

A Systematic Article

From Scribbles to Stories: A Systematic Review Exploring Handwriting Intervention approaches for Children

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Abstract

This study aims to review the literature related to effectiveness of various handwriting interventions in combating handwriting troubles in children aged 4 to 12 years. A thorough search across databases, including PubMed, Google Scholar, ResearchGate and others was conducted for studies published from 2013 till now. Included studies investigated handwriting interventions by occupational therapists, their effectiveness, and how handwriting impacts the brain and other function areas. Quality assessment and data extraction were done which adhered to predetermined criteria. Overall, 12 studies met inclusion criteria, covering issues like poor fine motor skills, dysgraphia, and dysfunctional pencil grasp. Examined interventions included pencil grips, pen sizes, sensory feedback, and sensorimotor training. Findings suggest positive effects on legibility, writing speed, fluency, letter form production, alignment, size, spacing, reading, spelling, composition, proficient letter recognition, letter naming, writing fluency, pinch strength, and pencil grasp and future academic success and development. Existing literature underscores complexity of addressing handwriting challenges in children with learning disorders as well as typically developing ones.

Keywords: Handwriting, Dysgraphia, Cognitive-based approach, Motor approach, Multisensory approach, Task-oriented approach, Occupational Therapy

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Introduction

Handwriting has a critical role in letter recognition and overall brain development ^[1]. Scarcity of comprehensive tools calls for a tailored, multifaceted intervention approach integrating the strengths of various strategies to enhance handwriting quality and improve patient outcomes, cultivating confident, self-motivated children primed for future academic achievement. Acknowledging individual differences is crucial, promoting a holistic approach for effective interventions and support for children with handwriting challenges.

Significance of the study

The significance of this study lies in the fact that handwriting troubles in children have been shown to significantly affect the development of a child's brain and difficulties with writing have been known to cloak a child's capabilities in other areas, making academic success harder to achieve. These children may be wrongly deemed as lazy, noncompliant or unmotivated which may cause further disappointment, low self-esteem and behavioural issues ^[2].

With students spending 31 to 60% of their day involved in tasks requiring handwriting and other fine motor skills, illegible or messy handwriting can interfere with a child's ability to achieve other higher order skills whether it is spelling or composition ^[2]. There is an estimated prevalence of 34% of handwriting difficulties among school going children. Altogether, 67% of boys and 33% of girls experienced handwriting difficulties- in areas such as writing speed, letter reversal and spacing ^[3]. It was found that children with writing disorders had a tendency towards lower mathematics achievement, low verbal IQ and higher attention difficulties ^[2].

The primary goal of this research is to offer a thorough and evidence-supported understanding of the efficacy of different interventions for tackling children's handwriting challenges. By consolidating existing studies, this analysis seeks to provide guidance to educators, parents, and practitioners by identifying effective strategies and shedding light on the most influential methods for enhancing children's handwriting abilities. This will enhance patient outcomes, fostering confidence, and cultivating self-motivated children primed for future academic success.

Furthermore, this study has the potential to enhance the quality of interventions aimed at combating handwriting troubles in children and ultimately prove invaluable for future research, helping researchers identify gaps in the current literature, highlighting areas requiring further exploration and aid forthcoming practitioners in devising innovative interventions firmly rooted in evidence.

Handwriting is communication in the form of a written script that is vital for any school-aged child. It is an extremely intricate skill and entails word synthesis, organization, memory, problem-solving, language, ideation and motor function. It allows children to explore and externalize their thoughts, emotions, and in transmission of ideas [3], [4].

The complexity of handwriting encompasses fine motor control, visual-motor integration, visual perception, attention, kinaesthesia, and sensory processing. Lots of children having difficulties in handwriting exhibit poor fine motor skills which encompass hand manipulation, grasping, motor planning and bilateral coordination. Deficits in these skills have been shown to influence handwriting performance [2],[4].

Handwriting is not only about training the hand to execute a motor pattern; it also involves memory and orthographic processes that work together to remember the letter forms and transcribe them onto a page. Thus, the goal of occupational therapists is to facilitate proficient handwriting which supports a child's literacy and academic development and is linked to basic spelling and reading skills [4].

