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Factors Influencing Handwriting Development among Preschool Children: A Systematic Review

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Abstract

Handwriting development is essential for academic performance, yet the research on the factors contributing to it is scant. This systematic review aimed to provide a comprehensive overview of the factors contributing to handwriting development among preschool children that may benefit public health knowledge, especially among teachers, parents, and therapists. A systematic search was conducted using four databases: PubMed, ERIC, CINAHL, and Google Scholar. During the preliminary search, 565 relevant studies were found. Screening, review selection, and characterization were performed based on the inclusion and exclusion criteria. The inclusion criteria included preschool children, quantitative, written in English, and published in January 2012–January 2022. The exclusion criteria were studies involving children with specific diagnoses. A consensus agreement was obtained, and ten studies were eventually selected for the comprehensive review. Executive function, letter knowledge, motor skills, and writing surface were identified. These factors indicated that handwriting was not an independent process, as its acquisition involved numerous components. This systematic review confirmed that executive function, letter knowledge, motor skills, and writing surface influenced handwriting development. More randomized controlled trials should be conducted to provide more conclusive and exhaustive evidence.

Keywords: handwriting acquisition, handwriting development, handwriting skills, kindergarten children, preschool children

Introduction

Handwriting is a medium of communication that allows users to project thoughts and ideas. During childhood, handwriting is a significant occupation required for classroom participation as it is part of the educational component and represents children's understanding of subjects during learning sessions and examinations. Handwriting development begins with children scribbling on paper before prewriting skills evolve, and over time they master handwriting skills.¹ In preschool, children are exposed to prewriting activities such as tracing and coloring; over time, they learn writing alphabets and simple words such as names. The acquisition of letter writing occurred between the ages of 6 and 7, while at the age of 8, children focused more on improving movement control and further achieved writing automation at the age of 10.²

Handwriting is vital and must not be underestimated, even in a world dominated by computers and keyboards. It could contribute to developing other skills such as reading skills,³ recognition skills,⁴ and visual-spatial

skills.⁴ The neural activation in the left inferior frontal gyrus (IFG), also known as Broca's area, and left anterior cingulate cortex, was observed to be more significant after writing than typing.³ Therefore, the study suggests that handwriting development during early childhood could aid in developing reading skills.³ Compared to typing by keyboard, handwriting could also encourage learning letters and improve visuospatial skills.⁴ In addition, a study found that handwriting fostered letter recognition and highlighted that hand production or handwriting encourages letter knowledge compared to visual study alone.⁵

Handwriting becomes increasingly important and intricate with increasing age. A review by Dinehart,⁶ elucidates how good handwriting can influence academic performance. According to the review study, first, teachers tend to give more marks to legible assignments. Second, children who struggle with handwriting are more likely to focus on the act of writing rather than on the content of their composition.⁶ Last, children who are frustrated with their handwriting are less likely to write more and

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tend to feel awful about their handwriting, which, consequently, affects their content.⁶ Furthermore, poor handwriting negatively affects students' academic performance in terms of time management, work completion, writing compliance, and legibility.¹

Difficulty in handwriting is also a specific learning disability, referred to as dysgraphia, a disorder that entails the inability to write; it encompasses acquired and developmental dysgraphia.⁷ Acquired dysgraphia is when brain pathways are disrupted, causing the loss of previously acquired skills, possibly due to brain injury or degenerative disease.⁸ Developmental dysgraphia entails difficulty in developing handwriting skills regardless of adequate learning opportunities and cognitive skills; this type of dysgraphia is common among children.⁷ Nevertheless, compared to dyslexia, which is more frequently highlighted in terms of specific learning disabilities, awareness and knowledge of dysgraphia are still scant. No gold standard is available to diagnose dysgraphia.⁸ A study conducted to assess the knowledge of specific learning disabilities among teachers in Ethiopia showed that teachers exhibited poor knowledge regarding specific learning disabilities.⁹ This is significantly alarming as teachers responsible for children's learning demonstrated poor knowledge of dysgraphia; the public presumably had poor or no knowledge at all. This lack of knowledge among teachers and the public, particularly parents, may lead to late diagnosis, which consequently affects children's learning performance. Public health awareness is important for educating people about dysgraphia and seeking early intervention.

