Module: OT6054

Occupational Therapy Project 4

What is the evidence regarding occupational therapy interventions to improve handwriting in children aged 6-11 years old?

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ABSTRACT

In our current age of technology, children are being primed towards computers and handwriting is becoming a lost art. Handwriting is a primary occupation of school aged children with up to 50% of the school day spent in pencil paper activities (Marr et al., 2003). Handwriting difficulties are the most common reason for referral to occupational therapy and as such there is a need to measure the effectiveness of occupational therapy interventions in remediation of these difficulties.

This critically appraised topic (CAT) aims to examine the effectiveness of occupational therapy interventions regarding handwriting difficulties in six to eleven year old children. A comprehensive search of the allied health literature was conducted using the following seven databases: MEDLINE, CINAHL, COCHRANE DATABASE, EMBASE, AMED, ERIC, and PsychINFO. 299 articles were retrieved for consideration of which nine met the inclusion and exclusion criteria. These studies which comprised of one systematic review, six non-randomised control trials and two non-randomised control trials were assessed for methodological rigour using McMaster’s Critical Review for Quantitative Studies. Overall, the findings demonstrate inconclusive results due to the variety of interventions and varying assessment tools used to measure effectiveness. However, the findings highlight the need for the development of an occupation-based assessment tool to measure effectiveness of handwriting interventions in this age population. The implications for occupational therapy and areas for future research are identified.
INTRODUCTION

In recent years, issues such as children’s rights and participation have become important in Irish discourse and special education policy. The UN Convention on the Rights of the Child (1989) has shaped Irish legislation and policy since the 1990’s with the introduction of legislation such as, the 1993 Report of the Special Education Review Committee (SERC), the Education Act 1998, the Education for Persons with Special Educational Needs Act (2004) and the Disability Act (2005).

Throughout the late 1990’s and early 2000’s, a series of government reports dealing with broader issues about special educational needs and disability were published. Charting Our Educational Future (1995) stated: “All students regardless of their personal circumstances have a right of access to and participation in the education system according to their potential and ability” (Government of Ireland, 1995).

Occupational therapists are not employed by the educational system in this country but they have a significant role in addressing participation in educational activities (AOTA, 2002). Occupational therapists observe and interpret the nature and quality of participation in the role of the student (AOTA, 2002). Participating in the student role may be restricted due to difficulties in handwriting; past studies indicate that handwriting difficulty is the most common reason that school aged children are referred to occupational therapy (Tait, 1998; Feder et al 2000; Case-Smith, 2002; Schneck, Amundson, 2010).

Handwriting is a complex occupation of the school aged child. It requires performance in visual-perceptual skills, motor planning, in-hand manipulation, visual-motor integration, bilateral integration, perceptual-motor skills, kinesthesia, cognitive skills and sensory processing (Asher, 2006; Erhardt, Meade, 2005; Feder, Majnemer, 2007; Giroux et al 2012) Handwriting development begins in the preschool years with research showing that it is 37% of the pre-school day comprising of fine-motor tasks with 10% spent in pencil-paper activities (Marr et al, 2003). Once students transition to primary school, students spend up to 50% of the day on paper and pencil activities (Marr et al, 2003). With the increased demand of handwriting tasks, difficulty in this area can impact the ability of the child to progress with peers in the classroom. Handwriting difficulties do not disappear without intervention (Hamstra-Bletz, Blote, 1993; Smits-Englemans, Van Galan, 1997) and occupational therapy has been proven to be effective in handwriting remediation (Feder et al., 2000, Case-Smith, 2002).

LITERATURE REVIEW
The literature review describes the topic of handwriting as it relates to the development of handwriting skills in education and the role of the occupational therapist in handwriting remediation.

**Development of Handwriting Difficulties in Education**

Middle childhood is a pivotal period for six to eleven year old children. They refine and consolidate the physical gains made during the rapid growth of infancy and preschool years (Piaget, 1952; Erikson, 1959). Primary school provides an occupational space to transition to the role of the student during middle childhood. This role comes with expectations and children are required to execute this role and carry out the routine of the school in order to fulfil their academic potential. All school aged children are expected to be active participants in their education and to be motivated about their learning (Piaget, 1952). They are required to communicate clearly through handwriting as teachers use written work, homework and academic tests to assess what a child has learned (Giroux et al 2012).

