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Original Article

FINE MOTOR SKILLS IN THE DIGITAL AGE: THE ROLE OF GRAPHIC EXPRESSION IN AN EXPLORATORY STUDY

A MOTRICIDADE FINA NA ERA DIGITAL: O PAPEL DA EXPRESSÃO GRÁFICA NUM ESTUDO EXPLORATÓRIO

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RESUMO
O desenvolvimento das tecnologias digitais transformou profundamente os hábitos quotidianos, envolvendo os alunos do pré-escolar e do 1º ciclo do ensino básico, que utilizam cada vez mais ferramentas digitais para actividades como a escrita e o desenho. Como resultado desta mudança, verifica-se um enfraquecimento crescente de competências que eram consideradas normais no desenvolvimento infantil até há algumas décadas atrás, como a coordenação motora fina. A amostra é constituída por 60 crianças com idades compreendidas entre os 5 e os 11 anos que frequentaram um campo de férias. O objetivo do estudo é avaliar os níveis de motricidade fina relacionados com a representação gráfica do desenho no contexto de actividades físicas lúdicas e recreativas típicas de ambientes informais de aprendizagem. O método envolveu a administração do Teste Hand to Shape, analisando 3 áreas específicas: Espaço, Organização Grafo-motora e Qualidade Motora. Os resultados mostraram que 87% da amostra foi globalmente adequada, na área do espaço 65% foram inadequados. Da análise estatística da correlação de Pearson, verificou-se que o coeficiente de correlação entre a idade e a pontuação da qualidade motora é de r = 0,580244, enquanto o valor de r entre o tempo e a pontuação global é de -0,0176. Os resultados do estudo confirmam que uma boa percentagem de crianças mantém capacidades físicas adequadas. No entanto, surgiram várias questões críticas relacionadas com valores baixos, como as competências visuo-espaciais, a qualidade motora e a postura, indicando deficiências evidentes na motricidade fina.
Palavras-chave: educação física. desenho. testes.

ABSTRACT
The development of digital technologies has profoundly transformed daily habits, involving preschool and primary school students, who increasingly use digital tools for activities such as writing and drawing. As a result of this change, there is a growing weakening of skills which were considered normal in child development until a few decades ago, such as fine motor coordination. The sample consists of 60 children aged between 5 and 11 who have attended a summer camp. The purpose of the study is to assess the levels of fine motor skills related to the graphic representation of drawing within the context of playful and recreational physical activities typical of informal learning environments. The method involved the administration of the Hand to Shape Test, analyzing 3 specific areas: Space, Grapho-motor Organization and Motor Quality. The results showed that 87% of the sample was overall adequate, in the space area 65% were inadequate. From the statistical analysis of Pearson's correlation, it emerged that the correlation coefficient between age and motor quality score is r = 0.580244, while the value of r between time and overall score is -0.0176. The study results confirm that a good percentage of children maintain adequate physical skills. However, several critical issues relate to low values, such as visuo-spatial skills, motor quality and posture, emerged, indicating evident deficiencies in fine motor skills.
Keywords: physical education. drawing. testing.

Introduction

The developmental age range between 5 and 11 years is characterized by rapid physical and cognitive development, essential elements for understanding how children acquire and refine physical skills, specifically fine motor skills, which are indispensable for many daily activities, including drawing and writing[1]. This period represents a very important phase for building these skills, which are closely intertwined with children cognitive and perceptual development. During this age, physical coordination, spatial organization skills and movement planning are refined[2]. Fine-motor coordination refers to the ability to control small body muscles, particularly those in the hands and fingers, to perform precise movements[3]. These skills are essential for many activities of daily life, such as graphic representation, the use of tools, and other actions requiring precision and dexterity[4].

Within the framework of human movement theory, studying fine-motor coordination is fundamental to understanding how the central and peripheral nervous systems integrate physical and sensory signals to produce smooth and coordinated actions[5]. Human movement results from a complex integration process between the central nervous system, muscles and the sensory system[6]. Bernstein was one of the first scholars to develop a motor control theory explaining how the brain manages the multiple variables involved in movement[7]. According to Bernstein, the central nervous system faces a “movement redundancy”, meaning there are multiple ways to achieve the same motor goal[8]. In fine-motor coordination, redundancy relates to how the brain selects the optimal movement pattern to perform specific tasks precisely.

Later theories of fine-motor skills focus on the close interconnection between physical, cognitive and emotional development[9]. According to the theory of physical and cognitive co-evolution, the development of fine-motor skills is closely linked to the growth of cognitive skills[10]. In this view, physical skills do not develop independently, but in parallel and in synergy with cognitive skills, particularly executive functions, which include planning, working memory and inhibitory control. Recent studies have highlighted that movements, such as using hands to manipulate objects, directly stimulate brain areas related to complex cognition, demonstrating how motor development supports problem solving and non-concrete thinking abilities[11].

The dynamic motor control theory, one of the most recognized in contemporary research, suggests that fine-motor skills are not pre-programmed in the brain, but emerge through the interaction between the nervous system, body and environment[12]. This model proposes that motor control does not follow rigid patterns, but is flexible and adaptive, based on constant feedback from the environment. Another key concept in the study of fine-motor skills is the ‘body schema’. This theory argues that motor development is closely connected to body awareness in space[13]. Fine-motor skills depend on the brain's ability to create an internal map of the body, allowing it to monitor and control hand and finger movements in relation to external objects[14]. Problems in the development of a correct body scheme can lead to difficulties in the coordination of movements[15].

