be characterized by the time of continuous use (Table).

A significant increase in the time of continuous working with MEDs in middle schoolers and high school students compared to the primary-level schoolchildren, and the increase in the time of continuous working with MEDs in undergraduate students compared to schoolchildren were revealed ($p \leq 0.05$).

It was found that the time of continuous use of MEDs in middle schoolers, high school students and undergraduate students exceeded one hour and increased on weekends and during vacations. The requirements of SanPiN 1.2.3685–21 "Hygienic Standards and Requirements for Ensuring Safety and (or) Harmlessness to Humans from Environmental Factors" set the acceptable time of using tablet in educational activities. Our findings suggest that the time of continuous use of tablet by the primary-level schoolchildren increased by 2.0 times during working days and by 2.9 times during vacations; in middle schoolers it

Table. The time of continuous use of mobile electronic devices by students in their leisure time, during working days, weekends, and vacations, M ± m

Students	Time of continuous use of tablet			Time of continuous use of smartphone		
	working days	weekends	vacations	working days	weekends	vacations
Primary school	32.8 ± 5.5*.**	–	43.8 ± 5.5*.**	25.0 ± 2.5*.**	–	35.5 ± 4.5*.**
Middle school	63.0 ± 20.0*	98.6 ± 27.0*	97.3 ±2 0.0*	88.0 ± 13.0*	96.9 ± 16.0*	112.5 ± 18.5*
High school	95.2 ± 8.0*	96.5 ± 9.0*	107.1 ± 11.0*	129.5 ± 16.5*	131.8 ± 16.0*	146.5 ± 18.0*
University (students)	143.5 ± 9.0	159.1 ± 10.0	155.8 ± 10.0	186.0 ± 11.0	184.5 ± 11.0	191.0 ± 17.5

* $p \leq 0.05$ — significance of differences between schoolchildren and undergraduate students
** $p \leq 0.05$ — significance of differences between the primary-level schoolchildren and middle schoolers/high school students

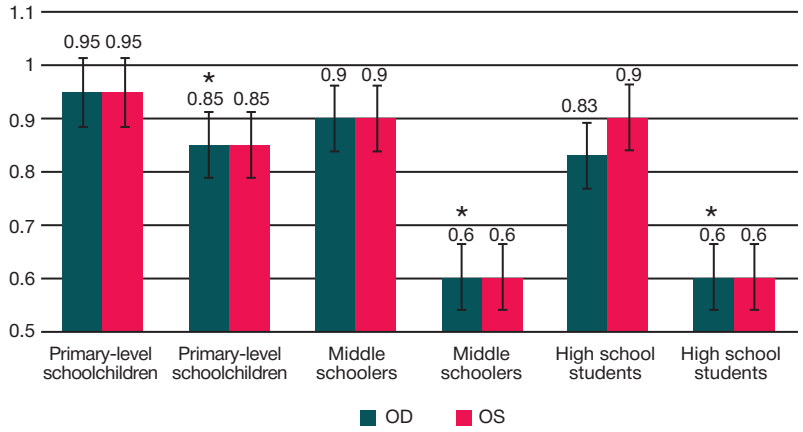


Fig. 1. Vusial acuity in schoolchildren and students, 2000–2005 and 2017–2021, diopters
* – $p \leq 0.05$

increased by 3.0 and 4.9 times, respectively; in high school students the time of continuous use of tablet increased by 4.9 and 5.3 times, respectively; in undergraduate students it increased by 7.0 and 7.8 times, respectively. However, educational activities never involved the use of smartphones by students.

Thus, it was shown that students took no timely breaks for rest, ocular gymnastics, increased motor activity or meals when working with MEDs. In accordance with the current safety regulations, such breaks should be taken every 10–15 of using an electronic device by the primary-level schoolchildren, and every 20 minutes by all other students.

The risk of health problems associated with using MEDs in students is aggravated by working in low light conditions, and the lack of workplace specially organized for this purpose. Among the students, almost every second person (40.0%) was at risk of health problems due to the features of unreasonable use of MED (wrong regime of use, wrong time of continuous use, poor lighting conditions at workplace, insufficient frequency and length of work breaks, wrong filling of breaks).

