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Problems with graphomotorics at the beginning and the end of primary education

Jana Havigerova*, University of Hradec Kralove, Rokitanskeho 62, Hradec Kralove 500 03, Czech Republic
Irena Loudova, University of Hradec Kralove, Rokitanskeho 62, Hradec Kralove 500 03, Czech Republic
Iva Kosek Bartosova, University of Hradec Kralove, Rokitanskeho 62, Hradec Kralove 500 03, Czech Republic
Karolina Kocourkova, University of Hradec Kralove, Rokitanskeho 62, Hradec Kralove 500 03, Czech Republic
Dominika Podubecka, University of Hradec Kralove, Rokitanskeho 62, Hradec Kralove 500 03, Czech Republic

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Abstract

The study monitors two phenomena of graphomotor problems among children at the beginning and the end of primary education. The study has a character of piloting. A series of seven graphomotor tasks were submited to preschoolers (n = 51) and in the ninth grade (n = 22). For each task, tremor and number of hand move interruptions were considered as indicators of graphomotor difficulties. The results showed that the tremor was detected at 33.3% to 78.4% of preschoolers and at 18.2% to 59.1% of ninth grade pupils. In both groups, the tremor was the least prevalent in the 'teeth' task and the most frequent in the 'double upper-lower loop' task. The prevalence of tremor in the solution of graphomotor problems decreases with age, the difference is statistically insignificant. Contrary to the expectations, more interruptions were found at nineth grade pupils. Based on the study results, we recommend to note in the instruction that the templates are 'straight lines'.

Keywords: Graphomotor skills, graphomotor difficulties, tremor, number of interruptions, preschool children, adolescents, pilot study.

* **ADDRESS FOR CORRESPONDENCE: Jana Havigerova,** University of Hradec Kralove, Rokitanskeho 62, Hradec Kralove 500 03, Czech Republic. *E-mail address:* jana.havigerova@uhk.cz / Tel.: + 420 493 331 341

1. Introduction

The transition from kindergarten to elementary school is an important period for developing the fine motor skills and graphomotor skills. Children learn during their first years at school to develop their fine motor skills and become competent handwriters (Feder et al., 2005). Writing is a skill that must be developed.

The development of graphomotorics involves a number of partial skills, which determine the resulting drawing / writing performance. According to Del Giudice et al., 2000, the subtle abilities determining the drawing / writing performance can be divided into three groups: visual perceptual abilities, grapho-motor abilities and representational abilities. Moreover, performance obviously depends on the neuropsychological development of the child. Vasileva (2015) presented a study aimed at a neuropsychological assessment of the relationship between graphic skills and maturation of brain structures. In a group of N = 365 children (4–7 years old), she found out that most influential factor of graphic motor skills in the preschool period is age (results demonstrate a regular increase with the effect F (2, 346) = 48.143, p = 0.0000); but, 'the analysis of the results reveals some particularities in the development of kinetic organisation of the movements which depend on the maturation tempo of pre motor area in the frontal lobe in the left hemisphere. In fact, the development of the serial organisation of the movements is an important component of the general formation of psychic functions and especially speech activity (spoken and written)' (Vasileva, 2015, p. 20). A deficiency in any of the partial skills that determine the drawing / writing performance or the problematic maturation of brain structures that are responsible for the drawing / writing process can cause that the child might have difficulty drawing and consequently writing, and as a result he or she begins to fail at school. Early detection of children in risk is therefore essential.