Children having poor handwriting may be suffering from dysgraphia - a learning disability concerned with the actual motor task of writing; unrelated to either reading or spelling abilities [5]. These children struggle with producing legible writing, writing speed and also experience fatigue and hand pain because of the intense concentration required which results in increased grip pressure [6], [7], [8], [9].

Occupational therapists are capable of identifying any underlying issues that may contribute to handwriting difficulties and treat the areas of dysfunction accordingly. Common areas that addressed by occupational therapists are: visual perceptual skills, visual motor skills, motor planning and sequencing, bilateral coordination, hand-eye coordination, kinaesthetic feedback and other predetermined skill areas that can act as a barrier to participation unique to different children [4].

A multitude of handwriting interventions exist - usually focusing on learning, developing, and maintaining a new skill. Specifically, in the treatment of handwriting difficulties, the approaches most commonly used in occupational therapy include cognitive based, motor and multisensory approach. In addition, therapeutic practice and task-oriented approach were identified as being common interventions for handwriting difficulties [4].

Research Methodology

Studies were included in the review based on the objectives of the current review. Inclusion and exclusion criteria were prepared and based on those criteria; various databases were used in the selection of the studies. The collected studies were checked for clarity and content and then used for the review.

Criteria for the sample collection

Two criteria i.e., inclusion and exclusion criteria were used for the collection of samples.

Inclusion criteria

- **Participants:** Children with handwriting difficulties within a defined age range (4-12 years)
- **Publication Types:** Peer-reviewed journal articles, conference papers, full text papers
- **Study Design:** Randomized controlled trials (RCTs), experimental studies, quasi-experimental studies, observational studies, case studies, longitudinal and cross-sectional studies
- **Types of interventions:** Studies utilizing interventions for improving handwriting difficulties
- **Outcomes and outcome measures:** Studies reporting improvement in legibility, writing capacity & speed, writing fluency, letter forms, alignment, size & spacing, pinch strength and pencil grasp using standardized assessment tools or validated measures

Exclusion criteria

- **Participants:** Studies involving participants outside the specified age range, with significant loss of fine motor control, with significant comorbidities or medical conditions that would make participation unsafe or limit hand and finger movements (e.g., hand deformities, fractures, contractures, etc), with an inability to understand or communicate verbally or follow instructions and commands or with significant cognitive impairment
- **Publication Types:** Non-peer-reviewed sources, editorials, dissertations and opinion pieces
- **Study Design:** Anecdotal reports and studies with methodological flaws or insufficient statistical power, meta-analyses

- **Intervention:** Studies evaluating interventions without the purpose of improving handwriting and those with insufficient detail on the intervention methodology
- **Outcomes:** Studies lacking relevant outcome measures or those focusing solely on behavioural and/or motor outcomes without a significant emphasis on handwriting abilities
- **Publication date:** Studies published earlier than 2013

Electronic database searching

The databases searched include PubMed, Google Scholar, ResearchGate, ERIC, Science Direct and other online journals.

Data extraction and quality assessment

The articles were selected on the basis of PRISMA flow diagram. Eligibility criteria were assessed for the extracted data. Those studies not meeting the criteria were excluded. Included studies were evaluated based on their relevance, appropriateness, clarity and methodology. Selected articles were assessed by two independent reviewers (2nd and 3rd author). The data extracted included participants, year of publication, study method, type of intervention and outcome.

Analysis

Steps in the analysis:

Step 1: Obtained data was tabulated and classified according to author/ year of publication, research design, number of participants & sample characteristics, intervention and results.

Step 2: Identifying the findings of the studies: The studies were identified via their setting, method, sample size, type of intervention and components of the intervention.

Step 3: Categorizing the findings: Findings were categorized under the headings of the effect of enhanced occupational therapy intervention on the study From Scribbles to Stories: A Systematic Review exploring handwriting intervention approaches for children.

Results

The reviewed studies included 50 potentially relevant articles out of which 22 were excluded as they did not meet the inclusion and exclusion criteria and 16 as they did not mention the category of the participants. Twelve studies were eventually included for the review.

