MULTIDISCIPLINARNI PRISTUPI U EDUKACIJI I REHABILITACIJI
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Development of fine motor skills in elementary school students: Gender and age effects

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Abstract
Fine motor skills are a good indicator of a child's overall development. They underpin almost all everyday activities from self-care skills such as dressing to academic skills such as writing and drawing. In this study we examined the development of fine motor skills of early elementary school children. The sample for this study consisted of 175 children (93 boys, 82 girls, mean age= 120 months; SD = 10.7 months). attending 3rd, 4th, and 5th grades. We used Grooved Pegboard test for measuring fine motor skills. We found a medium, statistically significant, correlation between age and motor skills, with stronger correlation at younger age. In relation to child's grade, there were statistically significant differences in motor skills between children attending 3rd and 4th grade, but no differences between children in 4th and 5th grade. As for the gender, there were no mean differences between boys and girls in the 3rd grade, but there were differences in 4th and 5th grade with girls achieving statistically significantly better scores on Grooved Pegboard test. Fine motor skills should routinely be examined in children and appropriate remediation programs should be set if a child falls behind in motor skills. We concluded a paper with several ways how elementary schools can include fine motor exercises in their curricula.

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Introduction

Fine motor skills are a good indicator of child's overall development and academic success. They can be defined as the ability to control precise movements through the coordination of the nervous system, fibers, and muscles, particularly in the fingers and hands (Syafril et al., 2018; Qi et al., 2018). Put differently, fine motor skills can be viewed as the coordination of muscles, bones and nerves to produce small precise movements (Kimmel & RatliffSchaub, 2011).These skills involve finely coordinated movements that necessitate the use of small muscles in the hands, fingers, and wrists to execute delicate motor activities, often in conjunction with visual perception. These skills involve the coordination of small muscles in activities such as using fingers and hands. Research has shown that fine motor skills are essential for various aspects of a child's life, including academic achievement, daily living activities, and cognitive development (Pitchford et al., 2016; Bos et al., 2013; Seo, 2018). In addition to this, the studies have shown strong predictive power of fine motor skills for future academic achievement (Grissmer et al., 2010).

In primary school-aged children, fine motor skills are particularly important as they spend a significant portion of their day engaged in tasks that require these skills (Doney et al., 2017; Medojevic, 2024). Fine motor skills have been linked to better performance in mathematics and reading, with some studies suggesting that they predict math ability better than reading ability in the early primary school years (Pitchford et al., 2016). Additionally, fine motor skills are associated with improved handwriting legibility, which is crucial for academic success (Qi et al., 2018). Proper fine motor development relies on several key factors, including the maturation of the Central Nervous System (CNS), muscle tone, and strength. Similarly, visual-motor integration skills are dependent on intact visual-motor abilities, fine motor coordination, motor inhibition, and sustained attention (Schultz et al., 1998). Thus, given this wide network of systems on which motor skills are based it is expected that deficits in fine motor skills might serve as an indication of challenges in child's development. Studies have shown that a number of neurodevelopmental conditions have been related to deficits in fine motor skills including intellectual disability (Memisevic & Djordjevic, 2018), autism (Liu, Capistran, & ElGarhy, 2021), and ADHD (Pillay, Meyer, & Mokobane, 2019). Understanding the developmental progression of fine motor skills allows educators to identify potential challenges in children and implement appropriate and timely interventions. Much research has been devoted to the development of fine motor skills at preschool age (Memisevic & Hadzic, 2013a; Suggate, Stoeger, & Pufke, 2017). Most children follow a predictable pattern of motor development, although the age at which they reach certain motor milestones can vary. A great deal is known about early motor development in children, guided by two key principles: the cephalocaudal and proximodistal patterns. The widely accepted proximodistal principle emphasizes that the development of trunk stability and control of the central axis are essential prerequisites for effective hand use (Case-Smith, Fisher & Bauer, 1989). In simple terms, this means that the development of fine motor skills is dependent on the earlier development of gross motor skills. At birth, infants have very limited control over their movements, with primitive reflexes

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dominating their actions. As they grow, these reflexes gradually disappear and are replaced by more sophisticated, intentional movements controlled by the brain. In typically developing children, voluntary movements begin to emerge between 4 and 6 months of age. By the end of the first year, children should be able to pinch and grasp small objects with their fingers, similar to adults.