Many authors (e.g., Vasileva, 2015, p. 17) point to the tendency 'that specialists and explorers predominantly pay attention to developmental problems in school age and the study of preschool age is insufficient'. Therefore, in our study we focus on two age periods, both of which characterise the moment of school transition stage: the pre-school age (i.e., before entering elementary school) and the ninth grade (i.e., before switching to secondary school). Early childhood (2–6 years old) is the time period when children develop and refine a wide variety of movement skills that have been developed from birth. During the preschool and early elementary years, there are rapid changes leading to an improvement in children's motor proficiency due to growth and maturation (Gallahue & Ozmun, 1998). Vasileva (2015) and other authors from the field of neuropsychology draw attention to asynchronous development of child's brain and different abilities of determining drawing / writing skills. Del Guidance et al. (2000) study shows, in accordance to other authors, that in various periods constructional abilities develop in the following order: visual perceptual abilities are increasing in pre-school age (the second wave of development is in later school years), representational skills develop during school attendance and grapho-motor skills evolve during the first year of schooling. For this reason, we chose pre-school children and not first-grade pupils as a research group. In adolescence, the graphomotor performance should be stabilised, this period is represented in our study by ninth grade pupils. Comparing these two age groups can provide valuable insights. According to the recent research, the prevalence of graphomotor problems is quite high although the authors disagree on a particular number. The literature suggests that the prevalence of dysgraphia in the school age population ranges from 5% to 30% (Kushki, Schwellnus, Ilyas & Chau, 2011; Rosenblum, Weiss & Parush, 2004; Smits-Engelsman & Van, 2001). As with other specific developmental learning disabilities, dysgraphia and graphomotor disorders also differ depending on gender, drawing / writing skills (construction abilities) are different according to gender. Rosenblum et al. (2004), for example, report that 11%–13% of female pupils and 21%–32% of male primary school pupils have difficulty in writing. In preschool children, gender difference was demonstrated, e.g., by Vasileva (2015, p. 20), who specifies 'A statistical influence is detected by reference to the crude rating and the gender factor (p < 0.04, providing F = 4.207). The higher rates are shown at the females than at the males'. Our study has the character of piloting with not a very large research group, so we will not analyse the calculations depending on gender, it is the limit of this study and the topic for future research. One of the issues discussed is also the relationship between graphomotor problems and intelligence. The study of Del Giudice et al. (2000, p. 366) performed on a group of *N* = 80 preschool children (3–5 years old) and *N* = 80 school age children (8–9 years old) shows that 'total scores were highly related to IQ, showing that the battery (testing visual perceptual, visual engine and grapho-engine abilities) was consistent with general intelligence performances'. The correlation can be interpreted by the fact that both skills share some similar sub-skills (e.g., visuoperative abilities, memory, executive functions, etc.). So there is no reason to consider intelligence as an intervening variable.

An important question in the study of graphomotorics is how to measure graphomotor skills, especially how to measure them in preschool age, which, as mentioned above, has remained until recently rather in the background of researchers' interest. The graphic performance of children is reflected in the so-called constructional tasks, where the child draws spontaneously and / or copy drawings (Del Giudice et al., 2000). The methods for measuring the graphics performance and the sub-skills that make this performance can also be divided into two groups—tests based on spontaneous drawing analysis and tests based on template drawing. In our study, we work with stimulus material of the second type—graphic performance analysis according to templates. This group of tasks is recommended for testing of graphic design skills in preschool age, e.g., Vasileva (2015, p. 23), who also recommends the following types of tasks for the development of graph skills: 'drawing of figures following a sample, completion of began figure, writing elements from letters within a margined space, outlining figures by connecting sets of dots,' etc.

De Giudice et al. (2000) used the following series of tasks in their study: visual scanning task, visual perceptual tasks, representational tasks, visual motor coordination task and executive (grapho-motor) tasks. Since we do not operate with partial assumptions of graphomotor performance in our study, we have chosen our own set of tasks, which by their nature correspond to visual-motor task. The author of the templates is an important Czech special pedagogue Jirina Bednarova (Bednarova & Smardova, 2006; 2011).

Note: In the research of the graphic performance and the subskills that make the above mentioned possible, a grip that can also play a role, may indicate difficulties on the one hand, and thus influence the course and outcome of the child's graphic activity. Although there are sufficiently valid and reliable grip measurement tools (e.g., Burton & Dancisak, 2000, who recommend using the Schneck and Henderson Grip Scale with a five-level scoring system for assessment for preschoolers), we have only tentatively recorded pathological grip, and we did not work with this information furthermore. For further research, more accurate grip measurement may be an additional element for analysing moderators or mediators of graphical performance, its determinants, and context.

2. Aim

This study has two aims:

1. To quantify the percentage of children in school transition periods (pre-school children and ninth grade pupils) with risk of graphomotor problems.
2. Determine how the graphomotor problems differ at preschool and ninth grade pupils.

3. Method

The study is conceived as a nonexperimental quantitative piloting.

3.1. Research tool

Graphomotoric difficulties are tested through graphical tasks. The children are gradually presented with seven templates containing drawing elements laid out on an A4 size paper. Respondents always have to draw a picture on a blank A4 paper so that it is as close as possible to the original template. Young children are said that this is a 'copier game'.