Previous literature showed that about 6% to 33% of children had handwriting difficulties.¹⁰ Commonly, occupational therapists use handwriting assessments to identify the problems and guide the intervention. Standardized assessments are beneficial in assessing handwriting performance and factors that influence handwriting, as well as monitoring progress.¹¹ However, there are discrepancies across handwriting assessments used by occupational therapists. Some available handwriting assessments, such as the Minnesota Handwriting Assessment and Test of Handwriting Skills–Revised, focus solely on performance tasks. In contrast, handwriting assessments, such as shore handwriting screening and print tools, incorporate both performance tasks and underlying factors. Performance tasks include copying, writing, and tracing, while underlying factors include fine motor, cognitive, and gross motor skills. Studies on early handwriting acquisition tend to focus more on the product than on the process underlying these skills, which may account for these discrepancies.¹²

According to Case-Smith and O'Brien,¹ alphabet writing, copying, composition, writing speed, legibility, and biomechanical factors need to be examined when evaluat-

ing handwriting. However, some components proposed by Case-Smith and O'Brien,¹ are unsuitable for assessing preschool children. For instance, composition and writing speed are important because preschool children are still in the handwriting development phase. Therefore, factors influencing handwriting development in preschool children must be identified so that occupational therapists and educators can provide interventions for children. Occupational therapists are health care professionals working with individuals to achieve optimal health and well-being through participation in life occupations. In the pediatric population, occupations from an occupational therapist's perspective are activities of daily living, education, social participation, and play.¹

Understanding the factors that affect handwriting performance could assist occupational therapists in providing interventions to help children improve.¹³ These factors may be biomechanical, sensorimotor, or teaching-learning perspectives. This review aimed to clarify and identify factors in terms of skills or components that might influence handwriting development among preschool children. Hence, the findings of this review would benefit therapists, educators, and parents as public persons in delivering the best intervention to improve handwriting acquisition and mitigate the risk of handwriting difficulties among preschool children. This review also might benefit public health by gaining more information on the factors influencing handwriting development.

Method

This review was conducted following the updated preferred reporting items for systematic reviews and meta-analyses (PRISMA).¹⁴ First, this review formulated the research question based on the PICO model, where P, I, C, and O denoted the patient/population, intervention, comparison, and outcome, respectively. As this review involved observational studies and no comparison of interventions, only P and O were used to formulate the research question.¹⁵ The target population was preschool children, and the outcome measured was the factors influencing handwriting development. Therefore, the research question of this review was "What are the factors that influence handwriting development among preschool children?" This review identified the existing evidence to answer this question.

The next step was to identify the relevant studies. The search strategy involved the search for potential studies, and the study selection was based on the inclusion and exclusion criteria. The search strategy, inclusion and exclusion criteria, study selection, and data extraction are explained below.

Search Strategy

A comprehensive search of electronic databases,

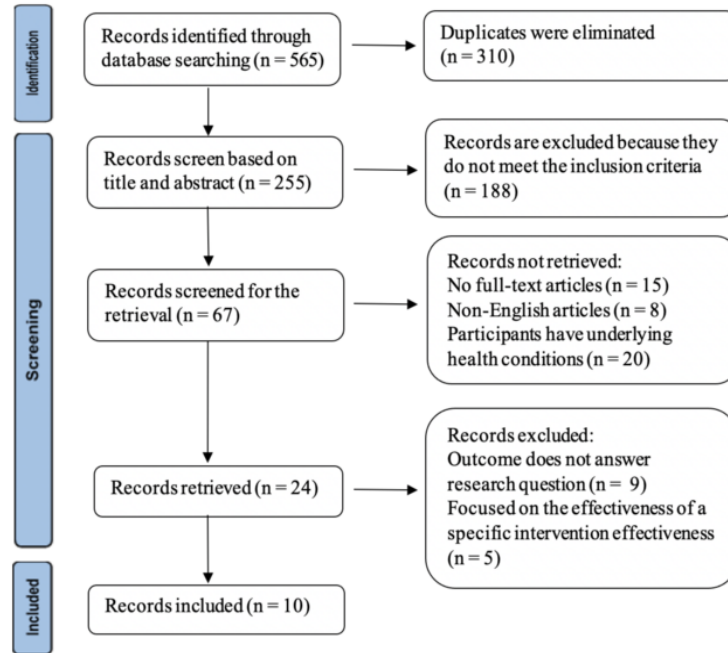


Figure 1. The Flowchart for the Studies Selection

including PubMed, ERIC, CINAHL, and Google Scholar, through the first 20 pages, was conducted from August 2021 to January 2022. The authors devised search terms refined through discussions with experienced librarians. The search strings including Boolean operators were used for combining the search terms; (“Factors” OR “associated factors” OR “components”) AND (“handwriting development” OR “handwriting acquisition” OR “handwriting readiness” OR handwriting skills) AND (“preschool children” OR “kindergarten children” OR “children aged 4-6 years”). The same search strategy was used for all databases (Figure 1).

