

CRITICALLY APPRAISED TOPIC

TITLE

Effectiveness of school-based occupational therapy interventions on handwriting in elementary school children.

AUTHOR

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CLINIAL SCENARIO

Teachers often refer children with handwriting difficulties (letter formation, legibility, speed) for school-based occupational therapy. A review by Feder (2007) cited a survey of 50 pediatric occupational therapists found "90% favored an eclectic approach in treating handwriting problems, irrespective of experience or work setting. An eclectic approach is also advocated in the handwriting literature; with greater effectiveness expected when a combination of techniques are used to improve handwriting performance". The trouble is, this "eclectic" approach is not defined in anywhere in the literature.

FOCUSED CLINICAL QUESTIONS

Can occupational therapy intervention improve handwriting in school-aged children?

What type(s) of intervention is (are) the most effective for improving handwriting in school-aged children?

SUMMARY OF SEARCH

There were relatively few studies on effective interventions handwriting. Of those I located, they seemed to focus on four main types of intervention; sensorimotor intervention (component driven), kinaesthetic intervention (movement driven), therapeutic practice, and whole class instruction for early writers. Of the three randomized controlled trials (RCTs), one compared kinaesthetic training, handwriting practice, and a non-treatment control (Sudsawad, 2002). Neither kinaesthetic training nor handwriting practice was found to have any effect on handwriting speed or legibility as recorded by outcome measures when compared to the control. Another compared the effects of two schedules of practice (random and blocked) on handwriting acquisition (Ste-Marie, 2004). A random practice schedule was found to be more effective than a blocked practice schedule on the development of proficient handwriting. The third compared the effects of sensorimotor intervention, therapeutic handwriting practice, and a non-treatment control (Denton, 2006). Therapeutic practice, including a random practice schedule, was found to be more effective than sensorimotor intervention on improving handwriting as recorded by the outcome measures.

CLINICAL BOTTOM LINE

Therapeutic practice, utilizing a random practice schedule with feedback, is an effective intervention for improving handwriting in otherwise typically developing children ages 6-12. Sensorimotor interventions might be slightly beneficial for improving visual perception and in-hand manipulation skills, but do not improve handwriting. In fact, they were less beneficial than no intervention at all.

This critically appraised paper (or topic) has /has not been peer-reviewed by one other independent person/lecturer. This CAT will be shared as part of in-service training for occupational therapy and physical therapy staff in a school based setting and may also be posted as a resource on an in-district staff website. This site does not have public access.

SEARCH STRATEGY

Terms used to guide the search strategy

- **P**atient/Client Group: School-aged children with handwriting difficulties
- **I**ntervention (or Assessment): Intervention for handwriting
- **C**omparison: Sensorimotor vs Therapeutic Practice
- **O**utcome(s): Improvements in handwriting

Databases and Sites Searched	Search Terms	Limits Used
PubMed	Handwriting Occupational therapy Intervention Effectiveness	Children Full Text English

INCLUSION and EXCLUSION CRITERIA

Inclusion Criteria

- Studies involving school aged children
- Studies involving one or more interventions for handwriting

Exclusion Criteria

- Studies without intervention(s) for handwriting
- Studies of diagnostic tools

RESULTS OF SEARCH

A total of 10 relevant studies were located and categorised as shown in Table 1 (based on Levels of Evidence, Centre for Evidence Based Medicine, 2011)

Table 1: Summary of Study Designs of Articles Retrieved

Study Design/Methodology of Articles Retrieved	Level	Number Located	Author (Year)
Systematic Review	1	1	Feder (2007)
Randomized Controlled Trials	2	3	Denton (2006) Ste-Marie (2004) Sudsawad (2002)
Cohort Studies with pre- post-testing	3	6	Alhusaini (n.d.) Case-Smith (2002) Case-Smith (2012) Case-Smith (2014) Howe (2013) Roberts (2010)

BEST EVIDENCE

- **Denton (2006) is the only randomized controlled trial which compared the effectiveness of two intervention types, sensorimotor activities and therapeutic practice, with a control group on handwriting.**
- **This study also explored the effect of intervention type on specific sensorimotor components (visual perception, visual-motor integration, proprioception, and in-hand manipulation).**