The studies encompassed a myriad of issues pertaining to poor or illegible handwriting such as poor posture, poor fine motor skills, dysgraphia, dysfunctional pencil grasp, etc. Multiple handwriting interventions including pencil grips, different sizes of pen, sensory feedback, sensorimotor training were examined across the included studies. Overall, the findings suggest that handwriting training has a positive effect in combating handwriting troubles in children. Significant improvements were observed in legibility, writing capacity & speed, writing fluency, letter forms, alignment, size & spacing, pinch strength and pencil grasp.

1. Characteristics of the article

Out of 12 studies included in the review, all of them were qualitative studies. Majority of the studies were conducted in the hospital setting. These studies were published between 2013 to 2024.

S.No.	Author/ Year of Publication	Research Design	No. of Participants & Sample Characteristics	Intervention/ Study Procedure	Results
1.	Magdelene M. Pearl, et al (2023) ^[10]	Pre-test, post-test quasi- experimental study.	43; 5-7yr kindergarten children.	EG: at least 3 handwriting activities in prone per week for 3 weeks. CG: normal handwriting curriculum.	Statistically significant improvement in memory; with the EG displaying a significant increase in placement, sentence, and total scores.
2.	Sonali Kadam et. al (2019) ^[11]	Pre and Post Experimental study.	124; 5 th and 6 th standard school going children.	EG: given pen of different diameter: EG-A-0.8mm, EG- B-10mm, EG-C- 12mm and EG-D- 14mm. 1-month daily writing training for 30min.	Statistically significant increase in writing capacity in all the groups. (EG-D> EG-B> EG-A = EG-C). Significant improvement in writing speed in EG- D.
3.	Monika Verma, et. al (2019) ^[12]	A single-arm interventional study.	40; 6-11yr children diagnosed with dysgraphia.	12, 45min sessions (3 /week) for 2 months. Protocol: 1.HWT™ Handwriting workbook (as per child's level), HWT notebook paper, pencils for little hands, HWT stamp, and see screen and wet- dry-try method 2.	Statistically significant improvements in memory, placement, and sentences in Grade 1 st , 2 nd , and 3 rd students; word and capital cursive in Grade 4 students. In Print Tool, capitals, lowercase, letter spacing, and word spacing improvements were highly significant. Boys have shown better

				Multisensory activities 3. Fine-motor Activities.	improvement in memory of alphabets and sequence and formation of lowercase letters.
4.	Aimee Piller and Elizabeth Torrez (2019) ^[4]	Retrospective study.	157; 5-15yr children with fine motor control delay.	Most commonly used 200 words/phrases in occupational therapy records placed into 5 intervention categories by experienced paediatric occupational therapists.	Multisensory and motor approaches were the most commonly used interventions followed by therapeutic practice, cognitive based and task-oriented approaches in that order.
5.	Pamela Reutzel (2017) ^[13]	Correlational study.	48; Kindergarten students.	1. LWF assessment- maximum lowercase alphabets written per min. 2. LNF- maximum upper & lowercase letters named per min. 3. RMCF- Several cut-out manipulatives of eight critical features were placed and students asked to assemble 17 lowercase letters as shown on	1. Significant correlations between each of the variables except WPCF & LNF. 2. LNF significantly predicts LWF and both are closely associated in acquisition and retrieval. 3. RMCF significantly accounts for variance in LWF.

				cards as prompts for the task. 4. WPCF- 22 pseudo-letter cards were presented one at a time to the student, who wrote the pseudo-letter shown.	
6.	Karin H. James (2017) ^[1]	Subjective study.	NA; 4-5yr old children.	1. fMRI used to observe brain changes in 4-year-old children after they learn about letters and words: either through see-and-say method or printing those letters. 2. fMRI after children learnt letters through the see-and-say method, printing, typing on a keyboard, or tracing. 3. fMRI after 5-year-old children learnt symbols of the Greek alphabet through seeing, copying & tracing typed	1. The visual regions that later become specialized in the literate individual for letter recognition became active. 2. After printing training, the brains of the children recruited the letter recognition network that is observed in adults. 3. All the conditions where children learned variable instances of the symbols, their categorization ability was enhanced.

