

## REVIEW ARTICLE

# Pre-writing Interventions for Developmental Disabilities and Typically Developing Children: A Scoping Review

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## ABSTRACT

This scoping mapped the evidence regarding pre-writing interventions for developmental disabilities and typically developing children. This review followed the PRISMA-Scoping Review guidelines. Evidence between January 2011 and July 2021 was retrieved from four databases: EBSCO, ScienceDirect, Scopus, and Web of Science. Selected articles were evaluated for quality using the Crowe Critical Appraisal Tool (CCAT). Ten articles were included in the study, with CCAT scores ranging between 68% and 85%. Findings were arranged in five themes: (1) pre-writing interventions, (2) pre-requisite handwriting skills, (3) protocol and interventions, (4) intervention pioneer, and (5) conveyance of interventions. Generally, pre-writing interventions were aligned with the pre-requisite skills of handwriting. Digitized-based interventions were commonly utilized and expanded in developing pre-writing skills. Acquiring effective pre-writing interventions for both populations will refine the handwriting performance. Further exploration of the integration of pre-writing skills with digitized-based intervention is required to evaluate the effectiveness of the intervention.

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## INTRODUCTION

Handwriting difficulties with delicate motor problems often affect children's academic-related tasks (1). A massive range of occupational therapy interventions surpassed handwriting difficulties (2). Prevalence of handwriting issues among children during early childhood was reported to be 5% to 27% based on age and other demographic of children (3). These issues usually occur among children during primary school education, especially male students (4). Handwriting problems a common among earlier school-aged children, causing them to grow disheartened. Children often overcompensate for the pre-writing abilities they lack, thereby developing inappropriate writing habits that are exceedingly difficult to correct later. Although typing and touch screens are growing more advanced in today's society, handwriting skills remain vital as the initial medium for children to learn in school (5). Poor handwriting skills, such as letter legibility and writing speed, will impact the learning process in the classroom,

including copying from the whiteboard, developing ideas, and exhibiting comprehension of the teacher's lessons (6). This situation will later impact the student's entire performance in the classroom, both internally and externally, such as feeling inferior to his classmates and manifesting inappropriate behaviour by avoiding the task such as refusing to write and learn, avoiding learning activities in classroom, and refusing to go to school (7). Thus, early intervention of pre-writing skills will nurture the children's handwriting skills to perform better in academic performance at school.

By six years old, typically developing children would have mastered handwriting. However, due to various challenges such as inadequate fine motor control, bilateral and visual-motor integration, motor planning, in-hand manipulation, proprioception, and visual perception, they may have difficulty reaching the normal development milestone of handwriting (8). Children with developmental disabilities, on the other hand, are more susceptible to handwriting difficulties, and it is common for these four conditions: Autism Spectrum Disorder (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), Cerebral Palsy (CP), and Dysgraphia (9). For example, handwriting issues are linked with sensory sensitivity, motor difficulties, attentional deficits,

poor language comprehension, and impaired executive function in children with such conditions (10).

Recently, a lack of attention was given to the literature and instructional programs on developing and assessing children's readiness for handwriting and pre-writing skills (11). Lamme (12) outlines six pre-requisite skill areas needed for handwriting. The pre-requisite skills include small muscle development, eye-hand coordination, holding utensils or tools, basic strokes, letter perception, and orientation to printed language. A previous study reported that handwriting depends mainly on developing fine motor skills involving small muscle movements of the hand (13).

The first pre-requisite skills is fine motor development which is also known as small muscle development. It refers to using the fingers, thumb, and hand muscles. For example, a child should have mastered using the thumb opposite their index finger by this age, known as the 'pincer' hold. The delicate muscles of the fingers, toes, wrists, lips, and tongue are all used while using a pincer grasp to grip, hold, and manipulate objects. Experience with a pincer grasp during this time helps a child develop more complex and valuable skills later on, such as drawing, writing, cutting, and threading (14). The second pre-requisite skill is defined as the ability of the vision system to coordinate information acquired via the eyes to control, guide, and move the hands in the performance of a task, such as handwriting or catching a ball. It is known as eye-hand coordination (15). Following that, the third pre-requisite skills is tool manipulation, dominant hand use, and crossing midline with the dominant hand are the following pre-requisites skills identified in the literature for legible handwriting (16). The fourth pre-requisite skills is basic strokes, which is defined as the ability to produce lines in a proper direction and clean intersections (12). These hand skills relate to the stages before children start to write (17).