SUMMARY OF BEST EVIDENCE

Table 2: Randomized controlled intervention study by Denton, Cope, & Moser, 2006

Objective of the Study
<p>To investigate the effectiveness of two different handwriting intervention approaches on both handwriting and sensorimotor components.</p> <p>Research questions:</p> <ul style="list-style-type: none">• Did children's handwriting performance change due to the type of intervention received?• Did children's sensorimotor component function change due to the type of intervention received?
Study Design
<p>This study used a three-group, pre- and post-test experimental design with random assignment to the sensorimotor, therapeutic practice, or control group. The raters were blinded to the children's group assignment and the children were unaware of the study's research questions.</p>
Setting
<p>Children were recruited from six private schools in two cities in the Midwest.</p>
Participants
<p>Inclusion criteria for the study were:</p> <ol style="list-style-type: none">(1) between 6.0 and 12.0 years of age;(2) no known physical problems that affected their handwriting;(3) normal or corrected vision;(4) no identified exceptional educational need; and(5) poor handwriting as defined by 1.5 <i>SD</i> or more below the mean for their age group on Test of Handwriting Skills. <p>Gardner's Test of Handwriting Skills (THS) (1998) was administered to 200 typically developing children, 6 through 11 years of age. Twenty-five percent of these children scored at least 1.5 standard deviations below the norm for their age. 38 children, 6.0 to 11.2 years of age participated in this study. The mean age was 9 with a <i>SD</i> of 1.1 years. There was no attempt to balance the design by gender. In total 12 girls and 26 boys were included. One child was unable to complete the posttest due to a broken arm and was dropped from the data. The children were tested on outcome measures then randomly assigned to the three groups. Intervention began within 2 weeks.</p>
Intervention Investigated
<p><i>Control</i></p>
<p>Children in the control group received no intervention and attended their normal classroom activities. They participated in pretest and posttest evaluation sessions at the same time as the children in the intervention groups. All children in all groups participated in handwriting activities or assignments as required by their classroom teacher during the length of the study.</p>
<p><i>Experimental</i></p>
<p>Both experimental groups received intervention four times per week for 5 weeks during regularly scheduled school hours. Each 40-minute session was divided into three segments with a 5-minute rest break between each segment resulting in 30 minutes of intervention per day. Total intervention time over the 5 weeks was 10 hours. The intervention was provided individually or in small groups (no more than three) in quiet, private rooms at the schools. The rest breaks for both groups used non-handwriting activities.</p> <p>Four registered occupational therapists and one licensed physical therapist with pediatric experience provided the intervention. Therapists were trained in an 8-hour training session on both forms of intervention. Follow-up calls and visits were made by the experimenters to ensure continued adherence to the protocols.</p> <p><u>Sensorimotor group (Intervention 1):</u> A focus group of experienced school-based therapists provided advice on intervention strategies for each of the four sensorimotor components in this study (see below). Components were targeted in 10-minute segments during each 30-minute session with four sessions in a week (2.5 hours total). Treating therapists were given toys, games, and activities as well as a rotation schedule of the components. Therapist were allowed the flexibility to choose from the provided activities based on the interests and engagement level of the child.</p>

- Visual perception- visual-closure, visual memory, figure ground and spatial relationships work sheets, word find exercises, parquetry blocks, and tanagrams.
- Visual-motor integration- making shapes in bags of sand (no letters or numbers), cutting, pasting, tracing activities, and Origami designs.
- Proprioception/kinesthesia- weight bearing through upper extremities to stimulate proprioceptors, eyes closed activities (Simon says, close eyes and touch fingers), scooter board, and lining up cans by weight.
- In-hand manipulation- putting two toys in bags and tell apart by feel, using chopsticks to pick up objects, playing with marbles.

Therapeutic practice group (Intervention Group 2):

Handwriting practice books were prepared for each child which included work sheets to practice dictated and copied handwriting as well as writing from memory. The workbooks matched their current writing method (manuscript or cursive) and style of instruction (D'Nealian, Zaner-Bloser, or Palmer). Each 30-minute session was divided into three 10-minute segments; work-sheet activities, real-life writing, and writing for fun (see below). The segments were presented in random order so that the handwriting practice schedule was randomized rather than blocked. Therapists were given a schedule of different letters to focus on for each week. For all sessions, students were encouraged to write for the entire 10-minute period. They were given feedback about performance at random times during the session. Students were encouraged to identify their best work.