It has been shown that age is strongly associated with fine motor development at preschool age, and that there are sensitive periods in fine motor development (Memisevic & Hadzic, 2013b). In relation to gender, studies have mostly shown girls advantage in motor skills in preschool children (Böhm, Lundequist, & Smedler, 2010; Matarma et al., 2020; Memisevic & Hadzic, 2013b;). However, most of the studies were examining preschool aged children and there is a lack of studies examining motor skills in elementary school children. In this study we wanted to fill this research gap and examine development of fine motor skills in elementary school children in relation to their age and gender.

Methods

Participants

The sample for this study consisted of 175 children (93 boys and 82 girls), aged 98 to 139 months old (mean age = 120 months, SD = 10.7 months). All children attended general elementary schools in Canton Sarajevo, and according to the educational records, they did not have any developmental or neurological disorder.

Procedure

Three elementary schools in Canton Sarajevo were chosen at random, and consent forms were given to the parents of children in the 3rd to 5th grades at these schools. Teachers supplied basic demographic details about the students. The testing was carried out individually in available classrooms, with each session taking around 20 minutes. All students gave their assent to participate, and only those whose parents had provided written consent were included in the study.

Instrument

For the measurement of fine motor skills we used Grooved Pegboard test. The Grooved Pegboard Test is a dexterity assessment that involves 25 holes, each with randomly positioned slots. To complete the task, pegs with a key on one side must be rotated to align with the slots before insertion, demanding more complex visual-motor coordination compared to typical pegboard tests. Time needed to complete the test in seconds was used as the measure of performance in the assessment. Lower scores (time) means better performance on the test.

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Statistical Analysis

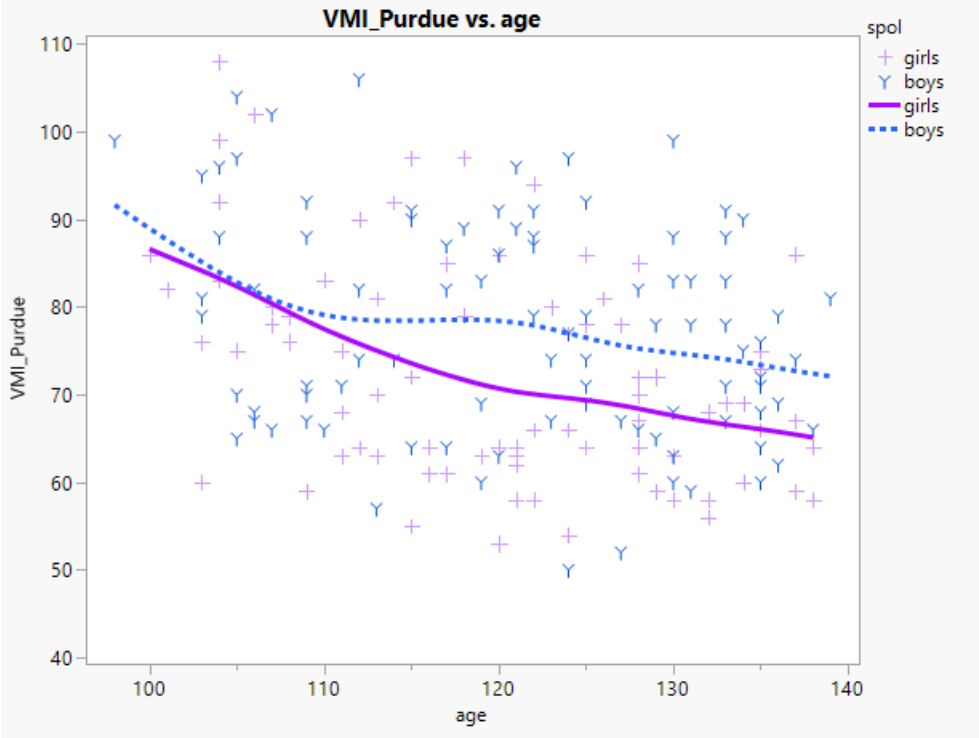
We first presented correlations between fine motor skills and age (for entire sample, and for girls and boys separately). We next performed ANOVA test to examine whether there are differences in fine motor skills in children attending 3rd, 4th, and 5th grade of elementary school.

Finally, we performed t-tests to examine gender differences in fine motor skills for each grade. An alpha level of .05 was used as a benchmark for statistical significance. Data were analysed with the computer program SPSS v.27 for Windows (IBM, 2020).

Results

We first present correlations between fine motor skills and age. The correlations are shown in Figure 1.