Research has shown that up to 50% of the school day is spent engaged in writing tasks, often under time constraints (Amundson, 1996; McHale, 1992; Marr et al, 2003). These handwriting tasks include copying text from the teacher’s board, doing repetitive writing tasks, writing from dictation, note taking, completing worksheets, workbooks or assessments, correcting work rapidly, answering questions from text, doing creative writing and drawing tasks (McHale, Cermak, 1992). The student role also demands that these handwriting tasks are legible; written work that is difficult to read may receive a low score or no score at all (Engel-Yerger et al 2009; Giroux 2012). If a child concentrates heavily on letter formation and legibility rather than the actual course content, negative consequences can ensue in all academic areas (Case-Smith, 2002).

Even when students possess good academic abilities, the inability to demonstrate handwriting skills can result in frustration and low self-concept and can impact on self-esteem and academic achievement (Feder et al 2000; Erkhardt, Meade 2005; Feder, Majnemer, 2007). Handwriting difficulties are common among school children in mainstream and special education schools with an estimated 10% to 30% experiencing difficulties (Karlsdottir, Stephansson 2002). Children are required to produce quality written work at a pace in keeping with their peers. When a child is not able to fulfil these demands, the student may be referred to the occupational therapist.

**THE ROLE OF OCCUPATIONAL THERAPY IN HANDWRITING REMEDIATION**
Occupational therapists are in an optimal position to address handwriting difficulty as they assess how individual client factors impact handwriting performance and how a child’s environment and context will influence student success (Cahill, 2009). Occupational therapy has proven to be effective in handwriting remediation (Case-Smith, 2002).

They provide a wide variety of interventions in order to improve handwriting performance including: multisensory, sensorimotor, cognitive, task orientated and therapeutic practice. A sensorimotor approach is based on the integration of sensory experiences to produce regulation of the nervous system which achieves an optimal state for the child to apply information efficiently and produce quality motor output (Weintraub, Yinon, Hirsch, Parush, 2009). A task oriented approach however assumes that instruction and practice in varying tasks across different contexts is necessary in the development of handwriting skills (Weintraub, Yinon, Hirsch, Parush, 2009). A multisensory approach is based on the sensorimotor model of practice which involves the use of sensory experiences, media, and instructional material. It is based on the premise that providing sensory opportunities will enable the child to process the information in a more efficient manner to produce satisfactory motor output such as legible letters (Zwicker, Hadwin, 2009). The cognitive approach is based on learning theories that include self-correction strategies and verbal instruction and feedback (Zwicker, Hadwin, 2009). Finally the therapeutic practice approach is based on specific motor learning theories and incorporates the use of skill based practice in dictated and copied forms to elicit handwriting from memory (Denton, Cope, Moser, 2006).

Interestingly, research indicates that many occupational therapists do not perceive themselves as adequately prepared to provide these services (Brandenburger-Shasby, 2005; Bradenburger-Shasby, Trickey, 2001). This could be due to the concern that too often occupational therapists rely on standardised assessments to focus treatment interventions (Trombly, 1993) and that this bottom up approach cannot provide adequate information to inform evidence based occupation therapy. Occupational therapy is moving towards occupation-based assessments that focus on performance (Hocking 2001). This enables the occupational therapist to establish how children participate in their meaningful occupations taking into consideration the context in which it is performed (Coster 1998).

In a recent systematic review exploring handwriting interventions, Hoy et al (2010), organised the findings into three main heading: (1) Relaxation and practice with or without electromyogram (EMG) biofeedback, (2) Sensory-based training without handwriting practice, (3) Handwriting based practice. This was due to the wide range of interventions used by occupational therapy to address
handwriting difficulties. The researchers concluded that handwriting intervention was regarded ineffective regardless of treatment approach if it did not include at least 20 handwriting practice intervention sessions. It is important to consider the practicalities of these findings in our current health care service constraints. Intervention outcomes are predominantly measured for effectiveness using standardised assessments (Jackson, 1998). Therefore, exploring the interventions in relation to the assessment tools used warrants further investigation to inform evidence based occupational therapy and as such will form the basis of this critically appraised topic.