The dynamic changes in the students' vision had been assessed since 2000–2005 (before the release of the first iPhone in 2008) to 2017–2021 (the period of the mainstream use of iPhones) (Fig. 1).

In 2000–2005, conventional technical means of training were used in educational institutions. Furthermore, by the time of graduation from school decreased visual acuity was ($p \leq 0.05$) was observed only in the dominant eyes.

In 2017–2021, interactive boards, personal computers, laptops, readers and MEDs (tablets) were widely used in educational institutions. The more intensive use of these devices was reported in 2020 during the period of distance learning. During this time, visual acuity in first-graders was significantly lower ($p \leq 0.05$) compared to their age-mates of the past decade. In the course of learning a significant decrease ($p \leq 0.05$) in visual acuity in both student's eyes was revealed earlier (in middle school) and persisted during the subsequent stages of educational process. The students' visual acuity was significantly lower ($p \leq 0.05$) compared to that of their age-mates of the past decade.

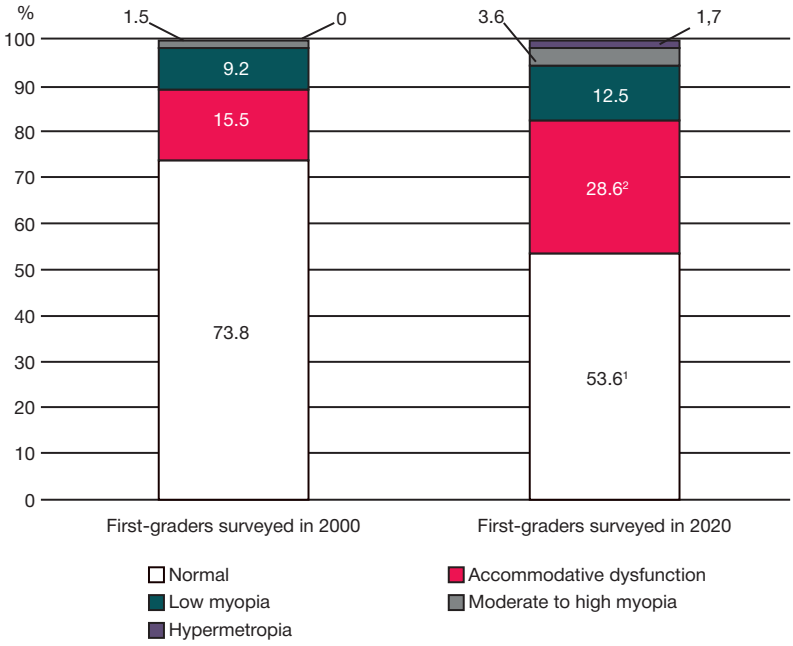
Studying the structure of eye diseases over time in 2000–2020 revealed a significantly increased share of students with various functional vision problems and chronic eye disorders in 2020. Among the surveyed first-graders, whose systematic education started in 2020, and who already had an experience with MEDs of at least a year, the share of students with no functional vision problems or chronic eye disorders (53.6%) was significantly lower ($p \leq 0.05$) compared to the data obtained in 2000 (73.8%). Disorders of accommodation were found in 28.6% and 15.5% of first-graders, and different degrees of myopia were found in 16.1% and 10.7%, respectively (Fig. 2).

The impact of the students' non-compliance with the regime of using mobile electronic devices on the development of vision impairment was studied. It was found that students, who adhered to the work-rest schedule when engaged with mobile electronic devices, significantly less often ($p \leq 0.05$) complained of health problems. Thus, only 7.5% of the respondents, who adhered to the safe regime of using MEDs, complained of heavy-headedness or headache. Among those who were non-compliant with the safety requirements, heavy-headedness or headache was reported by 92.5%; computer vision syndrome was found in 17.8% and 82.2% (contingency coefficient 0.51, $p \leq 0.05$), and carpal tunnel syndrome was reported by 3.9% and 96.1%, respectively.