The theory of brain plasticity states that the brain can modify its structure and functionality in response to experience and training[16]. This is particularly relevant for fine-motor skills, as repeated practice and specific activities can foster the development of neural connections that improve the movement precision and fluidity. Recent studies have shown that activities such as drawing, handwriting and using musical instruments can induce structural changes in the brain, improving coordination and related cognitive skills[17].

Informal learning contexts, including summer camps, can be ideal environments for skill development as they combine playful aspects with the application of specific tasks[18]. In these contexts, children are involved in manual, playful and physical activities that spontaneously stimulate psychophysical development, even for more precise and refine tasks, and consequently cognitive development through interaction with others and experiential learning[19].

The digital revolution that has impacted society for several years has certainly brought significant positive changes to students' learning, but at the same time it has privileged certain tasks, such as digitalization, at the expense of others, such as writing and drawing[20]. This has led to the loss of some movements requiring finer, more precise manual dexterity and therefore a specific fine-motor coordination competence, which is important because it is related to the acquisition of other knowledge in various subjects that require essential elaborative processes[21].

The development of physical and cognitive skills in children through writing and drawing, has a direct transferability with the improvement of skills such as language, logicalmathematical, iconic and representative ones, transforming them over time into complex competences that favor academic success and personal growth. Skills that were normal and acquired in children until a few years ago are now compromised. There is no longer the ability to control the small muscles of the body, particularly the hands and fingers, to perform precise movements[22].

These skills are essential for many daily activities, such as graphic representation, using tools, and other actions that require precision and dexterity. Furthermore, in the scientific literature there is a lack of studies on the correlation between fine-motor skills and grapho-motor skills, and there are no validated ad hoc tests to exclusively analyse these aspects.

The purpose of the study is to assess the levels of fine motor skills related to the graphic representation of drawing within the context of playful and recreational physical activities typical of informal learning environments, with specific measurement and comparison with the average performance levels reported in the literature.

Methods

Sample

The study involved 60 children (26 girls and 34 boys) aged between 5 and 11 years, recruited from a four-week summer camp offering sports, creative workshops, and recreational activities. Participation was voluntary and based on parental consent. Children were included if they were within the required age range, regularly enrolled in the camp, and had no history of neurological, visual, or musculoskeletal disorders that could interfere with motor performance. Exclusion criteria were previously diagnosed developmental disorders, uncorrected visual impairments, or lack of parental consent. Of the 68 children initially attending the camp, 62 met the eligibility criteria; two were excluded due to visual impairments, resulting in a final sample of 60 participants. No dropouts occurred during the study.

Procedures

For this study, the Hand to Shape test was employed, differentiating three areas and eight parameters that precisely indicate the child's graphic action. Each parameter defines relevant aspects of the graphic trace, allowing for a detailed investigation of the evolution and motor difficulties involved in the process of graphic representation. This is a standardized test specifically designed to assess graphomotor skills in children, with a particular focus on fine motor coordination and the ability to organize the movements required for writing and drawing. Its significance is especially evident within the context of psychomotor evaluation, where it is used to identify potential difficulties related to motor and visuospatial developmental disorders.

Scientifically, several standardized tests exist to assess children's ability to copy shapes, including the Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI), which measures visual-motor integration through the copying of geometric shapes with increasing complexity; the Denckla-Benton Test, which evaluates visual-motor coordination and copying skills; the Developmental Test of Visual Perception (DTVP-3), which analyses various components of visual perception and visual-motor integration; and the Bender Visual-Motor Gestalt Test, used to identify difficulties in visual perception and motor coordination through figure reproduction.

In this study, the Hand to Shape test was chosen because it allows for an accurate evaluation of the various areas involved in copying ability, offering a more detailed analysis. This approach contributes further to existing research by exploring less investigated aspects within the scientific literature. Through this test, it is possible to systematically identify potential difficulties in graphic representation that may be linked to conditions such as dysgraphia, characterized by disorganized and non-fluid handwriting; dyspraxia, involving difficulty in executing coordinated and intentional movements; and visuospatial disorders, which can impair the ability to orient and structure graphic space.

Within the study, the test was used to analyse aspects closely related to graphomotor representation, focusing on the evaluation of drawing as an indicator of children’s motor and perceptual skills. The choice of this tool is particularly relevant given the target age group, between 5 and 11 years, a critical period for writing development, during which children refine fine motor control and acquire more structured movement patterns. Through the analysis of parameters such as spatial organization, fluidity of the trace, and overall movement quality, the test helps to identify possible signs of difficulty.

The Hand to Shape test enables a detailed exploration of the motor skills involved in writing and drawing, proving to be a reliable tool for planning appropriate support and intervention strategies. The collection and analysis of data related to the various reference areas offer the opportunity to deepen the assessment of participants' developmental levels, demonstrating the connection between motor components and the quality of graphic representation. In this way, the test allows for monitoring the development of children's fine motor abilities in relation to their skill in drawing shapes and graphic structures, with important implications for identifying any inadequacies. This activity results from the coordination between visual-motor skills and the mental representation of the figure to be reproduced. The Hand to Shape Test was administered individually in a quiet room during morning camp activities, using standardized materials. Two specialists in physical education with prior experience in child motor assessment conducted the test. Before data collection, both examiners attended a refresher training session to ensure consistent procedures. Instructions were delivered following the test manual, and all children performed the task under identical conditions of setting and materials. In addition to the quantitative assessment prescribed by the test manual, qualitative aspects of performance were also systematically recorded using a structured observation grid. Posture was classified as correct (upright and symmetrical alignment) or incorrect (leaning, rotated, asymmetrical). Grip was categorised according to the typologies established by the Test (tripod, pincer, wrapped thumb, clamp). Pressure exerted on the sheet was described qualitatively, following the standardised indications, as light, elevated, regular or irregular, based on the visual inspection of the graphic trace. The order in which the figures were copied was noted, distinguishing between a correct or incorrect sequence in relation to the model. Each observation was independently recorded by the two raters, and discrepancies were resolved by consensus, thus ensuring reproducibility and reliability in the assessment process.

