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How are motor skills and writing readiness in children? A literature review
¿Cómo son las habilidades motrices y la preparación para la escritura en los niños? Una revisión bibliográfica

*Antonius Totok Priyadi, *Isti Dwi Puspita Wati, *Amriani Amir, *Tulus Gover Siringo Ringo, *Yohanes Gatot Sutapa Yuliana, **Fifukha Dwi Khory, *Putra Sasataman B, *Dyoty Auliya Vilda Ghasya, ***Procopio B. Dafun JR, *Mimi Haetemi, ****Albadi Sinulingga

*Universitas Tanjungpura (Indonesia), **Universitas Negeri Surabaya (Indonesia), ***Mariano Marcos State University (Philippines), ****Universitas Negeri Medan (Indonesia)

Abstract. Writing is one of the basic skills for moving up in the world of education and eventually carries over into adult life to interact in both communication and work. Basically, learning to write is a complex process that is integrated with the child's memory experience, combining meaningful visual and motor stimuli that are captured on paper. The study of writing is interesting from a motor perspective. This literature review research aims to examine writing from a motor perspective. Review articles were searched on Scopus and PubMed search engines with the keywords "writing AND motor AND skills". Initially 1,171 documents were found on Scopus and 1,059 on PubMed. After restriction based on year, theme, age specific, relevant abstract and full article reading, 10 articles met the criteria. The conclusion of this review explains that writing is a fine motor skill, especially visual motor. In fact, this skill does not automatically mature without the contribution of growth (physical), maturity (quality), intervention (learning and experience), and treatment (learning process).
Keywords: Motor Skills, Writing, Child Age

Resumen. Escribir es una de las habilidades básicas para ascender en el mundo de la educación y eventualmente se traslada a la vida adulta para interactuar tanto en la comunicación como en el trabajo. Básicamente, aprender a escribir es un proceso complejo que se integra con la experiencia de la memoria del niño, combinando estímulos visuales y motores significativos que se plasman en el papel. El estudio de la escritura es interesante desde una perspectiva motora. Esta investigación de revisión de literatura tiene como objetivo examinar la escritura desde una perspectiva motora. Se buscaron artículos de revisión en los motores de búsqueda Scopus y PubMed con las palabras clave «writing AND motor AND skills». Inicialmente se encontraron 1.171 documentos en Scopus y 1.059 en PubMed. Tras la restricción basada en el año, el tema, la edad específica, el resumen relevante y la lectura del artículo completo, 10 artículos cumplieron los criterios. La conclusión de esta revisión explica que la escritura es una habilidad motora fina, especialmente visual. De hecho, esta habilidad no madura automáticamente sin la contribución del crecimiento (físico), la madurez (calidad), la intervención (aprendizaje y experiencia) y el tratamiento (proceso de aprendizaje).
Palabras clave: Habilidades motoras, escritura, edad infantil

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Antonius Totok Priyadi
antonius.totok.priyadi@fkip.untan.ac.id

Introduction

These motor skills are broadly categorized as gross motor and fine motor. Motor skills are naturally used throughout life. However, at this stage of student development, it is necessary to improve motor development. Not all students' motor development processes are the same. Based on gender, fine motor skills in children aged 4-8 years are better in girls (Józsa et al., 2023). Research suggests that female students generally have better writing skills than male students, particularly in terms of legibility (Marquardt et al., 2016). Motor development plays a critical role in literacy, as writing is not an innate ability but one that must be acquired through guidance and practice (Ghanamah et al., 2022; Özkür, 2020). The development of writing skills is closely tied to the stages of motor acquisition and maturation.

Fine motor skills, essential for writing, are particularly challenging for preschool children to master (Huffman & Fortenberry, 2011). Various strategies have been employed to enhance these skills. For instance, one study showed that using the ABC application improved fine motor abilities (Sahid et al., 2024). Physical education programs targeting small muscle groups can also enhance fine motor skills and foster a greater interest in writing and learning at school (Akin, 2019). Another approach to improving fine motor skills is through activities like origami, which involve cutting, folding, and sticking (Harsismanto et al., 2021). Playing music has also been shown to support the development of fine motor skills (Gzibovskis & Marnauza, 2012).