A regression model ($p \leq 0.05$) was constructed for the relationship between visual acuity (OD, OS, diopters) and the regime of using mobile electronic devices:

$$Y = 0.43 + 0.31 \cdot X1 + 0.17 \cdot X2 - 0.09 \cdot X3 \quad (1),$$

where X1 was availability of the "day free from smartphone" (having no free day — 0, having free day — 1);
X2 — was availability of the "day free from tablet" (having no free day — 0, having free day — 1);



Note —
¹ — $p \leq 0.05$ — percentage of students with normal vision;
² — $p \leq 0.05$ — percentage of students with accommodative dysfunction.

Fig. 2. Dynamic changes in the prevalence of functional vision problems and chronic eye disorders in first-graders in 2000 and 2020,%

X3 — compliance with the regime of using mobile electronic devices (compliance — 0, non-compliance — 1).

DISCUSSION

Extensive use of MEDs by the vast majority of students, especially during the vacation period and leisure time, poses a significant threat to the health of the young generation. According to the data obtained, 40.0% are at risk due to inadequate regime of using MEDs. This, in turn, contributes greately to the impaired lifestyle and is a prerequisite for deterioration of health, including vision (both in terms of the increased prevalence and severity of eye disorders).

Some design features of MEDs that have an effect on the functional state of the student's organism are well known. A number of unresolved issues that determine the risk of health problems are reported: non-ergonomic keyboards (QWERTY); uncomfortable interface that complicates hand positioning; trouble using the device when walking (affects gait and increases the risk of injury) [18–20].

It has been determined that touch screens used in large mobile electronic devices have a distinct advantage over smaller touch screens in terms of space available for transferring of graphical data. The research has shown that users consider tablets the most useful in situations where precision of graphical interpretation is important and there are no time limits [21].

The text size and larger inter-line spacing (leading) significantly improve readability, the crowded display requires much greater time for reading and processing of information [22].

However, currently, it is hard to change some design features of mobile electronic devices, but today is necessary and possible to regulate the regime of using such devices.

Domestic hygienists have developed the regimes of using tablets in educational activities, as reflected in scientific papers and hygienic requirements for safe use [23, 24].

There are also some studies focused on assessing the impact of the regome of using mobile electronic devices (smartphones, tablets) in recreational activities [25].

The work-rest schedule of children, adolescents and youth when engaged with MEDs has become the key factor contributing to the health of the young generation in the context of distance learning. This factor affects the students' daily routine, their level of motor activity, functional and psychological state [26–29].

Meanwhile, the data on the impact of various regimes of the use of MEDs on the health of the young generation available in scientific literature are incomplete and address only some of its aspects. Thus, the study of young adults aged 18–23 with no eye disorders showed that 60 minutes of reading a book on the screen of smartphone resulted in the increased symptoms of eyestrain, drowsiness and fatigue, decreased binocular accommodation [30].

After 20 minutes of using smartphone, significant changes in the static balance and oculomotor function compared to the more short-term (5–10-minute) use, as well as dizziness were observed in healthy adults [31].

Thus, the use of MEDs (smartphones, tablets) both in educational and recreational activities should be strictly regulated. It is necessary to limit the time of using mobile electronic devices by students. According to scientific research, this would have a beneficial effect on the finctional state of the organism, prevent fatigue, and contribute to prevention of functional vision problems and chronic eye disorders [32–35].

Thus, the issues of adverse impact of the design features of various mobile electronic devices and the regimes of their use on the health of the young generation, and the development of measures to prevent health problems in future generations are still relevant and require further research.

CONCLUSION

The widespread use of mobile electronic devices (tablets and smartphones) among primary-level schoolchildren, middle schoolers, high school students, and undergraduate students is reported.

1. In 2000–2005 and 2017–2021, the more and more earlier detection of vision impairment in first-graders was observed.

2. High prevalence and increasing severity of eye disorders among students, including first-graders, were revealed.
3. The work-rest schedule of children, adolescents and youth when engaged with MEDs is a controllable risk factor for health problems in the younger generation.

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