The task consists of an organized copying activity of 19 figures. The sheet with the model figures was placed horizontally in front of each child, who, while seated, copied the model figures (shown in Figure 1) onto a blank A4 sheet, also placed horizontally, with only two reference lines (shown in Figure 2), using a pencil.

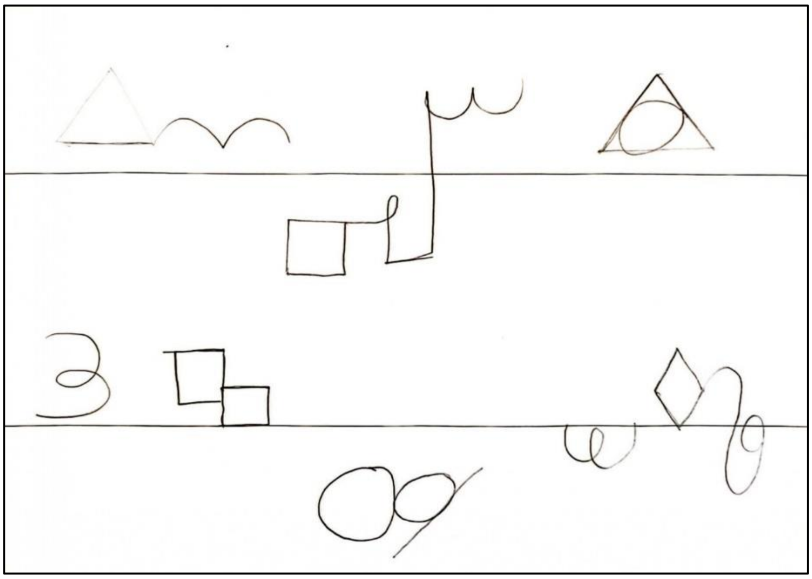

Figure 1. Model figures
Source: The authors.

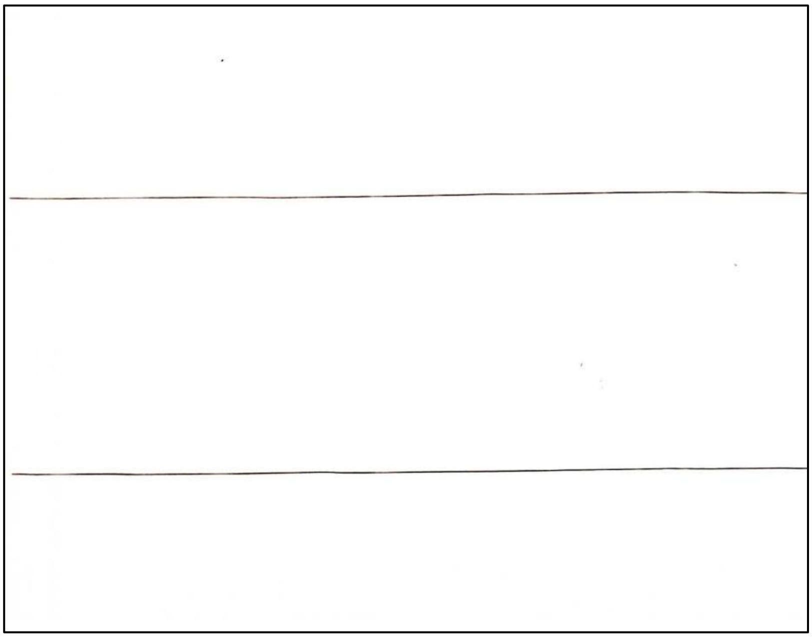

Figure 2. White A4 sheet
Source: The authors.

Before starting the task, the figures to be drawn were indicated on the model, and any spontaneous comments made by the subject during observation were listened to. During the execution, the time taken (in seconds) was also recorded, and observations were made regarding the hand used and the children's emotional state. Subsequently, scores were assigned based on the scoring tables provided in the reference manual. What is assessed from a qualitative-quantitative perspective is the level of correspondence between the drawn figure and the model figure.

The tool allows for the investigation of three areas: Space, Graphomotor Organization, and Motor Quality. All of this is presented in Figure 3.

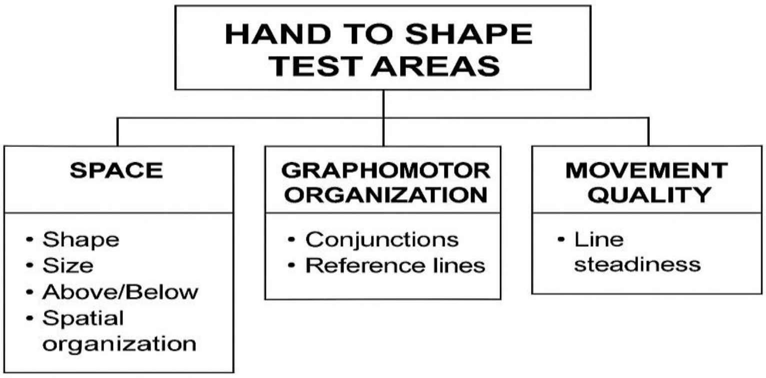

Figure 3. Areas and corresponding parameters assessed in the Hand to Shape Test.
Source: The authors.

For each area, various parameters can be qualitatively and quantitatively analysed and assessed using rating scales that reflect the maximum and minimum reproducibility of the drawing in the different evaluation domains.