Inclusion and Exclusion Criteria

This review comprised studies related to handwriting development among preschool children. The inclusion criteria in this study were studies involving preschool children, quantitative, written in English, and published in January 2012–January 2022. The exclusion criteria were studies whose participants had specific diagnoses such as dyslexia, autism spectrum disorder (ASD), and cerebral palsy.

Study Selection

A total of 565 articles were identified based on the inclusion and exclusion criteria. The study selection involved several critical steps. The first step was eliminat-

ing duplicate or similar documents, leaving 255 articles for subsequent phases. The screening of titles and abstracts of the studies selected was independently done. Of the 255 articles, 67 were selected for retrieval based on articles that met the inclusion criteria. Of the 67 articles, 15 were eliminated as no full-text articles were available, and 20 were eliminated as the participants had underlying health conditions, such as ASD and developmental coordination disorder (DCD).

In addition, non-English articles were eliminated, as the translation process might influence the exact meaning of the articles and the comprehension of authors, 24 selected articles were then reviewed; and discussions were held to reach a consensus on the final selection. Of the 24 retrieved studies, nine were eliminated as the outcome did not answer the research question, and five were eliminated as the studies examined the effectiveness of a specific intervention. For instance, a study measured the effectiveness of a specific handwriting curriculum, such as handwriting without tears. Since this review aimed to ascertain the influential factors to handwriting development, the intervention study did not answer the research question accurately. Finally, only 10 articles were selected for this review study.

Data Extraction

A standardized data extraction form was developed.

The selected studies were reviewed, and all relevant data were extracted independently. Two or three reviewers were suggested for the data extraction process to reduce bias and error.¹⁵ Relevant data, including author, year of publication, study design, sample size, country of population studies, and study findings, were extracted.

Results

Clinical Appraisal of the Studies

Table 1 shows the study appraisal using the McMaster Critical Review Form. The included studies were independently reviewed and discussed until reaching a consensus. All the included studies had a clear purpose, relevant literature, reliable and valid outcome measures, appropriate conclusions, and implications. However, none of the studies justified the sample size used. Moreover, five studies did not report dropouts.

Study Characteristics

This review included 10 articles from four databases; three studies were conducted in the United States, two in South Korea, two in Germany, and one in Brazil, Australia, and Egypt. Each study was published in 2012, 2014, 2015, 2016, 2017, and 2020, except for 2018 and 2021, two studies were published (Table 2). The studies listed were observational studies with a sample size ranging from 25 to 166 preschool children. Two studies compared other populations, including elementary-aged children and adults. Therefore, only data pertaining to preschool children were included in this review, which focused on preschool children. Four factors, including letter knowledge, motor skills, executive functions, and

writing surface, were identified in the included articles.

Letter Knowledge (n = 4)

Letter knowledge was assessed in terms of letter recognition,¹⁶ and letter naming,¹⁶⁻¹⁸ copying familiar letters, as well as unfamiliar symbols.¹⁸ Letter recognition was influenced by handwriting fluency,^{12,16,18} and name-writing,¹⁷ in preschool children. Reutzler, *et al.*,¹⁸ found that letter-naming and letter-writing fluency were associated. The study further suggested that competent retrieval of letter names contributes to the rapid and legible writing among kindergarten children. According to Fears and Lockman,¹² this fluency is attributed to a reduction in the information-gathering process prior to handwriting. This study required children to copy three familiar English letters and three unfamiliar Cyrillic symbols. The findings revealed that all the children required additional time to copy unfamiliar Cyrillic symbols. In addition, younger children needed more time than older children during the information-gathering phase.¹⁸ Letter knowledge affected the phase of writing the letter rather than the fluency of movement while drawing letter features. Therefore, it was concluded that a lack of letter knowledge causes disfluency in handwriting.¹⁶ According to Gerde, *et al.*,¹⁷ the most important predictor of children’s name writing was letter knowledge, specifically capital letters.