Writing proficiency is linked to the mastery of visual-motor perception and fine motor skills, which are crucial for improving children's writing abilities (Tse et al., 2019). As children enter formal education, writing skills become increasingly important, influencing not only academic success but also future employment and overall well-being. The ability to write, both by hand and through typing, is rooted in the integration of sensorimotor and linguistic processes (Cerni & Job, 2024). Writing is a core component of literacy development, with research demonstrating strong connections between writing, reading, and literacy skills (Khoury-Metanis & Khateb, 2022; Ray et al., 2022).

Writing not only involves cognitive, motor, and socio-emotional learning (Gerde et al., 2022), but it is also a crucial part of communication. According to (Gençten, 2022), writing is a complex skill that integrates cognitive, psychomotor, socio-cultural, and language acquisition abilities. It's recommended to explore a variety of themes to facilitate

the improvement of writing skills. Writing is influenced by and influences word mastery and language. For instance, writing with a pencil impacts both the cognitive and motor skills of children (Kocaman, 2022). Research suggests that writing is a challenging, systematic mental process interconnected with speech, motor, and visual motor skills (Podolyanchuk & Jolanta, 2023).

Structured activities, such as games, can stimulate fine motor and cognitive development in children (Harianto et al., 2023; Mariati et al., 2024; Yusroni, 2024). Mastery of rhythm has been shown to correlate with literacy in children, with rhythm synchronization influencing pen pressure during writing (Frey et al., 2022), painting and writing skills have a strong correlation (Frey et al., 2022). Additionally, skills like painting and weaving have a strong correlation with writing abilities (Ilham Kamaruddin et al., 2022), as they help improve finger dexterity and hand-eye coordination. Improved writing skills demonstrate better hand control, which is related to higher learning abilities (Vaivre-Douret et al., 2021). Activities like playing with plasticine also enhance fine motor skills (Harianto et al., 2023; Kamaruddin et al., 2023), while finger painting helps develop fine motor skills that can later be applied to writing (Hefniy et al., 2022). These studies indicate that various motor stimuli positively impact fine motor development.

This paper examines the relationship between motor skills and the development of children's writing acquisition. As in previous studies, it was stated that fine motor skills are not easily mastered by preschoolers (Huffman & Fortenberry, 2011). However, various efforts are made to improve fine motor skills. In the learning stages of children, the ability to write is part of early academic skills whose mastery is influenced by many factors (Kocaman, 2022; Podolyanchuk & Jolanta, 2023), and also writing is not a simple skill (Gençten, 2022; Thamrin et al., 2024). This study attempts to examine the relationship between fine motor skills and writing skills. Therefore, this study aims to examine the relationship between motor skills and writing readiness in children.

Methods

Search Strategy

Searches were conducted on Scopus and PubMed with several keywords "(writing AND motor skills)". The search was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines . In addition, PRISMA emphasizes review reports that evaluate randomized trials which can also be used as a basis in reporting systematic reviews for other types of research (Mohamed Shaffril et al., 2019).

Exclusion Criteria

The exclusion criteria used are as follows: (1) Articles that were not published in journals indexed in Scopus and WoS (2) Articles in languages other than English and had open access, (3) Articles published in 2019-2024 (4) Articles that did not explicitly mention motor skills and reading ability.

Procedure

Initially, 2,229 publications were obtained from identification through database searches (Scopus: 1171) and (PubMed: 1058). In the Scopus account with the keyword "(writing AND motor skills)" 1171 documents were found, limited to 2019-2024 found 319 articles, only those with open access became 133 articles, assessment based on reading the incoming abstracts became 28. Based on a search on PubMed with the same keywords, 1058 articles were found, 5 years were limited to 266, limited to age up to 12 years to 93 articles and open access 53. Of these 53, only 12 abstracts were suitable. This resulted in 40 articles ready for further analysis. After following the exclusion criteria, only 10 articles remained. Most of the items were discarded because the articles did not address children's motor skills and reading ability. All articles were extracted from the source and analyzed through Mendeley software to remove duplicate articles. More details are shown in figure 1.

