ASSESSMENT OF THE EFFECTS OF USING DIGITAL DEVICES ON PSYCHOMOTOR FUNCTION INDICATORS IN PRIMARY SCHOOL STUDENTS

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A significant change in the lifestyle of modern children associated with the active use of digital devices in educational and leisure activities can affect their psychomotor development. The study aimed to assess the effect of using smartphones and computers on psychomotor function indicators in primary school students. A questionnaire survey of 333 parents of the 1–4-year students attending Zemskaya Gimnasia in Balashikha on issues of children's life was conducted. The students' screen time when using a computer and smartphone throughout the day and week was estimated. To assess the students' psychomotor functions, the Little House test and motometric test conducted by teachers were used. Assessment of the effect of computer use on psychomotor development indicators revealed a correlation. Thus, when using a computer, a deterioration in fine motor skills was noted; the correlation coefficient (r) for the parameters of visual-motor coordination and the duration of computer use per day was 0.320 (p = 0.002). The correlation coefficient for the duration of computer use and the primary school students' final psychomotor development score was 0.235 (p = 0.028). The same result was obtained for the integrated assessment of fine motor skill development and its association with the duration of computer use per day: r = 0.253 (p = 0.025). However, there was no correlation between screen time when using a smartphone and psychomotor functions. The findings can be used in the development and justification of preventive technologies to prevent the negative impact of digital devices on the development of psychomotor functions in children, especially at the initial stage of systematic education.

Keywords: fine motor skills, visual-motor coordination, digital device, smartphone, screen time

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Compliance with ethical standards: the study was approved by the Ethics Committee of the National Medical Research Center for Children's Health (protocol No. 3 dated 25 March 2021).

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ОЦЕНКА ВЛИЯНИЯ ИСПОЛЬЗОВАНИЯ ЦИФРОВЫХ УСТРОЙСТВ НА ПОКАЗАТЕЛИ ПСИХОМОТОРНЫХ ФУНКЦИЙ У МЛАДШИХ ШКОЛЬНИКОВ

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Существенное изменение образа жизни современных детей, связанное с активным использованием цифровых устройств в учебной и досуговой деятельности, может влиять на их психомоторное развитие. Целью исследования было оценить влияние использования смартфонов и компьютеров на показатели психомоторных функций у младших школьников. Проведено анкетирование 333 родителей обучающихся 1–4-х классов МАОУ «Земская гимназия» г. Балашиха по вопросам жизнедеятельности детей. Было оценено экранное время школьников при использовании компьютера и смартфона в течение дня и недели. Для оценки психомоторных функций обучающихся использовали тест «Домик» и мотометрический тест, который проводили педагоги. Оценка влияния использования компьютера на показатели психомоторного развития выявила корреляционную зависимость: так, при использовании компьютера отмечено ухудшение состояния мелкой моторики; коэффициент корреляции (r) между параметрами зрительно-моторной координации и длительностью использования компьютера в день составил 0,320 (p = 0,002). Коэффициент корреляции между длительностью использования компьютера и итоговой оценкой уровня психомоторного развития у младших школьников составил 0,235 (p = 0,028). Аналогичный результат был получен для показателя интегральной оценки уровня развития мелкой моторики и его связи с длительностью использования компьютера в день: r = 0,253 (p = 0,025). При этом корреляционная связь между продолжительностью экранного времени при использовании смартфона и психомоторными функциями отсутствует. Полученные результаты могут быть использованы при разработке и обосновании профилактических технологий для предупреждения отрицательного влияния цифровых устройств на развитие психомоторных функций у детей, особенно на начальном этапе систематического обучения.

Ключевые слова: мелкая моторика, зрительно-моторная координация, цифровое устройство, смартфон, экранное время

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The study of psychomotor function development in the context of the widespread use of digital devices in everyday life is an urgent problem of health preservation in children. There are many studies focused on the digital media [1, 2], while the studies of the effects of gadgets on fine motor skills are much fewer.

The scientific research results show that the level of psychomotor function development has an effect on the reading skills [3], handwriting [4, 5], gross motor skill formation [6], and even development of imagination [7].

This issue is extensively studied by both domestic [8–10] and foreign scientists [11–13]. A number of authors point to the importance of the problem of negative effects of gadgets on fine motor skills in preschoolers and primary school students [14–17].

Some studies are focused on specific games for fine motor skill development, which can be used to prevent the effects of long screen time exposure [18].

When assessing the impact of various digital devices on psychomotor function indicators, it is worth noting a considerable number of studies focused on assessing the impact of tablets on the development of fine motor skills, and the effect is assessed as both negative [19, 20] and positive [13, 21–23]. In a number of studies, the effects of developmental toys were assessed relative to that of the touch screen [24].

However, despite numerous studies of the effects of digital devices on students' bodies, differential assessment of the impact of smartphones and computers on psychomotor function indicators in primary school students remains poorly understood.

The study aimed to assess the effect of using smartphones and computers on psychomotor function indicators in primary school students.