- Work sheets- hidden pictures, visual memory challenges, mazes, dot-to-dot pictures, word searches, similar and different pictures, and finishing a pattern.
- Real-life writing- writing a thank-you note, completing an invitation to a party, preparing a grocery list, writing in their daily planner, or completing journal entries.
- Writing for fun- A variety of pens, pencils, papers provided for students to write anything they wanted.

Outcome Measures

Test of Handwriting Skills (THS). The THS (Gardner, 1998) measures handwriting skills in children 5 to 11 years of age. The THS includes 10 subtests that use memorized, dictated, or copied stimuli to elicit written numbers, letters, or words. The THS was normed on 345 children in the United States. Standard scores ($M = 100$, $SD = 15$) are available for each 3-month age increment. Internal reliability of the THS ranged from .29 to .87 (Gardner, 1998); other forms of reliability have not been tested. The subtest scores were moderately related to each other, suggesting that there is construct validity of the THS. Concurrent validity has also been studied" (Denton, 2006, p. 19).

Developmental Test of Visual Perception (DTVP-2). "The DTVP-2 (Hammill, Pearson, & Voress, 1993) measures visual perception in children 4 to 10 years of age. It consists of eight subtests that use both motor-reduced and motor-enhanced formats. The DTVP-2 was normed on a sample of 1,972 children and standard scores are available ($M = 10$, $SD = 3$). Reliability for observer, time, and content of the subtests is reported to range between .89 and .94. The DTVP-2 is highly correlated with other measures of visual perception (.78-.87) providing strong evidence for criterion validity. Construct validity has also been demonstrated" (Denton, 2006, p. 19).

Test of Manual Pointing (TMP). "The TMP (von Hofsten & Rösblad, 1988) measures proprioception in children 4 to 12 years of age. Reliability and validity of the TMP have not been established, however it has been used to measure proprioception in children with motor disorders (Rösblad & von Hofsten, 1992) and normative data on children in this age group are available. The test required placing a pushpin under a table to match a target in each of four conditions: visual cues alone, visual and tactile cues, tactile cues alone, and no cues. Distance from the target was calculated and the mean absolute error scores for each condition were used. A lower score indicates better performance. This instrument was selected because it measures active proprioception and can be appropriately used with children without motoric limitations" (Denton, 2006, p. 19).

In-Hand Manipulation (IHM). "The IHM (Pehoski, Henderson, & Tickle-Degnen, 1997) measures rotation and translation skills in children 3 to 7 years of age. Interrater reliability was reported for the simple rotation task as .81 (Pehoski et al., 1997a) and the two translation tasks as .82 and .79 (Pehoski et al., 1997). The IHM is normed for children 3.0 to 6.6 years of age and adults (Pehoski et al., 1997) but the validity of the IHM has not yet been established. The IHM yielded data about four variables: maturity of method used in simple rotation, speed of simple rotation, maturity of method used in finger to palm translation, and maturity of method used in palm to finger translation" (Denton, 2006, p. 19).

The children were pre-tested using outcome measures by investigators trained to administer the tests two weeks prior to starting the intervention. All raters were blind to the child's group assignment when scoring the outcome measures. Two trained raters were used to score the THS. They achieved an interrater reliability of $r = .89$. One trained rater was used to score the DTVP-2 and the TMP. The IHM test was scored at the time of administration. Although the investigators were trained to administer and score this test, no formal measure of interrater reliability was obtained. Children were post-tested at the conclusion of the intervention on all outcome measures.

Main Findings

Mean (*SD*) Pretest, Posttest, and Difference Scores for Handwriting Performance by Group and Handwriting Scale (Denton, 2006, p. 22).