Motor Skills (n = 3)

Motor skills were categorized into fine and gross motor skills. A study identifying the relationship between handwriting and fine motor skills found that fine motor

Table 1. Study Appraisal using McMaster Critical Review

	Fears and Lockman ¹²	Fitjar, <i>et al.</i> , ¹⁶	Gerde, <i>et al.</i> , ¹⁷	Reutzler, <i>et al.</i> , ¹⁸	Seo ¹⁹	Dayem, <i>et al.</i> , ²⁰	Pazeto, <i>et al.</i> , ²¹	Valcan, <i>et al.</i> , ²²	Gerth, <i>et al.</i> , ²³	No and Choi ²⁴
Study purpose										
Was the purpose clearly stated?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Literature										
Was relevant background literature review?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sample										
Was the sample described in detail?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was the sample size justified?	x	x	x	x	x	x	x	x	x	x
Outcomes										
Were the outcome measures reliable?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were the outcome measures valid?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Results										
Results were reported in terms of statistical significance?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were the analysis method(s) appropriate?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Clinical importance was reported.										
Dropouts were reported?	✓	✓	x	x	✓	x	✓	✓	✓	x
Conclusions and implications										
Conclusions were appropriate given study methods and results.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2. Descriptive Summary of Reviewed Studies

Author	Year	Country	Design	Sample Size	Participant Characteristics	Key Findings
Fears and Lockman ¹²	2018	United States	Observational	n = 40	Mean age: 69.60 months	Children copied familiar English words more efficiently than unfamiliar Cyrillic symbols. Unfamiliar Cyrillic symbols needed more regathering information process during the act of writing than familiar English letters.
Fitjar, et al., ¹⁶	2021	Germany	Observational	n = 176	Mean age: 74.6 months Sex: 90 boys, 86 girls	Pen control ability (garlands and figure eights) could predict the fluency of copying characters. Good letter knowledge (phoneme to grapheme encoding) allowed children to copy letters and symbols proficiently.
Gerde, et al., ¹⁷	2012	United States	Observational	n = 103	Mean age: 47.35 months Sex: 59 boys, 44 girls	Letter knowledge and fine motor skills were more significant predictors of name writing than the other factors analyzed.
Reutzel, et al., ¹⁸	2017	United States	Observational	n = 48	Sex: 23 boys, 25 girls	A high correlation between letter naming and letter-writing fluency.
Seo ¹⁹	2018	South Korea	Observational	Preschool children n = 52	Mean age: 69.19 months Sex: 25 boys, 29 girls	Fine motor precision and in-hand manipulation skills were found as components that could influence handwriting legibility.
Dayem, et al., ²⁰	2015	Egypt	Observational	Group A n = 54 Group B n = 46	Group A Mean age: 56.7 months Sex: 29 boys, 25 girls Group B Mean age: 64.1 months Sex: 28 boys, 18 girls	Gross motor skills were strongly correlated to the speed of handwriting.
Pazeto, et al., ²¹	2014	Brazil	Observational	Kindergarten I n = 57 Kindergarten II n = 53	Kindergarten I Mean age: 4.35 years Sex: 19 boys, 18 girls Kindergarten II Mean age: 5.30 years Sex: 27 boys, 26 girls	In the field of executive function, only attention was significantly affected by the school level. Executive function correlated with handwriting in both groups of kindergarten.
Valcan, et al., ²²	2020	Australia	Observational	T1 n = 166 T2 n = 155	T1 Mean age: 5 years 8 months Sex: 81 boys, 85 girls T2 Mean age: 6 years 5 months Sex: 74 boys, 81 girls	Executive function could predict academic achievement, specifically reading and writing. Immediate effects pathway supported in handwriting automaticity and writing quality. The growth potential model supported reading and writing quality.
Gerth, et al., ²³	2016	Germany	Observational	Preschool children n = 25	Mean age: 5.4years Sex: 8 boys, 17 girls	Better handwriting quality during paper writing. Better velocity was found for tablet writing compared to paper.
No and Choi ²⁴	2021	South Korea	Observational	n = 97	Mean age: 79.06 months Sex: 39 boys, 58 girls	A larger print was recorded on the tablet. Writing speed improved on the tablet. Lesser pressure on the tablet.