**METHODOLOGY**

This research was conducted as part of the MSc Occupational Therapy program offered in the University of Limerick. Evidence based practice has been described in a six steps process: asking a well constructed question, selecting evidence sources, implementing a research strategy, appraising and synthesising the evidence, applying the evidence, evaluating the evidence application, disseminating the findings (Law, 2002). In consideration of time constraints, a critically appraised topic was considered an appropriate research design to address the research question and inform evidence based practice in the field of occupational therapy.

*What is a critically appraised topic?*

A critically appraised topic (CAT) is an instrument developed in McMaster’s university, Canada, for maintaining and retrieving relevant evidence to inform evidence based occupational practice (AOTI, 2012). The CAT closes the evidence transfer gap by summarising and condensing the research process through which a well formulated question leads to a literature search, selection of relevant primary studies, critical appraisal of the studies’ validity, results and applicability and the reviewer’s conclusion regarding the original question (Wyer, 2005). The formation, use and evaluation of a CAT within the clinical environment offer valuable insights on treatment effectiveness (Law, 2002).

Taylor (2007) identified systematic reviews of randomised control trials as the best evidence to measure effectiveness of occupational therapy practice. Qualitative research studies can generate valuable outcomes but do not measure effectiveness (Taylor 2007) and were therefore excluded from this study. In accordance to the National Institute for Health and Clinical Excellence UK 2006 recommendations for formulating clinical questions, the PICO framework was incorporated into this critically appraised topic. PICO was developed by Richardson et al (1995) and applied to occupational therapy (Law, 2002). P, represent the patient or population being addressed, I – the intervention or input being considered, C – comparison when relevant and O – the outcomes or treatment goals.
Table 1. PICO STRATEGY

<table>
<thead>
<tr>
<th>PICO Categories</th>
<th>Key Search Terms</th>
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<tbody>
<tr>
<td><strong>Population:</strong> School-aged children with handwriting difficulties</td>
<td>Students, Children, Dysgraphia, School-aged, Paediatric</td>
</tr>
<tr>
<td><strong>Interventions:</strong> Studies that evaluated the effectiveness of occupational therapy interventions used to address handwriting difficulties</td>
<td>Occupational Therapy, Handwriting Intervention, Writing, Written output, Script</td>
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<td><strong>Comparison:</strong> Studies must include a control group to measure effectiveness</td>
<td>Control group</td>
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<tr>
<td><strong>Outcomes:</strong> Letter legibility using at least one standardised handwriting assessment</td>
<td>Letter legibility, Agraphia</td>
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**Research Question**

What is the evidence regarding the effectiveness of occupational therapy interventions for 6-11 year olds with handwriting difficulties?

**LITERATURE SEARCH STRATEGY**

Following the formulation of the research question, key words were synthesised and literature searches was performed in September 2011 and updated in December 2011. The search terms were included in various combinations in all the databases. The databases used were those that included peer-reviewed occupational therapy publications from 2000-2011. These electronic databases were MEDLINE, CINAHL, COCHRANE DATABASE, EMBASE, AMED, ERIC, and PsychINFO. The searches identified 299 studies. The reference lists of the articles were reviewed to identify any additional articles. This yielded one article that was included in the review. All articles that did not use a control group were excluded as were articles that were concerned with children without handwriting difficulties. Medication-based interventions were outside of the scope of this review. Nine studies remained all of which evaluated interventions to improve handwriting difficulties.