Assessment of the parameters in the Space area:

- Shape: the child's drawing is compared with the model figure (score from 0 to 3; which in the conversion tables of the Test can reach a maximum of the 57th percentile)
- Dimensions: the Euclidean spatial components in the dimensions of polygons and open lines are evaluated using the provided transparencies (score from 0 to 2; maximum score: 38th percentile).
- Above/Below: assesses the arrangement of individual and composite figures in relation to the two reference lines (score: 0 or 1; maximum score: 11th percentile).
- Overall Spatial Organization: evaluates the correct placement of composite figures within the page space, using a transparency provided with the test (standardized score from 0 to 3, which in the test's conversion tables can reach a maximum of the 27th percentile).

Assessment of the parameters in the Graphomotor Organization area:

- Connections: assesses the accuracy of connection points between one figure and another, using a ruler (score from 0 to 2; maximum score: 24th percentile).
- Reference Lines: evaluates the accuracy of the contact points of the figures with the two reference lines (score from 0 to 2; maximum score: 14th percentile).
- Extension/Non-closure: assesses the accuracy of the closure of regular polygons (2 triangles, 3 squares, 2 diamonds, 4 circles) (score from 0 to 2; maximum score: 22th percentile).

Assessment of the Motor Quality parameter:

- Line Confidence: evaluates the steadiness of the line, which should not show tremors, changes in direction, interruptions, retracing, or excesses. This is done by comparing the drawing with numerous examples provided in the manual and through observation during the task. Pressure applied on the paper is also described qualitatively.

The steadiness of the graphic line and the pressure applied are described qualitatively because these aspects are closely linked to the subject’s psychomotor and emotional characteristics and cannot be easily quantified objectively due to individual variability and emotional and psychological components. Experts assess these features descriptively, considering variations in the line (tremors, discontinuities, sudden changes in pressure), which can provide richer qualitative insights than a simple numerical value. Hand pressure is not easily measurable in quantitative terms without specific instruments, and the graphic trace may include subtle variations that are not easily categorized with rigid scoring criteria.

Through the reproduction of geometric shapes, the child is required to organize their movements according to the spatial relationships between the various forms, maintaining precise topological, projective, and Euclidean relations in connection with the space on the page.

This approach offers a detailed perspective not only on motor development but also on how the child interacts with space and plans their movements. The whole can be seen in figure 4.

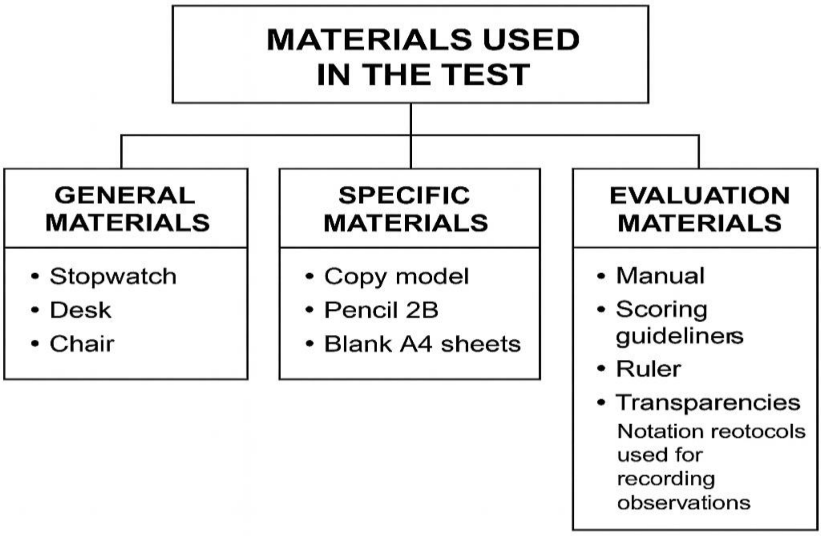

Figure 4. General, specific and evaluation materials used for the administration of the Hand to Shape Test

Source: The authors.

Informed consent was signed and obtained by parent/tutor of all subjects involved in the study. The study was conducted in accordance with the Declaration of Helsinki. According to Regulation (EU) 536/2014 and Directive 2001/20/EC, research involving minimal risks for participants may be exempted from formal ethical review, as it does not involve invasive or experimental interventions. Furthermore, pursuant to Legislative Decree No. 211 of 24 June 2003, research that does not present significant risks and that aims exclusively to improve educational practices may be exempted from review and approval by the Institutional Review Board (IRB) or the Ethics Committee.

Raw scores obtained for each parameter of the Hand to Shape Test were converted into percentiles according to the normative reference values reported in the official manual. For each participant, the scores of the three areas (Space, Graphomotor Organisation, and Motor Quality) were first standardised and subsequently combined into a global index. The calculation of this index followed the weighting procedures indicated in the manual, whereby the contribution of each area is balanced to obtain a comprehensive indicator of performance. This approach explains why, despite the high proportion of inadequate results in the Space domain, the global score showed overall adequacy in most of the sample, as strong performance in Graphomotor Organisation and Motor Quality compensated for spatial difficulties.

Statistical analysis

A qualitative-quantitative analysis was carried out. After acquiring the (copy) tasks performed by the children, the individual parameters of each area were analysed, following the guidelines provided in the manual. Scores were assigned to each parameter (using variable minimum and maximum ranges and scores depending on the parameter taken into consideration) which determined the raw score of the reference area. Each area's raw score was then translated into a decimal score, which was then converted into percentiles, thus obtaining a classification of performances that can be considered, according to the comparison of the updated values present in the literature.