The templates were created and validated within the framework of the project GA18-16835S.

The templates have forms that imitate the basic forms of the letters of the Czech written template for continuous writing font:

TASK1—large archimedes spiral,

TASK2—small archimedes spiral,

TASK3—upper loops,

TASK4—lower loops,

TASK5—teeth,

TASK6—curves (rainbow),

TASK7—double upper-lower loops.

For the purposes of this study, graphomotor difficulties are operationalised as:

1. Tremor: the result line in the task is not merely a clear solid line, but contains slight or pronounced 'ripples', it is an external manifestation of the uncertainty of guiding the movement of the pencil on paper, while the cause of the tremor is not addressed; the variable reaches values of 0 (clear fixed line = no tremor), 1 (at times slight ripple of the line = slight tremor) and 2 (at times strong ripple or in the whole task slight / strong ripple of the line = strong tremor).
2. Interruptions: the number of movement interruptions during the task solution, the number of evident stops with the writing tool lifting, reaches values of 0 (the task was performed in one continuous move in accordance with the assignment), 1 to *n* (*n* = number of the move interruptions).

3.2. Procedure and research group

The research group was obtained through the availability of nonprobability sampling method (Nestor & Schutt, 2015, p. 115). Ninth grade pupils' parents and children from two pre-school departments of kindergarten were approached through a cooperating teacher to sign informed consent of the child's participation in the anonymised research. Out of the 79 parents addressed, 76 expressed written consent. The testing took place from April to June 2019. The children were tested face-to-face in a separate room (teacher's study). The administrator always introduced herself to the whole class and then summoned the children one by one to a separate test room. Administrator gradually submitted individual templates to the respondents and exchanged clean papers, on which the children made their own 'copies' of the templates. Every child received a small motivational reward after completing all seven tasks. Testing of one child took approximately 15 minutes.

Three children, whose parents agreed with their participation, were not present at school due to illness (2) and participation at the competition (1) was not tested. Data from 73 respondents were, thus obtained from a total of 79 addressed children. The G0 respondents were preschool children in the strict sense, i.e., children in the last year of pre-school education who participated in the enrolment in April and started primary school in September, NG0 = 51, average age 6; 6. The G9 respondents were adolescents who attended the ninth grade at the time of testing, attended the single entrance examination for secondary schools in April and entered secondary school in September, NG9 = 22, average age 15; 2. A total of 43 boys and 30 girls participated in the research; For the distribution of respondents in G0 and G9 by gender see Table 1.

Table 1. Research sample subgroups (grade and gender): descriptives (*N* = 73)

Gender	G0	G9	Total
1 boys	29	14	43
2 girls	22	8	30
Total	51	22	73

4. Results

All tables should be numbered with Arabic numerals. Headings should be placed above tables, underlined and centred. Leave one-line space between the heading and the table. Only horizontal lines should be used within a table, to distinguish the column headings from the body of the table. Tables must be embedded into the text and not supplied separately.

Table 2. Tremor and number of interruptions: group descriptives (NG0 = 51, NG9 = 22)

Tremor	G0 % no problem	G0 % at risk	G9 % no problem	G9 % at risk	Interruptions	G0 % no problem	G0 % at risk	G9 % no problem	G9 % at risk
TASK1	49.0	51.0	45.5	54.5	TASK1	84.3	15.7	45.5	54.5
TASK2	51.0	49.0	54.5	45.5	TASK2	84.3	15.7	54.5	45.5
TASK3	49.0	51.0	50.0	50.0	TASK3	76.5	23.5	36.4	63.6
TASK4	37.3	62.7	59.1	40.9	TASK4	64.7	35.3	50.0	50.0
TASK5	66.7	33.3	81.8	18.2	TASK5	88.2	11.8	45.5	54.5
TASK6	64.7	35.3	54.5	45.5	TASK6	60.8	39.2	50.0	50.0
TASK7	21.6	78.4	40.9	59.1	TASK7	47.1	52.9	22.7	77.3
Min-max	21.6-66.7	33.3-78.4	40.9-81.8	18.2-59.1	Min–max	47.1-88.2	11.8-52.9	22.7-54.5	45.5-77.3
Mean	48.5	51.5	55.2	44.8	Mean	72.3	27.7	43.5	56.5

It is apparent from Table 2 that the tremor as a risk factor appears on average in about half of the research group of both pre-schoolers and ninth grade pupils. Interruptions appear as a risk factor only about one-fourth at pre-schoolers unlike the half of ninth grade pupils.