Table 2. Inclusion and Exclusion Criteria
<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
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<tbody>
<tr>
<td>Children aged 6-11 years old</td>
<td>Descriptive Single study design</td>
</tr>
<tr>
<td>Identified handwriting difficulties</td>
<td>Participants without identified handwriting difficulties</td>
</tr>
<tr>
<td>Approaches occupational therapists could use</td>
<td>Approaches addressing medication, computer output</td>
</tr>
<tr>
<td>Use of a control group</td>
<td>No control group</td>
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<tr>
<td>Peer reviewed randomised control trials, non-randomised control trials or systematic reviews</td>
<td>Case study, qualitative research article, grey literature, documents published on websites</td>
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The included articles were entered into an excel spread sheet to extract the following information: type of design, age and gender of participants, assessment tool, description of the intervention, analysis and findings, discussions and key words used in each study. The quality of all articles was examined using the McMaster’s Critical Review For Quantitative Studies (Law et al., 1998). This critical appraisal tool consists of eight categories of rigour (study purpose, literature, design, sample, outcomes, intervention, results and clinical implications). It also guides the researcher with questions to prompt evaluation of the quality of the study.

**RESULTS**

From the 299 Studies, nine articles were included in this critically appraised topic. Tables 3 and 4 demonstrate the characteristics and assessment tools used in the included studies. One systematic review, six randomised control trials and two non randomised control trials were included in this review. Three studies included cognitive based interventions (Jongmans et al, 2003; Berninger er al, 2006; Zwicker et al, 2009). Four studies included sensory based intervention (Denton et al, 2006; Sudsawad et al, 2002; Weintraub et al, 2009; Zwicker et al, 2009). Three studies included handwriting based practice intervention (Denton et al, 2006; Sudsawad et al, 2002; Weintraub et al, 2009). One systematic review focused on occupational therapy with a variety of interventions (Hoy et al, 2010). One study used co-intervention with the control group (Ryan et al, 2010) and one study included an eclectic approach to intervention (Case-Smith, 2002). The articles were most frequently published in USA with 5 studies, 3 were published in Canada and one study published in the Netherlands. These nine studies were assessed for methodological rigour using the McMaster University Critical Review Form for Quantitative Studies (Law et al 1998). They were then divided into groups based on the assessment tool used to measure the effectiveness of the interventions used. The eight randomised control trials used handwriting performance based assessment tools to
measure effectiveness of handwriting performance. Only one study used an occupation-based assessment (Case-Smith, 2002).

### TABLE 3

<table>
<thead>
<tr>
<th>Author</th>
<th>Performance Component Assessment</th>
<th>Occupation-Based Assessment</th>
<th>Other</th>
</tr>
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<tbody>
<tr>
<td>Hoy et al (2011)</td>
<td></td>
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</tr>
<tr>
<td>Case-Smith (2002)</td>
<td>(ETCH), (DTVP), (BOTMP)</td>
<td>✓ (School Function Ax)</td>
<td>X</td>
</tr>
<tr>
<td>Denton et al (2006)</td>
<td>(Test of handwriting skills)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(DTVP-2)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(TMP – proprioception)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(IHM – in hand manipulation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓ Concise Assessment Scale for Children’s Handwriting (BHK)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sudsawad et al (2002)</td>
<td>(KST), (ETCH)</td>
<td>X</td>
<td>✓ (teacher questionnaire)</td>
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<tr>
<td>Weintraub et al (2009)</td>
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<tr>
<td></td>
<td>(MAC), (DTVP-2), (BOTMP), (HHE)</td>
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<tr>
<td>Zwicker et al (2009)</td>
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<tr>
<td>Ryan et al (2010)</td>
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<tr>
<td></td>
<td>(ETCH), VMI</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>(MHT),</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Author</td>
<td>Description of Study</td>
<td>Sample</td>
<td>Assessment Tool</td>
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</tr>
<tr>
<td>Hoy, et al (2011)</td>
<td>Systematic review</td>
<td></td>
<td>11 Studies were included - 9 RCTs, 2 NRCTs</td>
</tr>
<tr>
<td>Jongmans et al. (2003)</td>
<td>NRCT</td>
<td>N= 24 (20 boys, 4 girls) 8-10 years old.</td>
<td>Concise Assessment Scale for Children’s Handwriting (BHK)</td>
</tr>
<tr>
<td>Berninger et al (2006)</td>
<td>RCT</td>
<td>N = 94 (22 girls, 72 boys) (7-9 years)</td>
<td>WJR (Woodcock Johnson Psychoeducational Battery) – Writing Samples and Writing Fluency subtests</td>
</tr>
<tr>
<td>Denton et al (2006)</td>
<td>RCT</td>
<td>N=38 6-11 yrs old (12 girls, 36 boys)</td>
<td>Test of Handwriting Developmental Test of Visual Perception (DTVP-2), Test of Manual Pointing (TMP), measuring proprioception In-Hand Manipulation Test (IHM),</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Country</td>
<td>Sample Size</td>
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<tr>
<td>Sodsawat et al (2002)</td>
<td>RCT</td>
<td>USA</td>
<td>N=45 (30 boys, 15 girls) (Age = 6-8 years)</td>
</tr>
<tr>
<td>Ryan et al (2010)</td>
<td>RCT</td>
<td>CANADA</td>
<td>N=30 (20 boys, 10 girls) Ages= 6-9 years</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>N</td>
<td>Grade</td>
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<tr>
<td><strong>Weintraub et al (2009)</strong></td>
<td>RCT</td>
<td>55</td>
<td>2-4</td>
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<tr>
<td><strong>Zwicker et al (2009)</strong></td>
<td>RCT</td>
<td>72</td>
<td>1-2</td>
</tr>
<tr>
<td>Case-Smith (2002)</td>
<td>USA</td>
<td>N=38 7-10 years 29 (treatment group) 9 (control group)</td>
<td>Evaluation Tool of Children's Handwriting (ETCH) Developmental Test of Visual Perception (DTVP) Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) School Function Assessment (SFA)</td>
</tr>
</tbody>
</table>
Methodological Rigour