- Adequate, when the score corresponds to a percentile equal to or higher than the 16th;
- At risk, when the score corresponds to a percentile in the range between the 6th and the 15th;
- Inadequate, when the score corresponds to a percentile equal to or lower than the 5th.

The data were summarized and described in terms of frequency and percentage. In order to evaluate the psychometric quality of the tool within our sample, additional reliability analyses were performed. Internal consistency was examined using Cronbach's alpha for each of the three domains, while inter-rater reliability was estimated through intraclass correlation coefficients (ICC) for quantitative scores and Cohen's Kappa for categorical observations (posture, grip, pressure, order of copying). Measurement error was calculated using the Standard Error of Measurement (SEM), providing an estimate of the precision of the observed scores. These indicators support the reproducibility and robustness of the findings obtained in this study. Additional statistical analyses were carried out in order to further explore the results and ensure greater methodological robustness. Mean values (M), standard deviations (SD), and 95% confidence intervals (95% CI) were calculated for the whole sample as well as for subgroups divided by age and sex. To compare boys and girls, an independent-samples t-test was used, also reporting the effect size (Cohen's d) to quantify the magnitude of the differences. To examine performance trends across the different age groups, a one-way ANOVA was conducted, followed by an analysis of covariance (ANCOVA) to simultaneously control for the effects of age and sex on the dependent variable. In this case, unstandardised regression coefficients (B), standard errors (SE), t statistics, significance levels (p), and the coefficient of determination (R^2) were reported. Pearson correlation was then calculated to verify any positive, negative or neutral correlations between two variables with different units of measurement.

Results

In addition to percentage data, the analysis also considered descriptive statistics of the scores in the different test domains. Overall, the global score showed mean values of 60.8 SD = 7.9; 95% CI [58.8–62.9]). Among the domains, the Space area reported the lowest results, with a mean of 40.1 (SD = 15.4; 95% CI [36.1–44.1]), while Motor Quality (M) = 68.0; SD = 12.7; 95% CI [64.8–71.3]) and Graphomotor Organization (M = 74.3; SD = 13.8; 95% CI [70.7–77.9]) recorded higher scores, outlining a profile in which visuospatial skills appear as the most critical aspect. The comparison between boys and girls using t-tests did not reveal significant differences, t (58) = .58, p = .563, with a very small effect size (Cohen's d = 0.15). The whole can be seen in Table 1.

Table 1. T-test between boys and girls on the global score

Sex	N	Mean	Sd
Female	26	60.14	7.67
Male	34	61.34	8.1

Note: Independent samples t-test comparing boys and girls on the global score revealed no significant differences, t statistic del Student's t-test (t) (58) = 0.58, p = .563. The effect size was very small (Cohen's d = 0.15), indicating negligible differences between sexes.
Source: Authors

Likewise, the analysis of variance across age bands (5–6, 7–8, and 9–11 years) did not reach statistical significance, F statistic of ANOVA (*F)* (2,57) = 1.64, p = .203, although it suggested a gradual improvement trend with age. This is shown in table 2.

Table 2. ANOVA across age groups on the global score

AgeGroup	count	mean	Sd
5-6	27	58.97	8.32
7-8	15	61.24	6.1
9-11	18	63.23	8.18

Note: The ANOVA across age groups was not significant, F (2,57) = 1.64, p = .203.
Source: Authors

An analysis of covariance (ANCOVA), which jointly considered age and sex, confirmed that age was a significant predictor of the global score, unstandardized regression coefficient (*B)* = 1.13, p = .035), whereas sex showed no relevant effect (p = .405). The model accounted for about 8% of the total variance (Coefficient of Determination (R^2) = .08), indicating that additional factors beyond age may contribute to explaining performance differences. Taken together, these analyses confirm that age represents an important, though not exclusive, factor in the development of fine motor skills. Gender differences, on the other hand, appear negligible. Particularly noteworthy is the variability observed in the Space area, as reflected in the wide confidence intervals: this finding suggests that visuospatial difficulties are not generalized but tend to cluster within specific subgroups of children, who therefore deserve targeted attention. This is shown in table 3.

Table 3. ANCOVA: predictors of the global score

Predictor	B	Se	T	P
Intercept	51.422	4.312	11.926	.0
Age	1.127	.523	2.157	.035
Sex	1.692	2.015	.84	.405

Note: Age was a significant predictor of the global score (p = .035), whereas sex was not (p = .405). The model explained 8% of the variance. Se= Standard Error
Source: Authors

From the data analysis, the following findings emerged:

- Global score: a low percentage had inadequate performance 5.3%, 7% are at risk while 87% of participant had adequate performance.
- Motor Quality: 91.7% had adequate motor quality while 3.3% are inadequate and 5% are at

risk.
- Space: 65% had inadequate performance, 15% are at risk and 20% of participant had adequate performance.
- GraphoMotor Organization: 96% of participants show adequate performance ,3.4% were inadequate, none were at risk.
- Age distribution Percentages: there was a concentration of younger children, 26.70% of 6 years old, 11.70% of 7 years old and 20% of 9 years old.

Dominant hand percentages: the predominance was the right hand, with 95% of the participants.
- Time taken percentages: most participants completed the test within adequate times.

From the qualitative evaluation of the data, the following results emerged:

- Posture: the majority (70%) of the participants had correct posture, while 30% did not.
- Grip: the distribution of the grip types shows “Wrapped thumb" as the most common type used (36.7%), followed by the "Static tripod" (28.3%) and “Pincer grip (26.7%).
- Order of copying the figures: 66.7% of participants followed the correct order of copying the figures, while 33.3% did not.