METHODS

We conducted a questionnaire survey of 333 parents of the 1–4-year primary school students attending Zemskaya Gimnasia in Balashikha using a specially developed questionnaire. The duration and frequency of using the computer and smartphone per day and week were assessed.

To assess the level of psychomotor function development in primary school students, a cross-sectional study was conducted that involved the Little House test and motometric test, allowing one to assess the development of arbitrary attention, spatial perception, visual-motor coordination. These indicators were considered when determining the final score of psychomotor development. The integrated assessment of fine motor skill development involved assessment of the Little House test and motometric test results [25].

The correlation analysis was performed using the Pearson's correlation coefficient, and mean values were compared using Student's t-test for unrelated samples for the screen time and psychomotor development indicators. The results were considered significant at $p < 0.05$. MS Excel (Microsoft; USA), SPSS v. 23 (IBM; USA), online risk calculator (https://medstatistic.ru/calculators/calcrisk.html) were used for statistical analysis.

RESULTS

The duration and frequency of using various digital devices by primary school students were assessed per day and week (Tables 1, 2).

The results of the study show that 64.4% of primary school students use the computer less than an hour a day; 61.4% of children are less than an hour a day on their smartphones.

According to [26], the time of using electronic learning tools, including for leisure activities, recommended for 1–2-year students is 80 min, and that recommended for 3–4-year students is 90 min. Thus, inappropriate duration (two hours or more) of using the computer is observed in 32.4% of children, and that of using the smartphone is reported for 66.9 of primary school students.

When analyzing the data in Table 2, it can be concluded that 34.3% of children prefer to use the computer 1–2 times a week, 25.5% of children — daily, 24,5% of children — on weekends only. At the same time, 53.2% of primary school students prefer to use the smartphone daily.

The results of psychomotor function development assessment in primary school students are provided in Table 3.

Statistical analysis of psychomotor function indicators has made it possible to determine that high level of the arbitrary attention function development is found in 75.5% of children, spatial perception — in 27.9%, visual-motor coordination — in 23.4%. Based on final assessment, high level of psychomotor function development has been determined only in 11.4% of children.

Medium levels of arbitrary attention development are reported in 10.0% of students, spatial perception — in 59.7%, visual-motor coordination — in 72.8%. Based on final assessment,

Table 1. Duration of computer and smartphone use per day in primary school students

Duration of use	Computer, $n = 101$			Smartphone, $n = 171$		
	Abs.	%	95% CI	Abs.	%	95% CI
Less than 30 min	32	31.7	22.6–40.8	52	30.4	23.5–37.3
Between 30 min and 1h	33	32.7	23.5–41.8	53	31	24.1–37.9
Between 1 h and 2 h	17	16.8	9.5–24.1	29	17	11.3–22.6
Between 2 h and 3 h	6	5.9	1.3–10.6	19	11.1	6.4–15.8
More than 3 h	13	12.9	6.3–19.4	18	10.5	5.9–15.1

Table 2. Frequency of computer and smartphone use per week in primary school students

Frequency of use	Computer, $n = 102$			Smartphone, $n = 205$		
	Abs.	%	95% CI	Abs.	%	95% CI
Only on weekends	25	24.5	16.2–32.9	19	9.3	5.3–13.2
1–2 times a week	35	34.3	25.1–43.5	15	7.3	3.8–10.9
3–4 times a week	9	8.8	3.3–14.3	34	16.6	11.5–21.7
5–6 times a week	7	6.9	2.0–11.8	28	13.7	9.0–18.4
Daily	26	25.5	17.0–33.9	109	53.2	46.3–60.0

Table 3. Psychomotor function development levels in primary school students (n = 290)

Development level	Arbitrary attention			Spatial perception			Visual-motor coordination			Final score of psychomotor development		
	Abs.	%	95% CI	Abs.	%	95% CI	Abs.	%	95% CI	Abs.	%	95% CI
High	279	75.5	94.0–98.4	81	27.9	22.8–33.1	68	23.4	18.6–28.3	33	11.4	7.7–15.0
Medium	29	10	6.5–13.5	173	59.7	53.7–65.0	211	72.8	67.6–77.9	179	61.7	56.1–67.3
Low	42	14.5	10.4–15.0	36	12.4	8.6-16.2	11	3.8	1.6–6.0	78	26.9	21.8–32.0

the medium level of psychomotor function development is reported for 61.7% of children.

The data obtained suggest that high levels of arbitrary attention development, medium levels of spatial perception and visual-motor coordination development predominate in primary school students.

Low level of the arbitrary attention development is observed in 14.5%, spatial perception — in 12.4%, visual-motor coordination — in 3.8% of children.

Based on final assessment, low level of psychomotor development is reported for 26.9%.

The results of the analysis of the correlation of psychomotor function indicators with the frequency and duration of using digital devices by children are provided in Table 4.

According to Table 4, weekly duration of the digital device use has no effect on psychomotor development. Table 4 shows that the daily computer use leads to a decrease in a number of indicators that is observed when using the smartphone.

When using the computer, deterioration in fine motor skills was noted. The correlation coefficient (r) for the parameters of visual-motor coordination and duration of computer use per day was 0.320 (p = 0.002).