The fifth pre-requisite skills is defined as the ability to recognize forms, keep track of the similarities and differences, remember the required motion to generate certain forms and the ability to precisely explain what they view (18). Lastly, the sixth pre-requisite skill is the ability to attend and orient to printed language, coordinate one's exploratory investigation of printed forms, distinguish left from right, and visually examine letters and words. These are all skills parallel to reading readiness (19). The main concepts or elements of orientation to written languages are the concepts of text and book, directionality, mechanical qualities, and alphabet knowledge (20).

The six pre-requisite skills required for handwriting were a reliable reference in observing and monitoring children's handwriting development from an occupational therapy perspective. From the occupational therapy practice's viewpoint that receives multiple school referrals for

handwriting, concerns are usually linked to poor fine motor skills development, difficulty recognizing and recalling uppercase or lower case letters, poor handwriting legibility, and children with below the developmental age speed of writing (21).

Current research on handwriting development focused mainly on school-aged typically developing and developmental disabilities children, with less attention on pre-writing skills of young children before joining formal education (22). Developing pre-writing abilities or handwriting readiness in early infancy could be beneficial for helping children in reading and writing (23). The six pre-requisite skills for handwriting by Lamme (12) were used as a guide for assessment and intervention in occupational therapists' practice. Multiple outcome measures and treatments were utilized to improve handwriting skills; however, deficiency in pre-writing skills and its intervention for young children has not been well discussed and synthesized in literature. Given the importance of pre-writing skills or handwriting readiness, this paper provides a scoping review of the literature about the current practice of pre-writing skills intervention for typically developing and developmental disabilities children. This study is the first to discuss the pre-writing interventions based on the six pre-requisite skill areas needed for handwriting. Hence, it justifies the need for a scoping review to map and synthesize the available evidence related to pre-writing interventions for young children.

## METHODS

A scoping review was conducted to provide an overview of extant scientific literature examining pre-writing interventions for developmental disabilities and typically developing children to offer directions for future research in the field (24). This scoping review complied with the Preferred Reporting Items for Systematic reviews and Meta-Analysis extension for scoping review (PRISMA-ScR) checklist (25). The method was selected as a guideline to map the recent advancement of pre-writing interventions and identify the depth of other themes aside from pre-requisites skills for the designated population (21).

### Identifying the Research Questions

Pre-writing skills are one of the focuses of occupational therapy practice in paediatric. Understanding the effectiveness of various pre-writing interventions for developmental disabilities and typically developing children at all levels would provide occupational therapists with a means to support the writing development. Hence, the following research question was formulated for this scoping review; to what extent is evidence available on pre-writing skills interventions for children with typical development and developmental disabilities?

## Identifying Relevant Studies

The following databases were used to search relevant published articles; EBSCO, Science Direct, Scopus, and Web of Science. The main keywords searched were guided by the Medical Subject Heading (MeSH), such as “pre-writing” OR “handwriting” AND “developmental disability” OR “developmental disorder” OR “children” OR “typical” OR “normal”. Potential studies were also identified from the reference list in the relevant studies. The initial search identified 1011 from four databases. However, 92 studies were removed after duplication screening, and 890 studies were excluded considering the type of paper and years of publications. None of the studies could not be retrieved after the title and abstract screening. Of 29 studies, 12 were eliminated due to the age range of participants, language used and type of study. Figure 1 shows the process of identifying relevant studies. Articles found from cross-reference and hand searching were also documented. The hand searching method was utilized to identify relevant studies but was not recorded to add value to the findings (26). NAH, NAZMZ, NIAR and HMH performed the search independently using the exact keywords.