Figure 2. Correlation between age and fine motor skills



Total Pearson correlation between age and fine motor skills (for both, boys and girls) was r = -.33, p < .001. It is obvious that age and fine motor skills are significantly related in this sample of children. Older children tend to have faster times on Grooved Pegboard test. However, the magnitude of correlation was much higher for the girls than for the boys; r (girls) = -.43; p < .001; r (boys) = -.27; p < .01.

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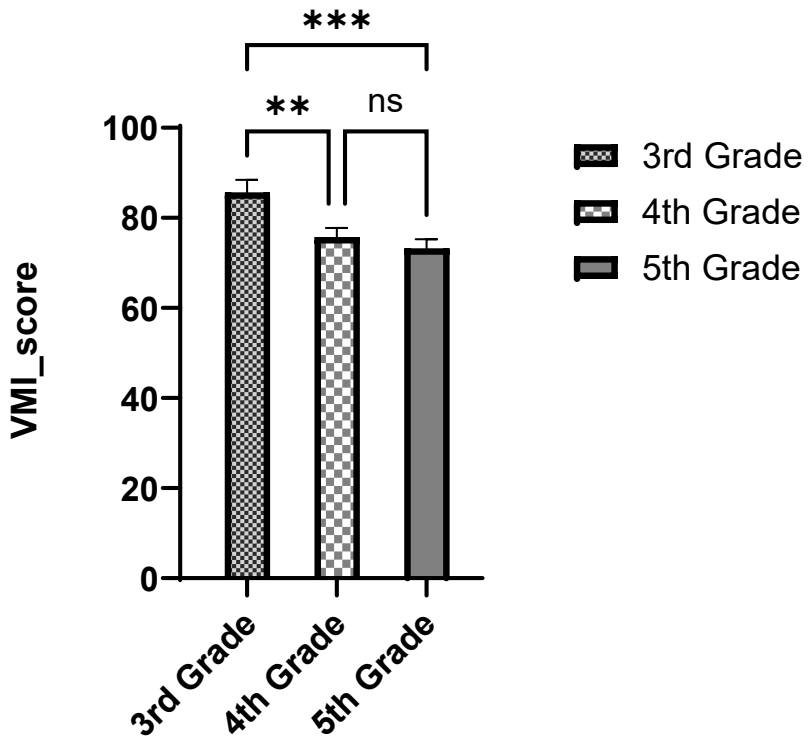
We next examined the differences in mean fine motor scores in children attending 3rd, 4th, and 5th grade of elementary schools. These data are shown in Figure 2.

Figure 2. Differences in mean scores on Grooved test in elementary school children attending 3rd, 4th, and 5th grades



Note. *** p < .001; ** p < .01; ns = non-significant

According to the one way ANOVA test, there were statistically significant differences in the mean fine motor scores in relation to the grade, F (2, 172) = 11.1, p < .001. We also examined between which grades there were mean fine motor skills differences and established that there were differences between children attending 3rd grade and 4th grade, and children attending 3rd grade and 5th grade. There were no statistically significant differences between children attending 4th and 5th grades.

We next examined gender differences in fine motor skills between children attending 3rd, 4th, and 5th grades.

This data is presented in Figure 3.

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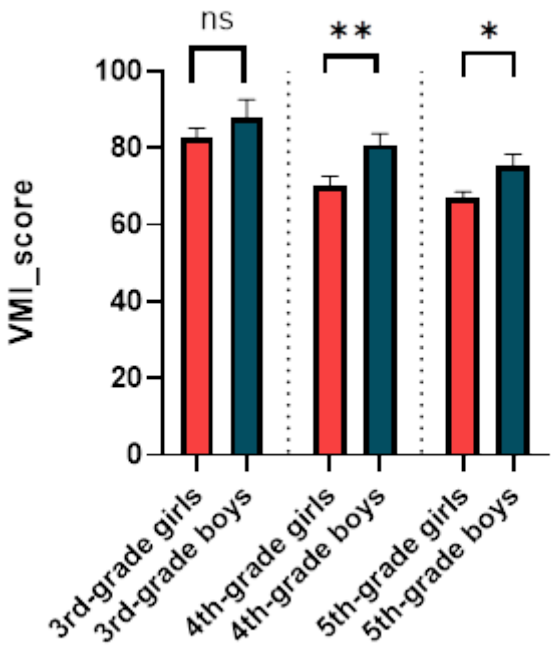
Figure 3. Mean fine motor skills differences between boys and girls in relation to children's grade



Note. ** p < .01; * p < .05; ns = non-significant

As illustrated in Figure 3, no significant mean differences were observed between boys and girls in the 3rd grade (t-test = 0.11, p = .90). However, in the 4th (t-test = 2.7, p <. 01) and 5th (t-test = 2.6, p < .05) grades, there were statistically significant differences in mean fine motor scores, with girls outperforming boys in both grades on this test.