				examples, seeing handwritten examples, copying symbols freehand, or crucially tracing handwritten examples.	
7.	M Amirkhani, A Movahedi (2016) ^[14]	Comparative study.	40; 9-11yr old female students with dysgraphia.	EG- Delacato sensorimotor training given for 4mon (2/week; 46 min each) in 4 stages. CG- only participated in the usual school & life activities.	Statistically significant difference in their writing and spelling scores.
8.	Adel A Alhusaini, et. al (2016) ^[15]	Prospective, one group pre-test-post- test experimental study	10; 6-8yr children.	SM-based intervention given 2/week for 40min for 5 weeks.	Significant improvement in MHA scores for legibility, form, alignment, size and spacing, with the exception of rate. Significant changes in legibility, time performance and physical and emotional wellbeing domains in the HPSQ, and grip strength.

9.	Alamargot D, Morin MF. (2015) ^[16]	Pre-test, post-test experimental study design	28; 14 2 nd graders and 14 9 th graders	All students wrote i) their name and surname twice starting with uppercase letters, ii) lowercase alphabets recalled in right order. Every student wrote directly on LCD tablet with plastic-tipped pen and on an A3 sheet placed on the tablet with a ball point pen.	The percentage of legible letters was significantly lower on screen than on paper. Pen pressure (screen>paper, Grade 9>2); Letter size- pen travelled greater distance on screen than paper; Pen speed (screen>paper; grade 9>2); Mean pause duration (screen>paper; grade 2>9).
10.	Shawn Datchuck (2015) ^[17]	Case report.	1; 8yr old female with a learning disability.	Model-lead-test instructional framework implemented for 15mins/day for several consecutive days.	Increased accuracy of letter formation and alphabet sequence.
11.	Esmie Smit (2013) ^[18]	Research Report.	45; grade 2 children with handwriting difficulties.	EG- used stetro pencil grip on their standardized HB pencils for all written work for 2mon. CG- wrote with standardized HB pencils.	Statistically significant difference in efficiency and functionality of pencil grasps, use of finger movements while writing. Improvements were retained after removal of pencil grip. No significant effects on speed and legibility observed in EG.

12.	Tsu-Hsin Howe, et. al (2013) ^[19]	A non- equivalent pre-test post- test group study.	72; Grade 1 and 2 students.	Duration- 12 sessions, 2/week for 40-45min. EG-1: intensive handwriting practice. EG-2: visual- perception-motor activities.	Statistically significant improvement in legibility in EG-1 as compared to EG-2. No significant effects on speed and visual motor skills observed.
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*EG= experimental group; CG= control group; HWT- Handwriting without tears; fMRI- functional MRI; LWF- Letter writing fluency; LNF- Letter naming fluency; RMCF- Recognition and Manipulation of critical features; WPCF- Written production of critical features; MHA- Minnesota handwriting assessment; HPSQ- Handwriting proficiency screening questionnaire.

Conclusion

In conclusion, the existing body of literature underscores the pervasive nature of handwriting challenges in both children with learning disorders and typically developing children. The critical role of handwriting in letter recognition and overall brain development, is very well known. Additionally, influence of proprioceptive feedback on various aspects of handwriting performance, reinforcing the complexity of addressing these challenges has been observed.

The impact of intensive handwriting practice and prone-position activities on legibility, memory skills, and overall handwriting abilities is research proven. It thus becomes crucial to ensure the proper development of a child's motor skills, particularly in cultivating writing habits during the initial school years, as these habits tend to be resistant to change once established. However, the scarcity of comprehensive tools targeting all deficit areas necessitates a tailored and multifaceted intervention approach.

This systematic review supports the need for development of a standardized protocol that integrates the strengths of various intervention strategies, such as multisensory activities, fine motor exercises, diverse pencil grips, pen sizes, and intensive handwriting practice

with stencils and workbooks. The overarching goal is to enhance handwriting quality, ultimately fostering a child's self-confidence, self-motivation, and paving the way for improved future academic achievements. Recognizing individual differences among children is paramount, and a holistic approach that addresses diverse needs can contribute to more effective interventions and support for children facing handwriting challenges.

Statements and Declarations

Conflict of Interests

The Author(s) declare(s) that there is no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

Author's contribution

The first author had the idea for the article, performed the literature search and data analysis, and drafted the work. The second, third and fourth authors critically revised and reviewed the work.

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