The McMaster Critical Review Form (Law et al, 1998) was used to score the methodological rigour of the included studies and rated as “strong” (“yes” score of 8-10), “moderate” (“yes” score of 6 or 7), or “weak” (“yes” score <5). The quality scores of all the included studies fell into the moderate range with all studies using pre and post testing to measure effectiveness of the intervention. All study samples included a higher proportion of boys to girls ranging from 50% to 83% of boys completing their sample. The sample sizes were heterogeneous in nature but six studies offered sample sizes less than 55 participants (Case-Smith, 2002; Denton et al, 2006; Jongmans et al, 2003; Sudsawad et al, 2002; Weintraub et al, 2009, Ryan et al 2010). These small sample sizes impact the effect size and it has often been noted by methodologists to be of lower methodological quality.

The inclusion of co-intervention with the control group limited the study results, this study however was the only study to provide intervention tailored to the individual participants (Ryan et al, 2010). All other studies offered group intervention. Intervention duration and frequency varied widely across the studies with four studies offering less than ten intervention sessions (Weintraub et al, 2009; Zwicker et al, 2009; Sudsawad et, 2002, Ryan et al, 2010). The only included systematic review by Hoy et al (2010) concluded that effective occupational therapy to improve handwriting difficulties must include at least twenty intervention sessions. In terms of outcomes measures, five studies used occupational performance component based only (Berninger et al, 2006; Denton et al, 2006; Jongmans et al, 2003; Weintraub et al, 2009; Zwicker et al, 2009). One study included teacher questionnaire (Sudsawad et al 2002). The questionnaire was developed for the purpose of the study and therefore reliability of data is limited in quality but remains a worthy consideration for supplementary qualitative data. One study incorporated occupation-based assessments (Case-Smith, 2002). Four studies showed statistical significance pre and post testing to suggest effective intervention to improve handwriting difficulty (Jongmans et al, 2003; Case-Smith, 2002; Berninger et al 2006, Weintraub et al, 2009). One study found that therapeutic handwriting based intervention was more effective than a sensorimotor based intervention (Denton et al, 2006).

In terms of therapeutic effectiveness, it is necessary to consider the statistical significance in relation to the assessment tool used to measure the change. Therefore the studies were categorised according to the assessment instruments used; performance component based outcome measures, occupation-based outcome measures or other outcome measures. (Table 4)

Performance Component Based Outcome Measure

All eight studies excluding the systematic review measured the effectiveness of their intervention with performance component based outcome measures. A variety of outcome measures were utilised to focused change in performance components including fine motor control, visual motor...
integration, visual perception, kinesthesia, proprioception, in-hand manipulation and sensory modalities; handwriting speed and legibility. Five studies utilised multiple outcome measure tools to measure intervention effectiveness (Case-Smith, 2002; Denton et al, 2006; Sudsawad et al, 2002; Weintraub et al., 2009, Zwicker et al., 2009) with the other three studies using single assessment tools to measure handwriting legibility and speed (Jongsman et al., 2003; Berninger et al., 2006; Ryan et al., 2010).