Group Scale	Pretest	Posttest	Difference Score
Sensorimotor (<i>n</i> = 14)			
Memory	74.00 (13.48)	65.36 (11.57)	-8.60
Dictated	73.45 (7.64)	65.47 (7.13)	-7.98
Copied	85.43 (14.16)	76.07 (13.63)	-9.40
Therapeutic Practice (<i>n</i> = 15)			
Memory	71.37 (13.07)	74.93 (16.68)	3.60
Dictated	73.67 (13.14)	79.64 (16.52)	5.97
Copied	81.88 (10.78)	88.54 (10.01)	6.70
Control (<i>n</i> = 9)			
Memory	67.44 (15.19)	68.31 (12.71)	.09
Dictated	65.44 (10.41)	64.89 (9.29)	.55
Copied	72.11 (10.64)	77.92 (11.34)	5.80

Question One: Did children's handwriting performance change due to the type of intervention they received?

"There was no interaction effect between group and difference in handwriting from pre- to posttest: $F(2, 32) = .209, p = .81$; effect size (f) = .11. When all three handwriting scales were considered together, there was a main effect for group: $F(2, 32) = 8.44, p = .001$; effect size (f) = .72. A comparison of the means for the three groups showed a significant difference in the mean scores between the sensorimotor group and the therapeutic practice group: $p = .001$. When all three handwriting scales are collapsed, there is a 95% level of confidence that the handwriting performance of group 1 (SM) declined between 3 and 14 points. Conversely, the handwriting performance of group 2 (TP) increased between 1 and 12 points. Neither intervention group was significantly different statistically from the control group" (Denton, 2006, p. 22).

Question Two: Did children's sensorimotor component function change due to the type of intervention they received?

"*Visual perception (motor-reduced)*: At pretest, 75% of the participants scored below average compared with their peers ($M = 33.10, SD = 23.02$). There was no interaction between the intervention group and visual perception scores: $F(2, 34) = .815, p = .451$; effect size (f) = .22. However, there was a statistically significant main effect for motor-reduced visual perception: $F(2, 34) = 4.247, p = .023$; effect size (f) = .50, showing that visual perception improved in all three groups from pretest to posttest. A comparison of the means for the three groups showed a significant difference in improvement between the SM group and the control group ($p = .02$). The SM group improved more than the TP group, but not enough to reach statistical significance: $p = .362$ " (Denton, 2006, p. 22).

"*Visual-motor integration*. At pretest, 70% of the participants scored below average compared with their peers ($M = 42.59, SD = 25.05$). However, the visual-motor integration scores did not change significantly from pretest to posttest: $F(2, 34) = .353, p = .71$; effect size (f) = .14" (Denton, 2006, p. 22).

"*Proprioception*. The participants' pretest proprioception scores fell within one standard deviation of the mean reported for the normative. Some of the children's scores fell below the mean for their age group on some subtests, but no clear trend in the scores was apparent. Proprioception scores did not change significantly from pretest to posttest for any of the groups: $F(2, 29) = 1.30, p = .29$; effect size (f) = .30" (Denton, 2006, p. 22).

"*In-hand manipulation*. At pretest, the participants were slower on rotation tasks ($M = 27.0$ sec, $SD = 7.94$) compared with the norms for 6.6-year-olds ($M = 22.0$ sec, $SD = 3.40$) and adults ($M = 20.0$ sec, $SD = 2.27$). None of the groups changed significantly between pretest and posttest on either use of the mature method: $F(2, 33) = 1.38, p = .27$; effect size (f) = .29, or speed: $F(2, 33) = 1.22, p = .31$; effect size (f) = .27" (Denton, 2006, p. 22).

"Finger-palm translation scores changed from pretest to posttest. There was a significant interaction between time of testing and group: $F(2, 35) = 4.28, p = .02$; effect size (f) = .49 as well as a significant main effect for time of testing: $F(1, 35) = 10.60, p = .003$; effect size (f) = .55. Post hoc tests revealed that all three groups used the mature finger to palm translation method more frequently at the end of the study than at the beginning. The SM group (group 1) improved more than the other two groups, but this difference failed to reach statistical significance" (Denton, 2006, p. 23)

"On palm-finger translation, there was no interaction between the time of testing and group: $F(2, 35) = .91, p = .41$; effect size (f) = .21. However there was a significant main effect for time of testing: $F(1, 35) = 8.98, p = .01$; effect size (f) = .24. Participants in all 3 groups used the mature method of palm-finger translation more frequently at posttest than they did at pretest. Although the SM group improved more than the other two groups, this difference failed to reach statistical significance" (Denton, 2006, p.23).