Table 3. Tremor and number of interruptions: group descriptives (NG0 = 51, NG9 = 22)

Task_feature	Mean G0		Mean G9	SD G0	SD G9	SE G0	SE G9
TASK1_tremor	0.569	≈	0.591	0.608	0.590	0.085	0.126
TASK1_interrupt	0.216	<	1.000	0.541	1.380	0.076	0.294
TASK2_tremor	0.569	≈	0.545	0.640	0.671	0.090	0.143
TASK2_interrupt	0.196	<	0.682	0.491	0.945	0.069	0.202
TASK3_tremor	0.667	≈	0.636	0.739	0.727	0.104	0.155
TASK3_interrupt	0.765	<	1.455	2.566	1.845	0.359	0.393
TASK4_tremor	0.863	>	0.591	0.775	0.796	0.109	0.170
TASK4_interrupt	0.706	<	1.409	1.254	1.943	0.176	0.414
TASK5_tremor	0.353	>	0.182	0.522	0.395	0.073	0.084
TASK5_interrupt	0.255	<	3.000	1.036	3.867	0.145	0.824
TASK6_tremor	0.392	<	0.545	0.568	0.671	0.080	0.143
TASK6_interrupt	1.765	<	2.409	3.386	2.873	0.474	0.612
TASK7_tremor	0.961	>	0.773	0.631	0.752	0.088	0.160
TASK7_interrupt	1.941	<	2.409	2.989	2.906	0.419	0.620

From Table 3, we can see that the average tremor values in the pre-school group are approximately equal for task 1, 2 and 3, higher for task 4, 5, 7 and 9 and surprisingly lower for task 6 (arches alias rainbow). Table 3 further shows that the average values of the number of interruptions in the group of pre-schoolers are surprisingly lower, i.e., in all the monitored tasks, the ninth grade pupils achieved in average higher number of interruptions in all tasks.

Table 4. Differences in tremor pre-schoolers versus ninth grade pupils: Mann–Whitney U test (*N* = 73)

Independent samples *T*-test	W	p	Rank-Biserial Correlation	95% CI Lower	95% CI Upper
TASK1_tremor	546.000	0.844	−0.027	−0.307	0.258
TASK2_tremor	576.000	0.845	0.027	−0.258	0.307
TASK3_tremor	571.500	0.895	0.019	−0.265	0.300
TASK4_tremor	673.500	0.148	0.201	−0.087	0.457
TASK5_tremor	648.000	0.186	0.155	−0.133	0.419
TASK6_tremor	496.000	0.364	−0.116	−0.386	0.172
TASK7_tremor	648.000	0.248	0.155	−0.133	0.419

Table 4 documents the test results of the two groups' comparison in terms of the variable tremor for each individual template. From the results, we can see that no statistically significant difference between the group of pre-schoolers and the group of ninth grade pupils was found in any of the tested graphomotor models.

Table 5. Differences in interruptions pre-schoolers versus ninth grade pupils: Mann–Whitney *U* test (*N* = 73)

Independent samples *T*-test	*W*	*p*	Rank-Biserial Correlation	95% CI Lower	95% CI Upper
TASK1_interrupt	340.500	< .001	−0.393	−0.608	−0.124
TASK2_interrupt	390.000	0.006	−0.305	−0.541	−0.024
TASK3_interrupt	336.500	0.002	−0.400	−0.613	−0.132
TASK4_interrupt	450.500	0.133	−0.197	−0.454	0.091
TASK5_interrupt	300.500	< .001	−0.464	−0.660	−0.209
TASK6_interrupt	480.500	0.284	−0.143	−0.410	0.145
TASK7_interrupt	436.000	0.120	−0.223	−0.476	0.064

Table 5 demonstrates the test results for the comparison of the two groups for the interruptions variable for each individual template. From the results, we can see that statistically significant difference between the group of pre-schoolers and the group of ninth grade pupils was found in graphomotoric models task 1, task 2, task 3 and task 5. From Table 3, we know that in all these tasks the ninth grade students reached in average higher number of interruptions than pre-schoolers.