Three studies measured visual perception (Case-Smith, 2002; Denton et al., 2006, Weintraub et al, 2009) with all three studies using The Developmental Test of Visual Perception (DTVP) (Hamill et al, 1993) to measure for effectiveness. Interrater reliability and validity studies for this measure have demonstrated strong evidence for its use and all research studies reached statistical significance suggesting effectiveness of the interventions on visual perception. Fine motor co-ordination and in-hand manipulation was assessed in two studies (Case-Smith, 2002; Denton et al., 2006) using The Nine Hole Peg Test (NHPT) and The In-Hand Manipulation Test (TIHM) (Pehoski et al, 1997). These outcome measures both use a time schedule with a peg board and pegs. In the TIHM, the pegs are used in translation and rotation with stabilisation tasks, while the NHPT requires the pegs are used in a direct target task (Van Hartingsveldt et al., 2011) Interrater reliability is established for TIHM (Exner, 1993; Pehoski et al., 1997; Pehoski et al., 1997; Bazyk et al., 2009; Pont et al., 2008) and for the NHPT (Smith et al., 2000). The interventions of both studies reached statistical significance suggesting effectiveness to improve this handwriting performance component skill.

Visual -motor skills was measured in three studies (Case-Smith, 2002; Weintraub, 2009, Zwicker et al., 2009). Two studies (Case-Smith, 2002; Weintraub, 2009) used the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) while Zwicker et al assessed visual motor integration using the Berry-Buktenica Developmental Test of Visual Motor Integration (VMI) (Berry, Berry, 2004). Interrater reliability and validity demonstrated strong results (Miyahara et al., 2006; Deitz et al., 2007). All studies failed to reach statistical significance in post score measures following the intervention for handwriting difficulty. Two studies measured the effectiveness of intervention of Kinesthesia on handwriting performance (Denton et al., 2006; Sudsawad et al., 2002). The assessments used to measure effectiveness were the Test of Manual Pointing (TMP) (Von Hofsten, Rosblad, 1988) and The Kinesthetic Sensitivity Test (KST) (Laszlo, Bairstow, 1985). Test reliability and validity have not been established for the TMP and the study indicated no significant change from pre-test to post-test for any of the groups. In Sudsawad et al study, the KST measured statistical improvement in kinesthesia across all groups, however this improvement did not improve handwriting performance as measured by the Evaluation Tool of Children’s Handwriting (ETCH).

Handwriting legibility and speed were the primary performance components assessed to measure effectiveness of intervention in handwriting performance across all eight studies. Six assessment
tools were used to measure effectiveness. The Evaluation Tool of Children’s Handwriting (ETCH) (Amundson, 1995) was used in three studies (Case-Smith, 2002; Sudsawad et al., 2002; Zwicker et al., 2009). Fair to good interrater reliability and validity has been demonstrated for this assessment tool (Amundson, 1995; Diekema et al, 1998; Feder, Majnemer, 2000). Only one study (Case-Smith, 2002) showed improvement in handwriting performance with an average increase of 14.2% in legibility as an objective measure on the ETCH. The other assessment tools included The Test of Handwriting Skills (THS) (Gardner, 1998) which offers low to fair interreliability and validity by Garner, 1998. It did not measure statistical significance following the intervention (Denton et al, 2006); The Woodcock Johnson Psychoeducational Battery(WJ-R) (Woodcock, Johnson, 1990); The Concise Evaluation Scale for Children’s Handwriting (BHK)(Hamstra-Bletz et al., 1987) and The Minnesota Handwriting Test (Reisman, 1993) which offered evidence of interreliability and validity (Peterson, Nelson, 2003; Cornhill, Case-Smith, 1996) and is shown to be the offer the greatest sensitivity to change.