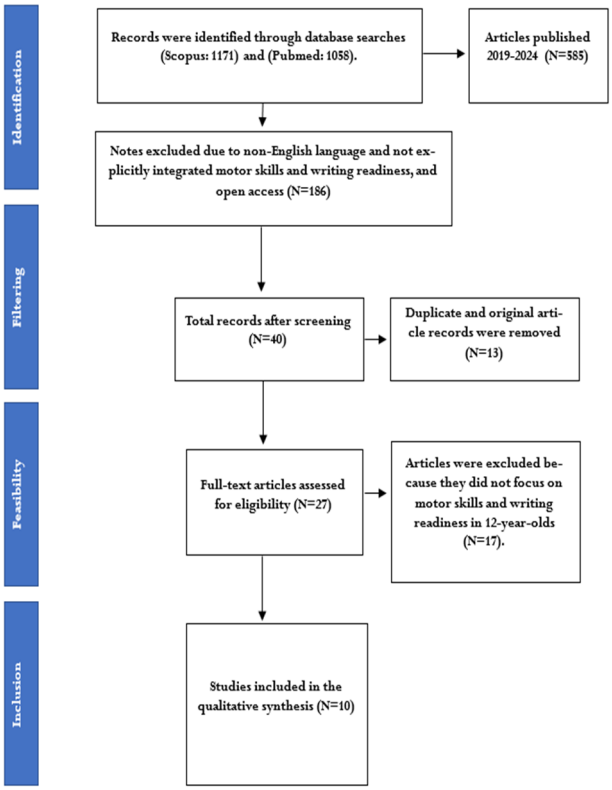

Figure 1. PRISMA chart

Results

The search yielded a total of 10 articles, which are presented in Table 1. This study focuses on the relationship between motor skills and writing readiness in children. The country category was not included, as all the articles examined take a global perspective on motor skills and writing readiness in children.

Table 1.
Results of the review of articles that match the research theme

Author and title	subject	Design and intervention	conclusion
Does neuromotor immaturity represent a risk for acquiring basic academic skills in school-age children?(Ivanović et al., 2019)	256 pupils. 51.20% were males. 7.75-11.25 years old primary school students in grades 2-5	Tests of motor maturity, writing quality (Simmer and Eidlitz), reading skills and evaluation of numeracy difficulties were conducted.	Motor maturity affects academic skills in school-age children, especially in writing, reading and counting skills.
The association between under-nutrition, school performance and perceptual motor functioning in first-grade South African learners: The north-west child health integrated with learning and development study(Pienaar, 2019)	816, comprising 420 boys, 396 girls, average age 6.78+ years)	Motor testing with the Bruininks - Oseretsky Test of Motor Proficiency, math, reading and writing with the South African National Standardized Test.	The condition of stanting has a negative impact on motor function in students, this is related to the ability of motor perception, writing, reading and math skills.
Who benefits from an intervention program on foundational skills for handwriting addressed to kindergarten children and first graders?(Taverna, Tremolada, Dozza, et al., 2020)	Sample 55 children. Kindergarten children = 42) first grade (n = 13). Age 5 years - almost 7 years	A quasi-experimental for 10 weeks, 60 minutes per session, twice a week by providing activities and games Treatment with hand-eye coordination stimuli, playing with moving fingers, moving objects, and playing with the hands.	Treatment for 10 weeks of physical activity and games had a positive impact on fine motor skills of the hands improving the ability to handle and write over time.
The impact of graphomotor demands on letter-like shapes recognition: A comparison between hampered and normal handwriting(Seyll & Content, 2020)	Grade 1 students, 13 six-year-olds	Visual-motor integration learning and fine motor skills were conducted for 10 weeks, then a recognition test was conducted.	Graffmotor has a positive influence on handwriting accuracy
Modeling the influence of motor skills on literacy in third grade: Contributions of executive functions and handwriting(Lê et al., 2021)	278 third graders (mean age = 8;5 years; SD = 4 months; 154 girls); they were recruited in 25 classrooms across 16 schools in the Nouvelle Aquitaine region in France.	evaluate motor skills, literacy skills, EFs, and handwriting skills. then, each child performed two individual sessions of 30 to 45 minutes, alternating between motor tasks, literacy tasks, and cognitive tasks.	It turns out that fine motor skills mediate executive function and writing skills, and also affect processing (reading, spelling, writing production).
Physical Activity With Eduball Stimulates Graphomotor Skills in Primary School Students(Wawrzyniak et al., 2021)	Experimental group 28 children control group 26 children. age 7-8 years old	The experimental group conducted physical education with eduball game for 6 months. Each session was 30 minutes for 32 meetings. The control group conducted regular physical education. Graphomotor skills were assessed using a standardized Polish test called the Profile of Graphomotor Efficiency.	Graphomotor is an activity that can stimulate writing skills, this skill needs to be improved, it is proven that eduball in physical education provides an increase in frafomotor skills.
Everyone Can Implement Eduball in Physical Education to Develop Cognitive and Motor Skills in Primary School Students(Wawrzyniak et al., 2022)	N: 70 Grade 1 students Control group 21 (11 girls 10 boys) Group E1 18 students (7 girls and 11 boys) E2 16 students (5 girls and 11 boys) Child age between 6-7 years old	Experiment with 3 groups The eduball group Regular physical education group Collaborative group	Eduball games have a significant effect on cognitive abilities (writing, reading and math), gross motor, especially object control and locomotor movements.
The effect of fine motor skills, handwriting, and typing on reading development(Suggate et al., 2023)	95 kindergarten children, from Bavaria, Germany, 5 years old (SD = 5.68 months). 45 girls, 50 boys, 13 left-handed children, 27 children using languages other than Jermam (research site)	Pre and post tests of working memory, vocabulary and basic motor skills were conducted. Unit 1. 7 minutes, as many units as possible, each containing three learning phases (learning, motor practice, reading) Y minute, same three phase, as many units as possible Ex 3. Recp of previous units, 7 minutes, same three phase, as many as units as posible Ex 4. 7 minutes, same three phases, ass many units as posoble	Basic movement skills and working memory affect motor writing in children
Hand copy performance of young children and the illiterate, semi-illiterate, and literate adults(Zhang et al., 2024)	Children aged 3-5 years 21 children.13 girls 8 boys Children aged 5-6 years 27 children 16 girls 11 boys Illiterate adults 28, 14 girls 14 boys	Analyze by comparing the results of imitating the writing of children aged 3-5 years, 5-6 years and illiterate adults.	Writing is a visual motor ability, stating that the ability to write is not automatically acquired but needs practice. Research was conducted by comparing the performance of children aged 5-6 years better than those aged 3-5 years, but illiterate adults when given a letter copying test turned out to be the same as 3-5 year olds.
Early handwriting performance among Arabic kindergarten children: The effects of phonological awareness, orthographic knowledge, graphomotor skills, and fine-motor skills(Salameh-Matar et al., 2024)	9 boys and 119 girls (age M = 70.50, SD = 3.50 months) participated.	longitudinal study The treatment was given for 20 minutes per session for 3 years and was conducted in the final semester of the school year. Tests were conducted on handwriting speed and legibility; linguistic skills (phonological awareness and orthographic knowledge); and graphomotor and fine motor skills.	Fine motor, graphomotor skills are very important in the early ability to learn to write.