precision, in-hand manipulation skills, and handwriting legibility were related.¹⁹ This study concluded that fine motor precision and in-hand manipulation skills contribute to handwriting legibility and that in-hand manipulation skills should be included once children learn how to write. A study by Gerde, et al.,¹⁷ discovered fine motor skills to be the most crucial predictor of name-writing skills in the development of children's handwriting. A study on gross motor activities reported that gross motor activities influence handwriting, especially handwriting speed, in both copying and dictation skills.²⁰

Executive Function (n = 2)

Two studies reported the relationship between executive function and handwriting.^{21,22} Executive function was measured via activities involving working memory,

shifting ability,²² inhibition,^{21,22} cognitive flexibility, and selective attention.²¹ Based on the two reviewed articles, the executive function had the ability to predict children's handwriting achievement.^{21,22} A related study described the relationship between executive function and handwriting in two groups of kindergartners: kindergarten I and kindergarten II.²¹ The findings showed that executive function correlated with the handwriting of both groups of children, and the study recommended executive function as a target of intervention to improve academic achievement.²¹ Another study investigated the mechanisms that enabled executive function to predict later academic success.²² The findings indicated that executive function could predict handwriting automaticity via the immediate effects pathway and writing quality via both the immediate effects pathway and growth potential

pathway.²²

Writing Surface (n = 2)

Two studies had identified the effects of the writing surface on handwriting by comparing writing on tablets and paper.^{23,24} One study investigated the effect of the writing surface using three tasks: graphomotor abilities, visuomotor abilities, and automatic handwriting abilities.²³ Visuomotor is the coordination of visual perception and motor movements, whereas the task involved in this study was copying geometric forms. The study's findings indicated that children had better handwriting quality while writing on paper because they were not automatized in their writing actions, which made writing on tablets difficult due to the lack of proprioceptive feedback.²³ Regarding the handwriting process, tablet writing was found to be faster than paper writing because of the smoother surface of the tablet. Therefore, a smoother surface requires additional control and challenges the learners' handwriting.²³ In their study, No and Choi,²⁴ evaluated three factors: print size, writing speed, and writing pressure. The study explained that a larger print was recorded on the tablet, and the pen was found to move faster and applied less pressure on the tablet.²⁴ This is consistent with Gerth, *et al.*,²³ reporting that writing on a tablet reduces handwriting clarity while increasing the writing speed and print size.

Discussion

Of 10 quantitative studies on handwriting development in preschool children in this review, there were four factors: executive function, letter knowledge, motor skills, and writing surface, were discovered. Generally, all the factors discovered in this review were interconnected and consequently contributed to handwriting development.

Executive function is a cognitive process involving working memory, inhibitory control, and cognitive flexibility.²⁵⁻²⁷ This review showed that executive function contributed to the prediction of children's handwriting development. Executive function facilitated children memorizing what they learned, shifting and controlling attention, and responding to stimulation appropriately. In line with Rosenblum,²⁸ efficient handwriting performance required components of executive function, including shifting, working memory, planning and organization, monitoring, and material organization. Moreover, executive function was found to be significantly associated with the growth of letter knowledge.²⁹

Letter knowledge facilitated automaticity in handwriting. Inadequate letter knowledge disrupts automaticity because children cannot automatically retrieve letters from memory.¹² A study found that improving handwriting automaticity could contribute to longer and bet-

ter text writing.³⁰ Therefore, lack of handwriting automaticity reduced writing speed as children might require references to write the letters. When the children used references, their gaze will frequently shift from the reference to the writing surface. Hence, letter knowledge significantly contributes to facilitating the handwriting process. Moreover, good executive function encouraged the learning and memorization of letter knowledge.

Motor skills were further divided into gross and fine motor skills; gross motor skills involved large muscle groups, and fine motor skills involved small muscle groups. Both fine and gross motor skills were necessary for handwriting acquisition.³¹ Gross motor skills were necessary for maintaining a stable and correct posture while writing in a classroom.²⁰ Fine motor skills were equally important and necessary to hold and manipulate writing tools during the handwriting process.²⁶ Writing tools, such as crayons, pencils, and pencils color, are usually small. Therefore, fine motor precision and hand manipulation skills were required to manipulate small writing tools. In addition, the writing surface could influence fine motor skills. Smoother writing surfaces required children to have good fine motor skills to manipulate writing tools effectively.