From the relationships between the variables analysed through the Pearson correlation, what emerged is:

- Relationship between time and global score: The correlation between time and global score is $r = -.0176$, a value very close to zero. This indicates that increasing or decreasing the time does not directly affect the score in a predictable way. In practice, a slight increase in time may be associated with a slightly lower score, but the effect is negligible.
- Relationship between age and motor quality. The correlation between age and motor quality score was $r = .580244$, indicating a moderate-strong positive correlation. Since the value is positive, it means that as age increases, the motor quality score also tends to increase on average. This correlation may reflect the natural motor development that occurs with age. However, it was essential to verify this value, as literature shows that even older children than those in the sample often present difficulties in fine motor and graphomotor skills.
- Relationship between age and graphomotor organization. The correlation between age and graphomotor organization was $r = .31975$, indicating a weak-moderate positive correlation. In this case, age does not have a significant impact on graphomotor organization. This may indicate that some children develop these skills earlier or later than the average age, which alone does not fully explain the development of graphomotor abilities without considering other contributing factors, such as practice and stimulation. The whole can be seen in Table 4.

Table 4. Pearson Correlation Result

RELATED VARIABLES	PEARSON CORRELATION RESULT
Age – Overall Score	0.47033
Time – Overall Score	-0.0176
Time – Space Score	0.44715
Age – Movement Quality Score	0.580244
Age – Graphomotor Organization Score	0.31975

Note: Description of Pearson correlation results
Source: Authors

Discussion

The results of the Hand to Shape test provide a general overview of children's graphomotor skills, highlighting both positive aspects and areas of concerns that require attention[23]. Based on the initial problem, the discussion of the results allows us to reflect on the probable educational implications and future interventions concerning fine-motor and graphic-kinesthetic development in children. The analysis of the overall percentiles is encouraging, as it indicates that most participants have no significant graphomotor difficulties.

However, the presence of a small but relevant percentage of children with below-average performance requires particular attention. Although limited, this minority may be at risk of developing more complex difficulties, making continuous monitoring and the introduction of educational interventions from an early age essential.

The relevant literature confirms that early intervention is essential to prevent future fine-motor and cognitive deficits[24,25]. Furthermore, the motor quality percentile shows a result that contrasts with the general situation of motor skills and could indicate that specific quality aspects, such as fluidity or precision of movements, are insufficiently developed[26].

The discrepancy between general motor skills and motor quality may suggest insufficient focus on improving fine motor skills, which require more practice and attention[27]. One of the most concerning aspects that emerged concerns the spatial percentile, with 65% of the children showing inadequacies in this area.

Visuo-spatial skills are essential not only for graphic drawing, but also for a better understanding of multidimensional space and for organizing thought[28]. This finding is particularly relevant because spatial difficulties can have repercussions not only on graphic activities, but also on overall cognitive development, influencing the ability to learn concepts related to other learning areas[29]. This divergence can be explained by the weighting procedure of the Hand to Shape Test, which balances the contribution of the different domains, allowing strong performances in Graphomotor Organization and Motor Quality to compensate for greater visuospatial difficulties. From a developmental perspective, it is also plausible that at this age children show asynchronous growth, with greater maturity in motor fluency and graphic organisation coexisting with spatial difficulties that are likely to improve at later stages.

From an educational perspective, this pattern suggests that, although children are generally able to reach overall adequate levels of graphomotor competence, specific support is needed for the acquisition of visuospatial strategies.

The high rate of inadequacy in this area indicates the need to implement specific programs to enhance visuo-spatial skills in children, including specific spatial perception exercises and activities that encourage exploration and manipulation of objects in space[30]. A positive result was observed in graphomotor organization, where children demonstrated good skills in managing the graphic task, with adequate integration of motor and cognitive skills. This outcome might reflect the importance of regularly engaging in school activities such as writing and drawing, which contribute to the improvement of graphomotor skills, despite the increasing use of digital devices.

The analysis of percentages by gender indicates a male predominance, a fact that may influence the results, as various studies have noted developmental differences between boy and girls[31,32]. Boys tend to develop gross motor skills earlier, while girls show better fine motor control at an early age[33]. This could explain some of the differences observed in the tests, and further research might investigate how gender influences specific fine-motor performance. The age distribution shows a moderate-strong correlation between age and motor quality. This result confirms that increasing age corresponds to an improvement in general motor skills, consistent with the data from the literature, where the improvement in motor skills is attributed both to the maturation of the nervous system and to accumulated practical experience[34]. It was essential to analyse this aspect, as there can be inadequacies even at an older age

However, the differences in motor development between the various age groups suggest that e differentiated interventions, which take into account the developmental stages of children and their specific needs, would be useful. The qualitative assessment of grip data shows variability among participants. However, the presence of 26.7% who use the "Pinser" grip suggests that some children might need more support to develop a more efficient grip technique. The use of less refined grips may reflect fine motor difficulties or lack of practice, issues that could be addressed with targeted enhancement interventions.

Posture was also a critical area for a significant portion of participants (30%). Inadequate posture during graphic activities can negatively affect the quality of performance and may reflect problems related to body awareness or muscle fatigue[35]. Targeted postural interventions, such as ergonomics exercises and body awareness training, would certainly improve these aspects.

A study suggests that greater reflection allows for broader evaluation and deeper understanding[36]. Another study emphasizes that increased exposure time to study materials or complex tasks promotes deep and lasting learning, suggesting that time is a key factor in the consolidation of information[37].

However, the Pearson correlation revealed no significant relationship between time and overall score, a result that contradicts the common expectation that spending more time on a task leads to better performance.

In this case, it suggests that the quality of the time spent on the task, rather than its duration, is the determining factor[38].