The risk analysis has shown that using a computer for more than an hour a day is a risk factor for underdeveloped visual-motor coordination functions: RR = 1.38 (1.13–1.69).

When assessing the impact of computer use on psychomotor development indicators, a correlation was also found between the duration of computer use is primary school students and the final score of their psychomotor development (r = 0.235; p = 0.028). The same result was obtained for the integrated assessment of fine motor skill development and its association with the duration of computer use per day: r = 0.253 (p = 0.025). When using the computer for more than an hour a day, the risk of fine motor skill underdevelopment based on the integrated assessment was as follows: RR = 1.40 (1.12–1.75).

When using the smartphone, no correlations between screen time and psychomotor function indicators were found.

DISCUSSION

In modern digital devices, there are two main technical methods of entering information: using buttons or touch panels — gestures (swipe).

When using physical (mechanical) keyboard buttons, a certain amount of pressure is required to press the key until the corresponding click occurs (between 0.25 and 1.5 H) [27], i.e. only the suprathreshold effort is required. The tactile feedback is reduced to a minimum — whether there is a press or not. When using a keyboard, for example for games, only the speed of sensorimotor reaction is important without taking into account its quality.

When using gestures typical for smartphone use, the movements, on the contrary, are more highly coordinated, requiring greater balance and flexibility of nervous processes. Kinesthetic feedback plays a major role in this case. Objects on the touch screen are smaller than keyboard keys, requiring more precise force and more complex movements.

Table 4. Relationship between psychomotor function indicators, frequency and duration of digital device use in primary school students

Psychomotor function indicators		Frequency of computer use per week	Frequency of smartphone use per week	Duration of computer use per day	Duration of smartphone use per day
Attention	r	0.109	0.116	0.15	0.143
	p	0.306	0.112	0.163	0.07
	n	90	190	88	162
Spatial perception	r	0.037	–0.017	–0.025	–0.014
	p	0.727	0.811	0.815	0.855
	n	90	190	88	162
Visual-motor coordination	r	0.076	0.037	0.320**	0.153
	p	0.474	0.613	0.002	0.052
	n	90	190	88	162
Final score of psychomotor development	r	0.156	0.013	0.235*	0.065
	p	0.141	0.855	0.028	0.413
	n	90	190	88	162
Fine motor skills (motometric test)	r	–0.043	0.047	0.032	0.006
	p	0.7	0.553	0.777	0.941
	n	83	165	82	146
Integrated assessment of fine motor skill	r	0.033	0.055	0.253*	0.152
	p	0.773	0.486	0.025	0.071
	n	79	161	79	142

Note: * — $p < 0.05$; ** — $p < 0.001$.

It should be noted that similar arguments are presented in the paper [28]. According to the author, tactile sensation forms a holistic polymodal perception of an object, which is impossible when using digital devices, when only a swipe or a button press is required.

It is important to note that there are studies that compare keyboard writing with handwriting [29] and assess the impact of various touch screens on fine motor skill development indicators. The results of these studies are contradictory [30, 31]. No comparative studies of keyboard writing and touch screen use have been found.

Keyboard writing and touch screen use are two fundamentally different sensorimotor tasks.

When typing using the keyboard, finger movements are discrete and precise. Parameters such as rhythm and automation of motor acts associated with motor memory come to the fore.

When using a touch screen, gestures are more variable and have more amplitude. Touching, swiping, zooming are present, great importance is given to visual-spatial processing, and the processing of tactile information. The role of positive emotional reinforcement is great.

Thus, the use of physical buttons has a positive effect on work productivity and the development of tempo and accuracy, while virtual buttons and gestures have a positive effect on the development of tactile and visual-motor functions of fine motor skills, which is correlated to a greater extent with the performance indicators embedded in the Little House test. Furthermore, as the study has shown, excessive stimulation of functions related to tempo and accuracy during keyboard writing leads to a significant disruption of tactile and visual-motor interactions more typical for the use of touch screens.

Thus, the use of touch screens with tactile gestures by children is physiologically more justified than using a keyboard, since there is no disruption to the development of fine motor skill functions.

However, it is important to note that keyboard writing must be taught to develop the skill of productive work, which depends on the speed and accuracy of task completion.

CONCLUSIONS

Assessment of the impact of computer use on psychomotor development indicators revealed a correlation. When using a computer, a deterioration in fine motor skills was noted, the correlation coefficient (r) for the visual-motor coordination parameters and duration of computer use per day was 0.320 (p = 0.002). The correlation coefficient for the duration of computer use by primary school students and the final score of their psychomotor development was 0.235 (p = 0.028). The same result was obtained for the integrated assessment of fine motor skill development and its association with the duration of computer use per day (r = 0.253; p = 0.025).

Using touch screen devices does not negatively influence fine motor skills development based on the Little House test results.

The findings can be used in the development and substantiation of preventive technologies to prevent negative effects of digital devices on the development of fine motor skills in primary school children, especially in schoolchildren with the decreased psychomotor function indicators.

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