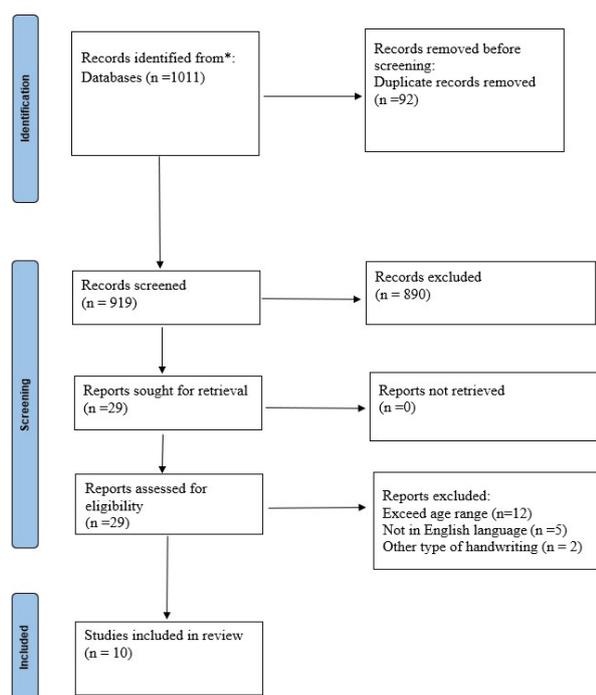


Figure 1: Flow diagram for the search and study selection.

## Selection of Studies

The inclusion criteria of the peer-reviewed studies were (i) all published studies in the English language, (ii) published from January 2011 until July 2021, (iii) focusing on the pre-writing intervention of developmental disabilities or typically developing children, (iv) the participants' age ranged between 3 to 10 years old for both population, and (v) conducted in children's institution care and education settings. The exclusion criteria were grey literature and review studies

(26). NAH, NAZMZ, NIAR, and HMH screened the studies according to the inclusion and exclusion criteria. Any issues regarding the study selection were discussed until the consensus was achieved.

## Charting the Data

The studies were summarised by authors, year, sample size, study location, study design, participants' age range and gender and their relation to the pre-writing intervention. NAH, NAZMZ, NIAR and HMH charted the data from all included studies. Then, the data was discussed and reviewed together with SAMA and AZCD. The quality of the studies was assessed using the Crowe Critical Appraisal Tool (27) by NAH, NAZMZ, NIAR and HMH. The charting of relevant studies was distributed based on each researcher's initial database search, and the critical data was put in developed charting forms using Microsoft software.

## Collating, Summarising and Reporting the Results

The scoping results were summarised and reported in the result section. Thematic analysis was used to categorize the main findings of this review. Both deductive and inductive thematic analyses were used in this study. The pre-set theme for deductive analysis for the second theme was apprehended based on Lamme's study (12). Other themes emerged from the inductive analysis, in which the theme was generated from all selected studies and recognized throughout the reading and discussion among the authors. All authors participated in collating, summarising and reporting the findings. Any issues about the study's findings were discussed among the authors until a consensus was achieved.

## RESULTS

Ten studies were included after screening for the inclusion and exclusion criteria. The included studies were summarised and synthesized in Table I. Six main themes were derived from the studies: pre-writing intervention, pre-requisite handwriting skills, intervention strategies, interventions' personnel, outcome measure and conveyance of intervention. The age range of participants was between 3 to 10 years old, and most studies were conducted in various settings such as preschool, kindergarten, school, and childcare centres. The sample size from all ten studies ranged between 5 and 113. Nine studies used quantitative design, and only one study used qualitative design. All the studies were conducted in western countries.