Original Authors' Conclusions

"Therapeutic practice had a positive, albeit modest impact on children's handwriting after a relatively short period of intervention...Close analysis of the treating therapist's records reveal that dictated and copied handwriting practice dominated the interventions sessions, with less time spent on practicing handwriting from memory. It appears that the students improved the most on those forms of handwriting that received the most practice" (Denton, 2006, p. 23).

"Participants demonstrated impairments in three of the four sensorimotor components (visual perception, visual-motor integration and in-hand manipulation) at the beginning of the study. This finding offers support for the assumption that deficits these skills are present with dysfunctional handwriting even in this sample of "typically developing" children. However, the impact of intervention on improving performance in these sensorimotor components was less strong. Improvement was demonstrated in only two areas: visual perception (motor-reduced) and in-hand manipulation—translation skills" (Denton, 2006 p, 24-25).

"The findings of this current study call into question prevailing clinical assumptions about relationships between sensorimotor components and handwriting intervention" (Denton, 2006, p 25).

Critical Appraisal

Validity

Internal Validity

The design of this study was a randomized controlled experimental design. Pre and post-test comparisons were made between groups as well as within groups.

The PEDro scale (partitioned):

Criterion 1 Random allocation	"Children were randomly assigned to the three groups" (Denton, 2006, p 18). The authors do not provided detailed information on the allocation process.
Criterion 2 Concealed allocation	The pre-test raters on the THS had no knowledge of which group children would be assigned to. However, they would have knowledge of whether or not the child's score was low enough to be eligible. The authors do not describe a process for concealing that information. Failure to conceal the allocation could represent a systematic bias.
Criterion3 Baseline similarity	All participants scored below 1.5 SD below the mean on the THS. So they were similar in that regard. However, no other baseline measure was taken and no other efforts were made to balance the groups based on gender, handwriting style, or age. "To identify a sample of children with handwriting difficulty but no identified exceptional educational need, Gardner's Test of Handwriting Skills (THS) (1998) was administered to 200 typically developing children, 6 through 11 years of age. Approximately 25% of these children scored at least 1.5 standard deviations below the norm for their age. Children were recruited from six private schools in two cities in the Midwest. Ultimately, 38 children, 6.0 to 11.2 years of age ($M = 9.0, SD = 1.1$), participated in this study. No attempt was made to balance the design by gender; 12 girls and 26 boys were included."
Criterion 4 Blinding of Subjects	"Children were unaware of the study's research questions" (Denton, 2006, p 18).
Criterion 5 Blinding of therapists	The therapist providing the intervention in the therapeutic practice group and the sensorimotor group were aware of the interventions they were providing and therefore could not have been blind to the group assignment, However, they had no role in administering or scoring the outcome measures which lessened the threat of experimenter bias to the construct validity.

Criterion 6 Blinding of assessors	"Raters were blinded to the children's group assignment" (Denton, 2006, p 18).
Criterion 7 Outcome measures from > 85% subjects	Thirty-eight children participated in the study. One child broke her arm and did not participate in post-testing. The remaining 37 had pre and post test data included in the analysis, or 97% of the subjects.
Criterion 8 Intention to treat analysis	Both groups received intervention with the intent for the intervention to treat handwriting difficulties. There was no apparent bias toward one treatment versus the other. "Therapists were trained in an 8-hour training session on both forms of intervention. Follow-up calls and visits were made by the experimenters to ensure continued adherence to the protocols" (Denton, 2006,).

Statistical Reporting

Criterion 9 Between-groups statistical comparisons	Pre and post-test comparisons were made between groups, as well as within groups, for all of the outcome measures.
Criterion 10 Point measures and measures of validity	Outcomes on the THS are reported as Mean and Standard Deviation on pretest, posttest, and difference scores for handwriting performance by group and handwriting scale (Denton, 2006, Table 4, p 22). There is no information provided on the range of scores within any one groups.