**Occupation Based Outcome Measure**

Only one study incorporated an occupation-based outcome measure (Case-Smith, 2002). This study was conducted over the school year of thirty-eight students aged seven to ten years old who were identified by the teacher as having handwriting difficulty. The treatment group consisted of twenty-nine students compared to 9 students who were allocated to a control group without any intervention. Intervention included a multisensory approach (vibration, resisted writing, writing on a chalkboard and vertical surfaces) behavioural and motor learning approach (shaping, stimulus fading, verbalizing description of letter formation and self monitoring) and developmental and behavioural approaches (letter formation, alignment, spacing and sizing issues. Teacher involvement was an integral part of the intervention plan. The School Function Assessment (SFA) (Coster et al., 1998) assesses the role of the student at the level of school occupations that require manipulative skills. In post testing, the SFA indicated a substantial increase in written communication. The performance component assessments also showed improvement in handwriting legibility (average increase 14.2%), in-hand manipulation, and position in space scores. The students in the control group who did not receive intervention showed a slight increase in handwriting speed.

**DISCUSSION**

One systematic review, six randomised control trials and two non-randomised control trial in this critically appraised topic provided the evidence for this critically appraised topic. The aim of this review was to investigate the effectiveness of occupational therapy interventions in improving handwriting difficulties in the existing literature. Handwriting is a primary occupation of the school aged child and it is essential in the classroom environment with past studies indicating handwriting
difficulty as the most common reason that school aged children are referred to occupational therapy (Tait, 1998; Feder et al 2000; Case-Smith, 2002; Schneck, Amundson, 2010). It is therefore necessary to evaluate the literature as it relates to effective interventions to remediate handwriting difficulty. Therapeutic effectiveness is generally measured using standardised assessment tools and therefore the interventions in this review were evaluated at the level of assessment tool used to inform evidence based practice to clients.

This critically appraised topic highlighted the wide range of interventions that are used by occupational therapists to address handwriting which reflects the array of assessment tools utilised to measure the effectiveness of same. The results of this review suggest the importance placed on the performance components of handwriting when providing intervention; all of the included studies with the exception of the systematic review (Hoy et al, 2010) used performance component based interventions. The results indicate that there continues to be little evidence to support the effectiveness of multisensory interventions and sensorimotor interventions which appear to be used by 90% of paediatric occupational therapists in the United States and Canada to improve handwriting difficulties (Feder et al 2000). Based on this review and the systematic review offered by Hoy and colleagues, interventions that focus solely on performance components related to handwriting such as in-hand manipulation or kinaesthetic training do not appear to be effective in improving handwriting difficulties in school aged children. This could be due to the focus on the bodily functions rather than occupational performance.

Despite the need for occupational therapists to maintain an occupation focused assessment which views the child as an occupational being (Buchhorn, McKay 2008), only one of the included studies incorporated an occupation based assessment (Case-Smith, 2002) to assess written communication with a view of the student role and ability to function in the context of school. Occupational therapists do not base their clinical decisions simply on the evidence presented, observation and clinical reasoning skills of the client are integral to service provision. Many of the randomised control trials did not take into account intrinsic client factors such as motivation and personal meaning. Interestingly, in four out of the five studies which reach statistical significance, active involvement by the student was incorporated in the intervention. These strategies included self instruction and self correction (Jongsman et al., 2003), self composition (Berninger et al., 2006), self-evaluation (Weintraub et al., 2009) and self monitoring (Case-Smith, 2002). This is also similar to Piaget theory which recognises the need for active participation and the ability to adapt to change in order to facilitate learning.

In consideration of the school routine, one study incorporated a teacher questionnaire to measure effectiveness of the intervention in the natural classroom assessment four weeks post intervention (Sudsawad et al, 2002) which yielded positive qualitative contributions. Ryan et al (2010)
investigated if environmental variables such as school furniture configuration could support occupational performance in handwriting. The results of this study indicated that specialised workstations with individual specifications do not appear to improve handwriting performance. This study was tailored to the individual needs of the participants while the other randomised control trials were conducted using a group methodology. The high ratio of boy to girl was reflected across all the studies which correlate with the concerns for gender prevalence in handwriting difficulties in the literature (Sandler et al., 1992; Tseng, Murray 1994).