Educational programs that teach children how to manage their time more effectively, focusing on attention quality and task organization, may be more beneficial than simply encouraging them to spend more time on motor activities.

Conclusion

The study clearly highlights the importance of implementing interventions aimed at enhancing fine motor skills in children, with the need to focus on the area of space, which includes concepts such as shape, dimensions, above and below and general spatial organization.

These aspects are often compromised, needing a more specific method to develop these skills. The results of the study confirm that, despite increasing digitalization, a good percentage of children maintain adequate motor skills. However, several critical areas emerge, such as visuospatial skills, movement quality and posture, which require specific interventions.

Future studies and research could delve deeper into gender differences and the influence of digital technology on physical skills, as well as investigate how targeted educational interventions can contribute to improving skills in children at risk or with inadequate performance.

The results show that age is a relevant factor in the development of physical and cognitive skills, as evidenced by moderate positive correlations with various performance indicators. As age advances, individuals tend to improve both in their global score and in specific areas such as motor quality and graphomotor organization.

However, the moderate strength of the correlations suggests that age alone is not enough to fully explain these improvements. Other factors, such as environmental context, practical experience and the type of training received, likely contribute considerably to the enhancement of these skills. Interestingly, there is also no significant correlation between the time dedicated to an activity and the global score.

This result suggests that the quality of time spent, rather than its quantity, plays an important role in improving performance, as also confirmed in the literature.

Consequently, educational interventions and training programs should focus more on focused and well-organized strategies, especially in relation to the development of fine motor skills, rather than simply prolonging practical activities. Implementing specific exercises for spatial and graphomotor organization could have a positive impact, accelerating progress not only in fine motor skills, but also in cognitive ones.

In the future it will be essential to develop studies that have proposals that can increase these aspects.

References

1. Esposito G, Di Domenico F, Ceruso R, Aliberti S, Raiola G. Perceptions/opinions about the formation of the bachelor program in exercise and sports science by students aimed at the new professional profile of the basic kinesiologist. Sport Sciences for Health. 2024. DOI: https://doi.org/10.1007/s11332-023-01139-8
2. Haywood K, Getchell N. Life Span Motor Development. 7th ed. Champaign: Human Kinetics; 2018.
3. Hudson K, Willoughby M, Wirth RJ. The multiple benefits of motor competence skills in early childhood. RTI Press Research Brief. 2021. DOI: https://doi.org/10.3768/rtipress.2021.rb.0027.2108
4. Raiola G. Motor control and learning skills according to cognitive and ecological dynamic approach in a vision on behaviorism, cognitive, Gestalt and phenomenology theories. Med J Soc Sci. 2014;5(15):504. DOI: https://doi.org/10.5901/mjss.2014.v5n15p504
5. Kelso JAS. Dynamic Patterns: The Self-Organization of Brain and Behavior. Cambridge: MIT Press; 1995.
6. D'Isanto T, Aliberti S, Raiola G, D'Elia F. Assessment of motor skills in 5–6-year-old Italian children using the MABC-2: a preliminary study. Physical Activity Review. 2024;12(1):112–20. DOI: https://doi.org/10.16926/par.2024.12.11
7. Latash ML. Motor Control: Theory and Practical Applications. Champaign: Human Kinetics; 2018.
8. Bernstein NA. The Coordination and Regulation of Movements. Oxford: Pergamon Press; 1967.
9. Schmidt RA. Motor Control and Learning: A Behavioral Emphasis. Champaign: Human Kinetics Publishers; 1982.
10. Raiola G. Body knowledge and motor skills. Knowledge Cultures. 2013 [cited 2025 Oct 16];1(6):64–72. Available at: https://www.researchgate.net/profile/Giulia-Savarese/publication/264645457_FROM_PERSONAL_IDENTITY_TO_PLURALISM_OF_INTERCULTURAL_IDENTITY_A_STUDY_ON_THE_TRANSFERABILITY_OF_SELF-KNOWLEDGE_TO_THE_MULTICULTURAL_SOCIAL_CONTEXTS/links/53ea0f0d0cf28f342f4178ef/FROM-PERSONAL-IDENTITY-TO-PLURALISM-OF-INTERCULTURAL-IDENTITY-A-STUDY-ON-THE-TRANSFERABILITY-OF-SELF-KNOWLEDGE-TO-THE-MULTICULTURAL-SOCIAL-CONTEXTS.pdf
11. Raiola G, D'Isanto T, Di Domenico F, D'Elia F. Effect of teaching methods on motor efficiency, perceptions and awareness in children. Int J Environ Res Public Health. 2022;19(16):10287. DOI: https://doi.org/10.3390/ijerph191610287