If arranged in a summary of the results of this study, it will be the following narrative:

Writing is a fine motor skill (Salameh-Matar et al., 2024; Taverna, Tremolada, Dozza, et al., 2020; Zhang et al., 2024). In addition, to prepare or improve writing ability, maturity, nutritional status and learning are required (Ivanović et al., 2019; Lê et al., 2021; Salameh-Matar et al., 2024; Seyll & Content, 2020; Taverna, Tremolada, Dozza, et al., 2020; Wawrzyniak et al., 2021, 2022; Zhang et al., 2024). The ability to write will be good if the nutritional status is good, fine motor, especially visual motor, is good, which is indicated by the ability to hold a pencil accurately, imitate existing examples (visual motor) by making lines and the right pressure results. Various efforts have been made to improve this writing ability with fine motor frafomotor exercises (Salameh-Matar et al., 2024; Seyll & Content, 2020; Wawrzyniak et al., 2021, 2022).

Discussion

Several factors influence the development of writing skills, with learning outcomes being affected by the child's

initial learning level (Gonzalves, 2021). Research indicates that stunting is weakly correlated with motor performance, visual perception, reading, and writing in children (Pienaar, 2019). Interestingly, fine motor skills can improve even in the elderly, as seen in a study where one year of piano lessons enhanced these abilities (Worschech et al., 2023). The most critical factor in improving writing ability is the development of fine motor skills. Strengthening these skills is essential for enhancing writing quality (Ji, 2023). Fine motor stimulation boosts graphomotor skills, which are crucial in acquiring writing abilities (No & Choi, 2022; Salameh-Matar et al., 2024).