## Theme 1: Pre-writing Interventions

Two studies used Handwriting Without Tears (HWT) to tackle children's pre-writing issues (28,29). There are two versions of HWT, Simply Smart Student Materials and Get Start School. Both versions of HWT focused on pre-writing skills, such as tracing over five solid black vertical lines of varying lengths (28). Three interventions were implemented using advanced technology, such as

**Table 1: Description of articles in the scoping review**

Authors	Study Design	Sample	Interventions	Findings	Critical Evaluation / Limitations	CCAT Score X/40(%)
(Bara & Bonneton-Bo, 2018)	Quantitative (Randomized Controlled Study)	n=72 Kindergarten 5-6 years old	Visual-Motor Intervention	Handwriting fluency, letter recognition, and handwriting direction improved more with the visuomotor training program than the visual training program.	There may be possible separate effects from the motor arm and body movements in the visuomotor training program	32/40= 80%
(Borghese et al., 2017)	Quantitative (Cohort Study Design)	n= 16 Kindergarten 5-6 years old	Exergames Intervention	Exergames allowed children to practise eye-hand coordination and forming basic strokes in multiple settings.	Small sample size and bias in the classification of handwriting performance which made solely based on drawing the figure of eight.	27/40= 68%
(Delegato et al., 2013)	Quantitative (Single-Subject Study Design)	n=5 Preschool students with developmental disabilities 3-5 years old	Handwriting Without Tears Handwriting Race-track	HWT increased four participant's pre-handwriting skills. The use of a handwriting racetrack can increase pre-handwriting skills. The use of HWT and the handwriting racetrack may improve pre-handwriting for preschool students with various delays.	There is inconsistent instructional time and intensity of the intervention program for the participants.	27/40= 68%
(Lust & Donica, 2018)	Quantitative (Quasi experimental)	n=40 Preschooler 4-5 years old	Handwriting Without Tears (Get Start School)	The experimental group showed significant improvements post-intervention as compared to the control group in pre-writing, kindergarten readiness, and fine motor skills.	There is uncertainty about the effects of treatment dosing, whether less or more frequency will produce the better effects.	32/40= 80%
(McGlashan et al., 2017)	Quantitative (Randomized Controlled Trial)	n= 78 Primary school at Nottingham 8-10 years old	Computerized Typing Interventions	Children's manual dexterity increased when they could practice tapping abilities, for example, by playing typing games. There was no significant interaction to suggest a group difference across time (first compared to the second tapping task). The intervention game improved children's manual dexterity skills for the MABC-2; this improvement did not generalize to the task-oriented approach.	Small sample size. Limited time for the intervention group, which affects the equality of the intervention group size.	32/40= 80%
(Neumann, 2018)	Quantitative (Randomized Controlled Trial)	n= 48 Child Care Centres Queensland, Australia 2-5 years old	Pad Literacy Program	Children in the iPad group had significant and positive gains in writing their name compared to the control group. There were significantly higher scores at the posttest in letter knowledge, print concepts, and name writing but not letter writing when compared to the control group.	Only English-speaking youngsters were included in this small samples. There is possible variability of language skills present within the sample.	32/40= 82%
(Oh et al., 2013)	Quantitative (Randomized Control Trials Study Design)	n=113 Elementary school Five years old	Specialized Teaching and Enhancement of Performance Skills for Kindergarteners (STEP-K)	The intervention group showed a statistically significant improvement in fine motor and visual-motor abilities. Meanwhile, the control group showed a little deterioration in both.	Small sample size that limits generalization of findings.	30/40= 75%
(Podobnik, 2017)	Qualitative (Observation and art works)	n=42 Kindergarten 3-.6-year-old	Visual Arts Activity	The pictorial activity is use to stimulate the children's symbolic play. Children begin to link the two modes of communication on their own at a young age, which should be taken into account when teaching them to read and write.	Small sample size. The was limited time in analyzing pictorial materials.	30/40= 75%
(Roberts, Vadasy & Sanders, 2018)	Quantitative (Randomized Controlled Trials Study Design)	n= 83 Preschoolers 5-6 years old	Alphabet Learning program	The results back up the value of explicit alphabet instruction, which includes the cognitive learning processes that are essential for alphabet learning. Letter perception, proper instructions, cognitive skills and language proficiency, single-focus letter name and sound significantly improved after the intervention.	Process measures (OL) lacked the desired level of measurement reliability, rendering results unreliable.	30/40= 80%
(Taverna et al., 2020)	Quantitative (Quasi-experimental Study Design)	n=55 Kindergarteners 4-6 years old	Conventional Pediatric Occupational Therapy (Visual Motor Integration & Fine motor) interventions	The visual-perceptive performances, motor coordination improved in copying figures and discriminating geometric targets. Only visual perception abilities and the capacity to regulate precise motions are required for recreating figures and linking dots inside trails.	Lack of a control group to assess the effectiveness of the intervention	34/40= 85%