Eligibility

Eligibility Criteria	Inclusion criteria for the study were: (1) between 6.0 and 12.0 years of age; (2) no known physical problems that affected their handwriting; (3) normal or corrected vision; (4) no identified exceptional educational need; and (5) poor handwriting as defined by 1.5 <i>SD</i> or more below the mean for their age group on Test of Handwriting Skills (THS). (Denton, 2006, p)
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External Validity:

The authors acknowledge several limitation that represent threats to external validity. "The sample size was small and represented children without a known educational need or diagnosis" (Denton, 2006, p 25). Therefore, the results could not be widely generalized to children with disabilities or in special education.

The groups were not equal in number and the control group was smaller than the two intervention groups, so the statistical analyses need to be conservatively interpreted (Sensorimotor (SM) (n = 14), Therapeutic practice (TP) (n = 15), Control (n = 9) (Denton, 2006, p 25).

The children in both intervention groups and in the control group participated in educational activities outside of the so there is the potential for children at one school to be receiving additional handwriting than at another school which would be a confounding variable. The authors noted that none of the settings reported spending much time in handwriting instruction and that there was "no differences between schools on pre-test handwriting scores" (Denton, 2006, p 25). This would suggest that instruction was similar across all of the schools.

Interpretation of Results

Typically developing children who have handwriting difficulties may also demonstrate difficulties in visual perception, visual motor integration, proprioception, and in-hand manipulation skills.

Therapeutic practice using a random practice schedule can be used to improve handwriting performance in children 6-12. Practice activities include work-sheet activities, real-life writing, and writing for fun. Students should be provided feedback at random intervals as well as being encouraged to evaluate their own work. Therapeutic practice in a structured OT setting may be only slightly more beneficial than standard classroom activities (control). Therapeutic practice is significantly more beneficial for improving handwriting performance compared to sensorimotor activities

Sensorimotor activities designed to address visual perception, visual-motor integration, proprioception, and in-hand-manipulation did not improve handwriting performance when compared to therapeutic practice. In fact, sensorimotor activities in a structured OT setting appear to be slightly less beneficial than standard classroom activities. Sensorimotor activities are significantly less beneficial for improving handwriting performance compared to therapeutic practice.

Therapeutic practice, sensorimotor activities, and standard classroom activities are all effective for improving visual perception. Sensorimotor activities were statistically more beneficial than standard classroom activities for improving visual perception. Therapeutic practice, sensorimotor activities, and standard classroom activities are all effective for improving in-hand translation skills (finger-palm and palm-finger). Sensorimotor activities may be slightly more beneficial than therapeutic practice or standard classroom activities, but the difference was not significant. Neither intervention, nor standard classroom activities, had any effect on visual-motor integration or proprioception.

Summary/Conclusion

Therapeutic practice which includes a random versus blocked practice schedule delivered in 10 hours over the course of 5 weeks has been shown to be an effective intervention for improving handwriting in children 6-12 who have deficits in handwriting without any other identified educational need.

Under the same intensity, frequency, and duration, sensorimotor interventions designed to target component skill (visual-perception, visual-motor integration, proprioception, and in-hand manipulation) were not shown to be effective at improving handwriting performance and but rather resulted in a decrease in handwriting performance post intervention.

Both intervention groups, and the control group, showed an increase in visual perceptual and in-hand manipulation (translation) skills from pre-test to post-test. Participants in the sensorimotor group showed a slightly larger improvement, however the differences between the groups was not significant. There was no change in visual-motor or proprioception.

IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

For typically developing children ages 6-12 who have handwriting difficulties, the occupational therapist must carefully weigh the potential benefits of therapy in a structured OT setting compared to standard classroom activities. Students in this study improved with therapeutic practice and with standard classroom activities. The gains were slightly greater in the therapeutic practice group, particularly in the domains that were practiced the most (dictation and copying). Sensorimotor activities conducted in a structured OT setting were less effective than therapeutic practice or standard classroom activities and should not be used as interventions for handwriting. Sensorimotor activities may have limited usefulness for improving visual-perception and in-hand translation skills. None of the groups showed a change in visual-motor skills or proprioception skills. Which leads me to question the efficacy of addressing these components in the school-based setting. Is it worth sacrificing class time to address components that did not change with or without intervention?

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