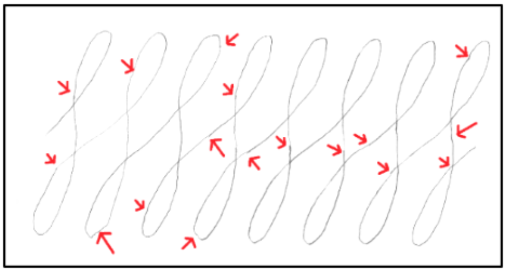

Figure 1. Respondent number HK1915—many problematic graphomotor elements at task 7 lower-upper loops

5. Discussion

This study had two objectives. The first objective of the study was to quantify the estimated prevalence of children in school transition periods (preschool children and ninth grade pupils) at risk of graphomotor problems. Graphomotor problems were operationalised as tremor and interruptions in simple graphomotor tasks.

Our study showed that the tremor in the line occurs at pre-schoolers in the range of 33.3–62.7%, at ninth grade pupils in the range of 18.2%–59.1%, depending on the template. The literature suggests that the prevalence of dysgraphia in the school age population ranges from 5% to 30% (Kushki, Schwellnus, Ilyas & Chau, 2011; Rosenblum et al., 2004; Smits-Engelsman & Van, 2001). Percentage is about 11%–13% of pupils and 21%–32% of primary school pupils who experience difficulty in writing (Rosenblum et al., 2004). Our results show a higher prevalence than reported in the literature, but we have to consider that we are deducing by a single indicator (in this case tremor) in a single task.

Looking at the results in more details, the lowest percentage of children whose line has the tremor mark appears in a single task of drawing straight lines. When tasks require curve drawing, the percentage of children whose line shows a tremor increases by two to three times. This is an interesting result because classic arguments for cursive handwriting were based on the beliefs that are easier for children to make curved lines than straight ones, that the cursive movements follow naturally from scribbling, and that cursive is fewer pen lifts than manuscript and is faster (Schwellnus, Cameron & Carnahan, 2012). On the contrary, based on the results of this piloting, it appears that the curves are more difficult and the straight lines are easier and that the tremor in the straight lines can therefore more reliably indicate difficulties in fine / graphomotor. Since the percentage of children with tremor in a straight line task is the lowest, we also consider tremor in straight lines as the most reliable indicator of the risk prevalence of graphomotor problems. However, only further research can support the correctness of this opinion.

The most difficult in terms of tremor in this study was task 7 containing four alternately upper and lower loops flowing sequentially. In addition, the tremor in this task can be influenced by the interaction of emotions—the task is difficult, the first error or hesitation occurred after the first loop, which could trigger negative emotions (starch, rage, tension, etc.). Negative emotions deactivate motor-skill areas in the brain, anxiety affects movement in both gross and fine motor tasks (Causer, Holmes, Smiths & Williams, 2011); under load tremor appears at part of the paediatric population (Pesova & Samalik, 2006).