Discussion

The goal of the present study was to examine fine motor skills in elementary school children in relation to their age and gender. We have found a strong correlation between age and fine motor skills in children between 8 to 12 years old. What is somehow surprising is that correlation was higher in girls than in boys. One potential explanation for the stronger correlation between age and fine motor skills in girls compared to boys might be related to differences in developmental trajectories. Research has shown that girls generally develop fine motor skills earlier and more rapidly than boys, which could result in a more pronounced improvement as they age (Alsakhawi et al., 2023). Another finding in this study was that fine motor development seems to be more intensive between 3rd and 4th grades, than it is between 4th and 5th grades. This suggests that early elementary years may represent a critical period for fine motor development, while further refinement of these skills may plateau or progress more gradually from grade 4 to grade 5 and beyond.

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As for the differences in fine motor skills in relation to gender found in 4th and 5th grades but not in 3rd, that finding is also somehow counterintuitive, as we expected to see statistically significant mean differences in this group as well. It might be the case that this finding is sample specific and that future studies in different samples would find the difference. Another likely explanation is the non-linear developmental trajectory of fine motor skills that has periods of stagnation and rapid developments. However, to exactly determine this, one would need a much larger sample size collected from different cultures. As for the mean differences in motor skills between boys and girls in the 4th and 5th grade, there seems to be several potential explanations. It is possible that girls may engage in activities that more frequently require and refine fine motor skills, such as drawing, writing, or crafts, leading to a stronger relationship between age and skill development. Hormonal differences and their effects on brain development could also play a role, potentially making fine motor skill maturation more closely tied to age in girls (Arifiyanti, 2020). Finally, social and cultural factors play a significant role in child's overall development, including motor development (Graf et al., 2012; Salem, Elhadidy, & Salem, 2022). Thus, social and cultural factors might encourage girls to focus more on tasks that enhance fine motor coordination, further contributing to the observed gender difference in correlation strength.

School professionals (psychologists, special educators, teachers) need to know how the typical motor development unfolds so they can recognize any potential problem and provide timely and efficient motor intervention. Schools are pivotal in advancing the motor development of their students, complementing the foundational role played by the home environment. In the early years of education, schools contribute significantly to the holistic growth of children, providing structured opportunities for the development of essential motor skills. There are many ways in which schools can adapt activities to foster motor development in children, from swimming (Vranesic-Hadzimehmedovic & Memisevic, 2018) to engaging in origami activities (Anisa, Syafrudin, & Drupadi, 2021). Fine motor skills are highly malleable, meaning they can be significantly improved with practice and targeted activities. The development of these skills, as mentioned, is important for a range of everyday tasks, from writing and drawing to using tools and handling small objects. Given their importance, educators should prioritize the inclusion of fine motor skill activities in their daily routines. This can be achieved through structured tasks like cutting with scissors, threading beads, and engaging in art projects, as well as through play-based learning that encourages manipulation of small objects. By regularly incorporating these activities, educators can support the gradual improvement of fine motor coordination, helping children to build the dexterity and precision needed for academic and practical success.

This study is not without limitations. We will mention the one related to generalizability of the sample. As the children are from Sarajevo Canton only, we do not know whether these findings are generalizable for children in other parts of Bosnia and Herzegovina as well. The second limitation regards the use of only one test as a proxy measure for fine motor skills. Fine motor skills are a complex function which cannot be captured using a single test. Although we used

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somewhat elaborated test, it is still not possible to capture all the complexity of motor function. Thus, future studies should employ a wider choice of tests and multiple test batteries for the assessment of fine motor skills.

This study paves the way for several future research avenues. A particularly valuable direction would be to investigate the developmental trajectories of motor skills across a broader age range. Ideally, such research would adopt a longitudinal design, tracking the same cohort of children from birth through high school. This approach would enable researchers to identify specific sensitive periods in fine motor development with greater precision. By understanding these critical windows, interventions and educational strategies could be better timed and tailored to support optimal motor skill acquisition throughout childhood and adolescence.

Conclusions

There is a significant correlation between age and fine motor skills and the correlation is stronger in girls than in boys. There were statistical differences in mean fine motor scores from grade 3 to grade 4, but not from grade 4 to grade 5 indicating that these skills may plateau or progress more gradually at an older age. Girls outperformed boys in fine motor skills at grades 4 and 5 but not in grade 3.

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