Further research on children's motor skills is essential for understanding writing development (Patiño-Robles & Reyes-Meza, 2022). Motor skill development, typically fostered through physical education and play activities designed for learning, plays a key role in writing. Additionally, gross motor skills have been found to strongly correlate with writing speed (Dayem et al., 2015). In addition, various studies have shown that fine motor skill interventions have an effect on holding skills and a positive effect on handwriting outcomes (Taverna, Tremolada, Dozza, et al., 2020).Physical activity will have an effect on improving fine and gross motor skills if it is designed, not just physical activity (Telford et al., 2022). Coloring activities can train muscle strength, especially the hands that are used to hold pencils, both of these activities are fine motor skill activities (Marhaeni et al., 2022). Cutting is an important fine motor skill for children. (Nor Az Zahraa & Kamariah, 2022). Tools such as scissors (for cutting), origami paper, blocks, pencils are powerful weapons to develop children's fine motor and visual motor skills (Mu'ammar et al., 2023), and this learning media becomes very important in the learning process to improve learning outcomes and children's interest (Rosalianisa et al., 2023), with one of the activities carried out is coloring (Jumiyati et al., 2023). Drawing habits that help improve pre-writing skills (Safitri Dia Pramita, 2023)

Writing skills are the result of fine motor skills, visual motor skills of children (Taverna, Tremolada, Tosetto, et al., 2020). One of them is included in fine motor which functions to develop basic writing skills is graphic motor programs (graphomotor) which functions for the recognition of b forms such as letters (Seyll & Content, 2020). Impact of psycho-educational activities on visual-motor integration, fine motor skills and name writing among first grade students: A kinematic pilot study (Taverna, Tremolada, Tosetto, et al., 2020). The research evidence is very convincing that fine motor development, fine motor enrichment is instrumental in the acquisition of various literacy skills such as, writing reading. In relation to writing, it is evident that fine motor skills have an effect on the readability quality of students' writing. (Seo, 2018)Also, it is related to the ability to write upright. (Sundari et al., 2019). Furthermore, it is stated that fine motor skills affect literacy, including writing. (Basto et al., 2021; Chandler et al., 2021; Ghanamah et al., 2023; Lê et al., 2021)Therefore, the better the fine motor skills, the better the writing ability.

Fine motor skills develop after 3-6 years of age (Faber et al., 2024). With painting intervention, there is an increase in fine motor skills (Octavianti & Tama, 2023), in relation to fine motor skills, it turns out that based on research left-handed children are more skilled than the dominant right (Mentese & Kutlu, 2024). The development of these motor skills requires well-programmed interventions. One of them is various play activities. Play activities will improve various things, be it gross or fine motor skills, by playing, visual motor skills will develop, where there is a close link between visual motor and reading and writing skills (Calixto et al., 2020; Cerni & Job, 2024; Zhang et al., 2024). Other research states that children's fine motor development will be faster in relation to intensive interaction with parents and playfulness (Krombholz, 2023).

Conclusion

Writing is a fine motor skill. In order to be skilled in writing several things need to be prepared. First, the need for good nutrition. Second, the development or practice of motor skills. Stimulation of fine motor skills will improve graphomotor skills which in turn can improve writing skills. Third, the need for intervention on fine motor skills to improve learning outcomes and children's interest in improving pre-writing skills. Fourth, fine motor skills affect literacy including writing. The better the fine motor skills, the better the writing skills. Fifth, considering that fine motor skills develop from an early age, it is necessary to intervene programmatically, for example with various play activities so that writing skills can develop.

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Datos de los/as autores/as y traductor/a:

Antonius Totok Priyadi	antonius.totok.priyadi@fkip.untan.ac.id	Autor/a
Isti Dwi Puspita Wati	isti.dwi.puspita.w@fkip.untan.ac.id	Autor/a
Amriani Amir	amriani@fkip.untan.ac.id	Autor/a
Tulus Gover Siringo-ringo	tulus@untan.ad.id	Autor/a
Yohanes Gatot Sutapa Yuliana	yohanes.gatot.sutapa.y@fkip.untan.ac.id	Autor/a
Fifukha Dwi Khory	fifukhakhory@unesa.ac.id	Autor/a
Putra Sasataman B	putrasastaman@fkip.untan.ac.id	Autor/a
Dyoty Auliya Vilda Ghasya	dyoty@fkip.untan.ac.id	Autor/a
Procopio B. Dafun JR	pbdafun@mmsu.edu.ph	Autor/a
Mimi Haetemi	mimi.haetami@fkip.untan.ac.id	Autor/a
Albadi Sinulingga	father@unimed.ac.id	Autor/a
Rezza Dewintha	atapoltekkes@gmail.com	Traductor/a