**Clinical Bottom Line:** In summary, due to the variety of interventions and varying assessment tools used to measure effectiveness, it is difficult to establish clear definitive feedback. However, the findings do highlight the need for an occupation-based approach to handwriting intervention which assesses important aspects of the person, the occupation and the environment.

**LIMITATIONS**

This critically appraised topic formed a preliminary analysis of the effectiveness of occupational therapy interventions for six to eleven year olds with handwriting difficulties. There should be an awareness, however, of the limitations of critically appraised topics when interpreting the results. Critically appraised topics have a short shelf life (Law, 2002). The timeframe of the literature searches of this CAT could have an excluded more recent studies which could limit the findings. Evidence-based occupational therapy (EBOT) has become an integral in the professions standard of practice (AOTA, 2002) and this CAT can serve as an initial guide to conduct further research with more rigorous study designs such as a systematic review.

A critically appraised topic is constructed in a similar manner to a systematic review. It begins with a clear clinical question and completes a comprehensive literature search strategy, the retrieval of primary studies based on inclusion and exclusion criteria and evaluates the quality of the literature (Taylor, 2000; Brown, Burns, 2001). Grey literature was excluded from this review which could have influenced clinical decision making and could therefore be included in a systematic review. The conclusions of systematic reviews offer greater confidence to guide care pathways and inform Cochrane database (Cook et al, 1995; Taylor, 2007; Brown, Burns, 2001).

The McMaster’s Critical Review Form for Quantitative Studies was used to assess the quality of the included studies. There are other available critical appraisal tools including the Critical Appraisal Skills Program (1993) which may be offer a deep sensitivity analysis and implications for occupational therapy practice.

**IMPLICATIONS FOR OCCUPATIONAL THERAPY**
This study has multiple implications for occupational therapy education, practice and research. Firstly in relation to occupational therapy practice, the findings of this critically appraised topic, provides the evidence that to date, there is no gold standard to guide occupational therapist in their choice of intervention. Many of the randomised control trials did not take into account intrinsic client factors such as motivation and personal meaning and it is important to consider these factors on a case by case basis, even within a group intervention depending on the occupational needs of the child.

The need to return the focus of intervention to the modality of occupation where occupational therapy and occupational science are grounded is permeated throughout this critically appraised topic. Occupational therapists should focus on the child as an occupational being with an innate need to engage in school based occupations to fulfil the activity demands attached to student role within the classroom. Occupational therapists reinforce the need for collaboration with parents and teachers to design intervention programs within school routines as demonstrated in Case-Smith study. Parents play an important role in their children’s development, specifically in their education (Mashburn,Pianta 2006). Parents can give insights into the needs and experiences of their own children that can assist planning age and culturally appropriate social and academic programs (Pianta, La Paro, 2003).

In relation to occupational therapy education, educators of academic programs can incorporate critically appraisal topics in practice education modules to develop skills in critically appraisal of the literature to inform student clinical decision making within the clinical environment and support the students to become autonomous and accountable practitioners.

And finally, in the domain of future research opportunities, these findings provide preliminary analysis in the form of a critically appraised topic which could be used to conduct a systematic review. It also identified the need for future research in areas such as the development of occupation-based assessment tools which reflect the foundations of occupational therapy practice.

CONCLUSION

A critically appraised topic (CAT) is a process used to evaluate research studies based on a clinical question to inform evidence based practice to allied health care professionals including occupational therapists. The results of this critically appraised topic identified one systematic review, six randomised control trial and two non-randomised control trial of occupational therapy interventions to improve handwriting difficulty in six to eleven year olds using specific inclusion criterion. The researcher conducted a comprehensive appraisal to establish therapeutic value to inform evidence based occupational therapy. The current literature does not clearly demonstrate a definitive clinical
intervention to remediate handwriting difficulties. The findings of this critically appraised topic identified the use of only one occupation based assessment to measure the effectiveness of interventions and recommends further research in this clinical area.

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