computerized games and software applications (30–32). These interventions aimed to enhance fine motor skills, form basic strokes, and letter perception. Two studies investigated the influence of visual-motor integration treatments with fine motor skills tasks on letter learning, graphomotor abilities, and handwriting performance (33,34). The Specialized Teaching and Enhancement of Performance Skills for Kindergarten (STEP-K) interventions were implemented to improve fine motor and visual-motor skills in 10 weeks time frame based on the Response to Intervention model (RTI) for Individuals with Disabilities (35). Another intervention is Alphabet Literacy Programs to improve letter perception, proper instructions, cognitive skills, and language proficiency (36). This intervention was provided for nine weeks, in 10-min per session and four days per week. Lastly, Visual Arts activity was used as an intervention related to child's exploration of various visual materials to facilitate their pre-writing skills (37).

### **Theme 2: Prerequisite Handwriting Skills**

Fine motor skills and visual motor skills intervention were discussed in nine studies (28,29,31–34,36,37). Two studies used HWT intervention for pre-writing interventions (28,29). Another three studies examined the effects of fine motor and visual-motor skills intervention simultaneously with two groups of children and found that the intervention group in both studies showed significant improvement compared to the control group (31,34,38). Finally, two studies that used computerized typing and touch screen tablet interventions showed significant fine motor improvements (32,34).

Handwriting interventions that incorporated eye-hand coordination were examined in nine studies (28,29,31–34,36,37). In a study, eye-hand coordination intervention was provided using Ipad among children aged 5 to 6 years old; children who received the intervention were prone to develop immature handgrip. The intervention did not help to improve the eye-hand coordination skill, although the intervention received positive feedback from the children who participated in the study (30). Four studies that used visual-motor integration and fine motor skills-based intervention showed significant improvements in pre-writing skills (29,34,37,38).

Nine studies used holding utensils or tools skills in the pre-writing intervention (28–34,37,38). Two studies utilized the HWT programs that address pre-writing skills for handwriting, including the ability to hold writing utensils (28,29). Finally, three studies used a digitized intervention that incorporated computerized typing intervention, an Ipad literacy program, and exergames (30–32).

Eight studies reported the effects of essential stroke intervention in improving children's handwriting (28–31,33,37,38). Studies that used HWT (stroke intervention) programs demonstrated improvements in

pre-writing skills (28,29). For example, the participants were asked to perform tracing over vertical lines and tracing over the first four letters of their name (28). Another study that used basic stroke formation using the HWT program showed that the intervention group significantly improved pre-writing skills, kindergarten readiness, and fine motor skills compared to the control group (29).

Eight studies included letter perception component in the pre-writing intervention (28–31,33,34,36,37). One study found that the Ipad literacy program for nine-week has shown significant improvement in letter formation, sound knowledge, print concept, and writing skills compared to the non-Ipad group (31). Similarly, the other eight studies reported a significant difference in letter perception after the pre-writing interventions (28–31,33,34,36,37).

Six studies included the orientation to printed language components in their pre-writing intervention (28,29,31–33,36). For example, after nine weeks of training, one study found that Paired Associate Learning (PAL) was substantially linked to the growth, accuracy, and speed of naming taught letters (36). At the same time, Articulating Referencing Learning (ARL) was significantly connected to the improvements in naming taught letters.

### **Theme 3: Intervention Strategies**

Four intervention programs were implemented with their original protocol and strategies in terms of time frame, instructions and materials, such as HWT (SSMT), HWT (GSS), STEP-K, and Alphabet Literacy Programs (28,29,36,38). Overall time frames for the four interventions were between two and ten weeks, with the frequency of three to five sessions per week. The duration per session ranged from five to thirty minutes. Only two interventions were implemented without a specific protocol, such as the exergames and visual arts activity that used adapted questionnaire feedback and observation of participant performance to measure the improvements (30,37).