12. Davids K, Glazier P, Araújo D, Bartlett R. Movement systems as dynamical systems: the functional role of variability and its implications for sports medicine. Sports Med. 2003;33(4):245–260. DOI: https://doi.org/10.2165/00007256-200333040-00001
13. Longo MR, Haggard P. Anatomy of body representation: evidence from the rubber hand illusion. J Exp Psychol Hum Percept Perform. 2009;35(2):382–391. DOI: https://doi.org/10.1037/a0012726
14. Raiola G, Aliberti S, Esposito G, Altavilla G, D'Isanto T, D'Elia F. How has the practice of physical activity changed during the COVID-19 quarantine? A preliminary survey. Physical Education Theory and Methodology. 2020;20(4):242–7. DOI: https://doi.org/10.17309/tmfv.2020.4.07
15. Raiola G. Motor learning and teaching method. J Phys Educ Sport. 2017;17:2239–43. DOI: https://doi.org/10.7752/jpes.2017.s5236
16. Draganski B, May A. Training-induced structural changes in the adult human brain. Behav Brain Res. 2008;192(1):137–142. DOI: https://doi.org/10.1016/j.bbr.2008.02.015
17. Aliberti S, Raiola G, Cherubini D. The role of emotional states and mental techniques in dancesport: a systematic review. Baltic J Health Phys Act. 2023;15(3):8. DOI: https://doi.org/10.29359/BJHPA.15.3.08
18. D'Isanto T, Altavilla G, Esposito G, D'Elia F, Raiola G. Heuristic learning and sport: theoretical lines and operational proposals. Encyclopaideia. 2022;26(64):69–80. DOI: https://doi.org/10.6092/issn.1825-8670/14237
19. Aliberti S. Physical education in European primary schools: an up-to-date overview. Sport Sci. 2023 [cited 2025 Oct 15];16(2):30–34. Available from: https://efsupit.ro/images/stories/octombrie2024/Art%20270.pdf
20. D'Isanto T. In-service training of primary school generalist teachers on physical and sport education: perceptions and proposals. Sport Science. 2023[cited 2025 Oct 16];16(1). Available at: https://www.cabidigitallibrary.org/doi/full/10.5555/20230483110
21. Altavilla G, Ceruso R, Esposito G, Raiola G, D'Elia F. Physical education teaching in Italian primary school: theoretical lines and operational proposals. Pedagogy of Physical Culture and Sports. 2022;26(3):151–7. DOI: https://doi.org/10.15561/26649837.2022.0302
22. Wang L. Relationships between motor skills and academic achievement in school-aged children and adolescents: a systematic review. Children. 2024;11(3):336. DOI: https://doi.org/10.3390/children11030336
23. Ambrosini C. Hand to Form – Graphic Proof of Construction Practice. Florence: Giunti Psychometrics; 2022.
24. Odom SL, Collet-Klingenberg L, Rogers SJ, Hatton DD. Evidence-based practices in interventions for children and youth with autism spectrum disorders. Prev Sch Fail. 2010;54(4):275–282. DOI: https://doi.org/10.1080/10459881003785506
25. Jones S, Smith R, Williams T, Zhang L, Patel M, Lopez F. Early interventions and cognitive-motor deficits in children: a review of approaches and efficacy. J Dev Pediatr. 2023;49(3):145–60. DOI: https://doi.org/10.1016/j.jdped.2023.02.00 1
26. Raiola G, Altavilla G. Testing motor skills, general and special coordinative, in young soccer. J Hum Sport Exerc. 2020;15(Proc2):S206–12. DOI: https://doi.org/10.14198/jhse.2020.15.Proc2.11
27. Bender A. Explicating numerical information: when and how fingers support (or hinder) number comprehension and handling. Front Psychol. 2011;2:214. DOI: https://doi.org/10.3389/fpsyg.2011.00214
28. Fan JE, Li M, Reagh ZM. Drawing as a versatile cognitive tool: insights into how drawing enhances visuospatial processing in cognition and learning. Front Psychol. 2023;14:11377027. DOI: https://doi.org/10.3389/fpsyg.2023.11377027
29. Verdine BN, Golinkoff RM, Hirsh-Pasek K, Newcombe NS. Finding the missing piece: blocks, puzzles, and shapes fuel school readiness. Trends Neurosci Educ. 2014;3(1):7–13. DOI: https://doi.org/10.1016/j.tine.2014.02.005
30. Raiola G. Study between neurophysiological aspects and regulation documents on preschool in Italy. J Phys Educ Sport. 2011(cited 2025 Oct 16];11(1):42–7. Available at: https://www.efsupit.ro/images/stories/imgs/JPES/2011/1/microsoft%20word%20-%205%20macheta.pdf
31. Palmer K, Harkavy D, Rock S, Robinson L. Boys and girls have similar gains in fundamental motor skills across a preschool motor skill intervention. J Mot Learn Dev. 2020;8(2):1–11. DOI: https://doi.org/10.1123/jmld.2019-0043
32. Zheng Y, Ye W, Korivi M, Liu Y, Hong F. Gender differences in fundamental motor skills proficiency in children aged 3–6 years: a systematic review and meta-analysis. Int J Environ Res Public Health. 2022;19(14):8318. DOI: https://doi.org/10.3390/ijerph19148318
33. Roth K, Anderson M, Lee J, Brown P, Williams S, Davis L, Thompson R. Gender differences in motor skill development in early childhood. J Child Dev. 2023;94(2):235–50. DOI: https://doi.org/10.1111/jcdev.12632
34. Zhou J, Zhang Y, Liu Q, Wang L, Chen H, Sun Y. Age-related development of motor skills in children: the role of nervous system maturation and practical experience. Dev Psychol. 2023;59(1):78–92. DOI: https://doi.org/10.1037/dev0001392

35. Garcia M, Fernandez A, Rivera J, Lopez P, Sanchez R, Martinez J. The impact of posture on performance in graphic activities: implications for body awareness and muscle fatigue. Ergonomics J. 2023;66(4):321–35. DOI: https://doi.org/10.1080/00140139.2023.2156789
36. Schraw G, Dennison RS. Assessing metacognitive awareness. Contemp Educ Psychol. 1994;19(4):460–75. DOI: https://doi.org/10.1006/ceps.1994.1033
37. Pashler H, McDaniel M, Rohrer D, Bjork R. Learning styles: concepts and evidence. Psychol Sci Public Interest. 2008;9(3):105–19. DOI: https://doi.org/10.1111/j.1539-6053.2009.01038.x
38. Wang L, Wang L. Relationships between motor skills and academic achievement in school-aged children and adolescents: a systematic review. Children. 2024;11(3):336. DOI: https://doi.org/10.3390/children11030336

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