Interruptions as a risk factor in the drawing appear at pre-schoolers in the range of 11.8%–52.9%, at ninth grade pupils in the range of 45.5%–77.3%. At pre-schoolers this is about the same range as for the tremor, while for the ninth grade pupils the result is shifted to almost double minimum and maximum values than for tremors, as compared to pre-schoolers. How is it possible that the interrupted line showed such a high (almost double) percentage of drawings of the ninth grade pupils? Suppose that the proportion of children with graphomotor difficulties is the same in the population of ninth grade pupils. The higher occurrence of interruptions in drawings according to our models must then be the result of the participation of other intervening variables. One such variable may be the size of the original in this study, which was about 10 cm in height. Graphomotor exercises of this size are standard in preschool age, while in primary school children practice basic shapes in the first grade, in the third grade the font between rows, while the inter-row height decreases gradually from 14 to 10 mm (the result of the actual measurement of n = 14 Czech copybooks accredited by the Ministry of Education for primary education). Therefore, we believe that the ninth grade pupils probably quitted fine-motor movements to a greater extent than interlinear spaces, which could have contributed to a higher number of interruptions while drawing larger templates. In the second place, the manner of the accomplishment could have been influenced by the interference of past experience, in which case, in our opinion, the experience / habit of some ninth grade pupils could lead to the use of cursive handwriting that is discontinuous. Why? All ninth grade pupils in the research group had as a written template for learning the continuous writing (they all were encouraged to write words in one move in the first grade). In the Czech school system, however, the similarity of writing to the template is required by the third grade, until when writing is graded. From the fourth grade onwards, pupils can write in any way; Czech children create their own manuscript since the fourth grade. In our ninth grade pupils group 72.7% (!) use cursive handwriting for dictations. We did not find out whether there is a relationship between spontaneous use of cursive handwriting and tremor in tasks with rounded continuous moves, but this is a hypothesis suitable for further research. Last but not least, the number of interruptions in the drawing of ninth grade pupils could be more strongly intervened in the drawing process by some personality characteristics. We mean, for example, perfectionism, pursuit of efficiency or laziness—it is easier and more reliable to interrupt moves for some tested tasks to achieve the optically correct result (in the same drawing). For tasks 5 and 6, interruptions are obvious at the vertices (teeth and arcs). For other tasks there are no clear areas for stopping and linking in the template, but ninth grade pupils may already have the feeling of making an interrupted line so that they may have the impression the resulting interrupt shape will not be visible, and are therefore more freely interrupting moves to achieve a better result. The interruption allows the hand or pen position to be moved to a position that facilitates accurate movement. Let us remind that the instruction did not explicitly state that the tasks should be solved as 'single lines'.

From the results of this study, the section on interruptions, one might also conclude that the prevalence of age-related problems even increases from approximately ¼ to nearly ½ children (minimal prevalence pre-schoolers → ninth grade pupils: tremor 33.3 → 18.2; interruptions 11, 8 → 45.5), which would sound alarming. However, based on the suggested interpretations, we conclude that the number of interruptions in the design study used is not a reliable indicator of the prevalence of difficulties. It could only happen if the respondents were clearly told in the instruction that they should copy the drawing in a single line.

The second research question focused on the differences between pre-schoolers and ninth grade pupils in the monitored graphomotor indicators. Regarding tremor, the prevalence in both studied groups was approximately the same for all the tasks tested (no statistically significant difference was found). Let us repeat that tremor as a risk factor appears on average in about half of the research group of both pre-schoolers and ninth grade pupils. Interruptions as a risk factor occurred in only about one quarter of pre-schoolers unlike half of ninth grade pupils, the differences were statistically evident in task 1 (large Archimedes spiral), 2 (half Archimedes spiral), 3 (upper loops) and 5 (teeth). To accomplish all these tasks, ninth grade pupils demonstrably needed more moves than pre-schoolers. For the interpretation of the differences found, see the discussion above. To sum up, a greater number of move interruptions with the writing tool at ninth grade pupils could have been caused by the interference of the following: 1. ninth grade pupils have ceased to draw larger shapes, their graphomotorics is predominantly in-line spacing, 2. ninth grade pupils can create their own manuscript from grade 4, a significant percentage prefer discontinuous cursive handwriting, 3. more developed and strengthened personality characters such as perfectionism or laziness (it is easier to achieve the perfect shape by interruption when the respondent notices that the move is not perfect), 4. the respondents were not told that the drawings should be made as 'single lines'.

6. Conclusion

It is desirable to monitor graphomotor problems from pre-school age. They may indicate a number of less or more serious problems (memory disorders, visual disturbances, learning disorders, organicity, epilepsy, etc.). Especially, in the school educational process, they may be involved in underachievement or failure in the performance of a pupil, and may be negatively impacted on their experience and behaviour. The results of our study show that the prevalence of graphomotor problems based on tremor tracking in line copying can be nearly 50% in both pre-school and ninth-grade adolescents. It has also been shown that the number of line interruptions is probably an unreliable indicator of graphomotor difficulties. In order to better assess its possible use for this purpose, it should be emphasised when assigning tasks that these are tasks whose solution should be a single line. New research questions have also arisen, among which the most interesting are the more detailed assessment of the differences between straight and rounded line drawings and the differences in their potential to predict children 's graphomotor difficulties and to verify whether there is a correlation between cursive handwriting preferences and number of interruptions in tasks requiring more single movement. We consider the issue of graphomotor difficulties and possibilities of early identification of children in risk to be always actual and open to new research.

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