### **Theme 4: Outcome Measures**

More than half of the interventions were implemented with standardized outcome measures to collect the subject's baseline performance and improvements (28,29,31–34,36,38). The measures evaluated the children's fine motor skills, visual-motor integration, grasp patterns, writing readiness, cognitive skills, pre-writing skills, letter perception, and language proficiency. Among the measures that were most commonly used in the studies were Bruininks–Oseretsky Test of Motor Proficiency 2nd Edition Fine Manual Control (BOT–2), Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery VMI), Movement Assessment Battery for Children-2 (Movement ABC-2), Developmental Scale of Pencil and Crayon Grips, Pre-Writing domain of the Learning Accomplishment Profile 3rd Edition (LAP–3),

Check Readiness Tool, Rey-Osterrieth Complex Figure Test (Rey-O), Clay's Concepts About Print test, Pre-IPT Oral Language, Proficiency Test Peabody Picture Vocabulary Test III Alphabet Knowledge Cognitive Learning Process, and British Ability Scales 2nd edition (BAS-2).

### **Theme 5: Interventions' Personnel**

Occupational therapists, in collaboration with teachers have developed two pre-writing intervention programs such as HWT (GST) and (STEPS-K) (29,38). For instance, (the STEPS-K) program was collaboratively developed with teachers to reinforce the modification and motor skills training throughout the school day (38). Other professionals such as medical doctors, psychologists, special education teachers, early childhood researchers, software engineers, and art teachers led more than five interventions for pre-writing skills (28,30,31,33,37).

### **Theme 6: Conveyance of Intervention**

More than half of the interventions were implemented through typical administration, such as paper-based worksheets and therapeutic activities for fine motor, visual-motor integration, and play exploration (28,29,33,34,36-38). In addition, three pre-writing interventions were implemented using advanced technology such as exergames, an Ipad literacy program, and computerized typing games (30-32). These interventions used advanced technology that focuses on fine motor skills, eye-hand coordination, manual dexterity, and letter perceptions using digital pen and screen technology.

## **DISCUSSION**

This scoping review aimed to review and map the available evidence related to pre-writing interventions, parallel with the pre-requisite handwriting skills. The six pre-requisites skills were small muscle development, eye-hand coordination, holding utensils or tools, basic stroke, letter perception, and orientation to printed language, which allow children to learn a particular alphabetic writing skill (12). However, children must be able to draw and identify basic strokes of particular forms and shapes before they can master the last two essential skills, which support the foundation of literacy and enable the children to write and read independently. It provides visual cues on how children should begin to write where the children need to have a good proportion of strokes and radicals; thus, overall alignment could be achieved. Concepts of stroke sequence are essential for beginning writers because skilled writers would develop their writing habits on word formation (39).

The evidence suggests that HWT, combined with a handwriting racetrack, was used in the pre-writing intervention to provide better treatment outcomes (28). The academic racetracks are generally created with 28 boxes in car racetracks design, and a picture of the car

is known as handwriting racetracks. The children need to learn to write letters, words, numbers, math facts or read a detailed list of words. For example, if children were learning to write five words, they would be given a fixed period, and any mistakes they made on the tracks would be addressed immediately. After the child has completed one word, he can move on to the next box until he reaches the racetracks' finish line within the time given (40).

Many researchers incorporated more than one intervention to obtain more holistic and functional outcomes (28,33,34,38). Thus, this complex intervention provides a better understanding of how intervention programs interact with different environments in which contextual elements were crucial or prohibitive to their implementation (41). As a result, the combined intervention strategies may enhance learning and handwriting performance more effectively. For example, using a combination of handwriting without tears and the handwriting racetrack may improve pre-handwriting or handwriting skills for developmental disabilities children with various conditions and typically developing children (28).

The accomplishment of children to recognize similarities and differences in the production of letter/form indicates their readiness for a more challenging handwriting level (42). Most studies acknowledged and emphasized letter perception skills in the pre-writing intervention (28-31,33,34,36-38). Letter perception skill assists children in understanding the primary language used for communication (43). In addition, the skill would allow the children to assess their thoughts when writing something on paper.