The handwriting process was guided by proprioceptive feedback. However, low-friction writing surfaces such as tablets reduce proprioceptive feedback, causing writers to rely more on visual feedback.³² According to dynamic system theory, sensory perception and motor systems are coupled and continually interact to acquire new skills.⁶ Generally, sensory input is transmitted to the brain to generate motor commands before producing written output. A study comparing the effect of a smooth tablet surface on handwriting quality and kinematics in children in grades 9 and 2 found that handwriting on a tablet reduced letter legibility and augmented letter size in both age groups.³³ The smoother surface demanded greater graphomotor control due to the lower proprioceptive feedback.²³

The findings coincided with the conceptual framework of Malay language handwriting.³⁴ This framework explains that neuromotor development (fine and gross motor skills), ergonomics (writing surface), orthography (letter knowledge), and cognitive factors all contribute to Malay handwriting (executive function).³⁴ According to the framework, neuromotor development and ergonomic factors are acquired from the occupational therapy discipline.³⁴ While, the education discipline lays out most information on linguistic and memory factors. Hence, the involvement of multidisciplinary teams is essential for handwriting development.³⁴

According to Dinehart,⁶ the best strategy for teaching handwriting among young children before schooling was unclear; thus, this study encouraged practitioners to de-

velop effective handwriting strategies. Accordingly, the findings from this review could guide teachers, parents, and occupational therapists to implement effective strategies in teaching handwriting. For instance, as the review explained, smoother writing surfaces demand more graphomotor control and provide lower proprioceptive feedback; therefore, teaching handwriting using pencils and paper promises more benefits. Moreover, pencils and paper have been extensively used in classroom learning. Additionally, based on both gross and fine motor skills review explains that teachers, parents, or occupational therapists should focus on both skills and not only on fine motor skills.

Furthermore, these findings encouraged the public to obtain more information on the influential factors to handwriting development. Awareness of these factors could make the public realize that handwriting is a complex task that depends on multiple components. The public could be aware of the possibility for children to face handwriting difficulty, even though the writing task could be perceived as easy for adults. Therefore, less awareness about this issue may cause people to think they are lazy. Awareness and understanding of this issue could prevent late intervention programs and negative perceptions towards children with handwriting difficulty.

The strength of this review was that it might be the first systematic review to examine the factors influencing handwriting development among preschool children. Children begin learning handwriting at an early age; thus, the factors discovered may be beneficial for improving handwriting acquisition among preschool children. However, this review does not include a study of ergonomic factors. According to Case-Smith and O'Brien,¹ ergonomics factor, such as sitting postures and desk and chair height, should be analyzed. Second, this review also incorporated a study involving the Korean (non-English alphabet). The Korean and English alphabets have distinct features. Therefore, it would be ideal for explaining this distinct feature and its relationship with handwriting development in children.

Conclusion

Overall, this review explains the four factors influencing handwriting development and provides an understanding of the relationship between all the factors discovered. This review supports the notion that handwriting depends on various components, including executive function, letter knowledge, motor skills, and the writing surface. Occupational therapists, educators, and parents may implement the factors discovered to facilitate handwriting acquisition among preschool children. For instance, before handwriting learning, educators may implement letter knowledge activities such as alphabet flashcards, and tablet use may be avoided to teach hand-

writing among preschool children.

These findings also help raise public awareness of the factors influencing handwriting development. Therefore, more people would be aware of this issue, and more strategies could be developed to support handwriting development among children. However, as most handwriting studies examine school-aged children, the findings are insufficient to make definitive clinical recommendations. More Randomized Controlled Trials studies examining handwriting development among preschool children should be conducted to provide more conclusive and comprehensive evidence.

Abbreviations

IFG: Inferior Frontal Gyrus; PRISMA: Preferred Reporting Items for Systematic Review and Meta-analyses; PICO: Patient/population, Intervention, Comparison, Outcome; ASD: Autism Spectrum Disorder; DCD: Developmental Coordination Disorder.

Ethics Approval and Consent to Participate

The ethical approval was granted by the Medical Research and Innovation Secretariat, Universiti Kebangsaan Malaysia (JEP-2021-474).

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

This review used four databases: The data PubMed, ERIC, CINAHL, and Google Scholar.

Authors' Contribution

ZI contributed substantially to the concept, work design, and manuscript drafting. ZI and NAR screened the title and abstract. ZI, NAR, MK, and FWY were involved in reviewing 24 articles to reach a final consensus. ZI and NAR reviewed the final ten articles. NAR, MK, and FWY were involved in critically reviewing the manuscript's content, and NAR revised the final version to be published.

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