Most pre-writing interventions use multiple assessments as outcome measures. These outcome measures were developed or adapted to fill the need for supporting and evaluating children with handwriting problems. Assessments are necessary to identify students who require pre-writing intervention accurately. Providing universal screening methods within the RTI framework will help determine the prevalence of problems while identifying students who may have otherwise gone untreated (44). Hence, the RTI assessment components are critical elements to be implemented since the results of the assessments drive the adjustments in children who have been recognized as being at risk of failing to fulfil academic objectives (45).

Evidence-based assessment and intervention go hand-in-hand; this has previously been identified as a hallmark of effective RTI system (46). The most commonly used assessments for pre-writing intervention are Bruininks-Oseretsky Test of Motor Proficiency 2nd Edition Fine Manual Control (BOT-2), Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery VMI) and Movement Assessment Battery for Children-2

(Movement ABC-2).

Current studies show that several professionals conducted pre-writing interventions (28,30–34,36,37). Thus, this study suggests that pre-writing intervention should be provided using an interdisciplinary approach rather than a single professional. A previous study reported that teachers' training in this area of handwriting seems to lack, and they do not feel competent in teaching handwriting (47). Notably, this provides an opportunity for occupational therapists to offer their skills because one of the domains of occupational therapy in school is handwriting performance. Only two studies were developed by individuals with occupational therapy backgrounds, which urges more occupational therapy scholars to produce more works in this area (29,38). Occupational therapy practitioners may also assist in the instruction and remediation process through the specialized knowledge of handwriting development and instruction of handwriting (48).

Most studies use the conventional approach in providing pre-writing intervention because of the therapist's convenience in delivering the intervention (28,29,33,34,36–38). However, the instructional context for writing tools remains critical in the absence of digitalization that can give macro-level and message-focused feedback related to strategy in teaching and writing. Thus, manual writing tools such as pencil, pen, eraser, paper and many more are still used in the pre-writing intervention (49). However, digitalization-based intervention is increasingly used along with the modernization of daily technology (30–32). In addition, the use of tablets and other touch screen technologies attracts children to engage in pre-writing activities compared to conventional pre-writing intervention. For instance, children are more attracted to interactive features of touch screen technology where activities are primarily offered in games. Therefore, using digitalization technology may be feasible in improving children's handwriting and warrant further exploration (23).

Handwriting is a skill that children will use throughout their lifetime. For that reason, it is essential to monitor for red flags and train the children according to typical handwriting development. Digitalizing pre-writing intervention should be cautiously used in practice due to the lack of a multisensory approach than holding any writing tools and paper to write, especially for children with developmental disabilities (50). However, the benefits of digitalized pre-writing and handwriting intervention might be potentially used for children with developmental disabilities who already have problems holding a pencil properly, such as children with cerebral palsy (51). This review's limitations were confined to limited databases and might not include all studies written in English. Furthermore, other studies published in non-peer-reviewed journals such as abstracts, paper

presentations, and e-books were also omitted from the search. Hence, the generalization of the result should be made carefully, and future studies were needed to verify the appraised issues from this study and which warrant a systematic review to be conducted. However, more pre-writing intervention studies are required to support the effectiveness of the intervention. Only two studies have adequately powered, focusing on more than one of the pre-requisite skills such as small muscle development, basic strokes, letter perception, and orientation to printed language (29,36).

## CONCLUSION

This scoping review mapped the evidence of pre-writing interventions in the literature, which may be helpful for occupational therapy practice. It outlined the contemporary pre-writing interventions and classified the findings according to six themes. The conventional approach of pre-writing intervention produces better effects, given that it incorporates a multisensory approach in the treatment. However, the contemporary pre-writing intervention that uses digital technology offers occupational therapy to explore this new trend for pre-writing interventions while emphasizing all the pre-requisites handwriting skills. Handwriting issues are complicated and require an interdisciplinary approach. Thus, occupational therapy should collaboratively work with other professionals to provide a holistic service and care for the children.

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