THESIS

SYSTEMATIC REVIEW OF THERAPEUTIC INTERVENTIONS IN OCCUPATIONAL THERAPY FOR CHILDREN WITH TRAUMATIC BRAIN INJURY

Submitted by

Erik Richard Ferland

Occupational Therapy Department

In partial fulfillment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Spring 2010

COLORADO STATE UNIVERSITY

May 13, 2009

WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY ERIK FERLAND ENTITLED "SYSTEMATIC REVIEW OF THERAPEUTIC INTERVENTIONS IN OCCUPATIONAL THERAPY FOR CHILDREN WITH TRAUMATIC BRAIN INJURY" BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate work

David Greene PhD, OTR

Carol Seger PhD

Advisor Pat Sample M Div., PhD

Department Head Wendy Wood, Ph.D., OTR/L, FAOTA

ABSTRACT OF THESIS

SYSTEMATIC REVIEW OF THERAPEUTIC INTERVENTIONS IN OCCUPATIONAL THERAPY FOR CHILDREN WITH TRAUMATIC BRAIN INJURY

Objective: The aim of this study was to conduct a systematic evidence-based search and review of the published literature pertaining to occupational therapy interventions for children with traumatic brain injuries. Data sources: The databases searched included PsychINFO (EBSCOhost), Academic Search Premier (EBSCOhost), CINAHL (EBSCOhost) and PsycARTICLES (EBSCOhost) as well as the reference lists of articles found. Search terms: Whole words included *brain, head*. Wild card searches included *child*, injur*, p?ediat*, rehab*, interven*, traum*, occupation*, therap**. Inclusion criteria for research articles: The participants must be children and youth with traumatic brain injuries (TBI) sustained from birth – 21 years old; the intervention must be an associated occupational therapy intervention; the study must include between groups designs, with either quasi-experimental or randomized experimental design, and within subject single subject designs. Data interpretation: The author assessed each article against a rubric that looked at the quality various aspects of the study (e.g. design, methods, and outcome variables). Results: The researcher analyzed six articles with a total of 39 children with TBI. Three articles researched restrain therapy, one researched Lycra-based splints, one researched an antecedent behavioral intervention, and one discussed a problem-solving intervention for families of children with TBI. Conclusion: The researchers found positive effects for the CIT interventions, the antecedent

behavioral intervention and the family problem-solving intervention. The researchers who looked at the Lycra splinting found mixed results that were inconclusive.

Erik Richard Ferland
Occupational Therapy Department
Colorado State University
Fort Collins, CO 80523
Spring 2010

Table of Contents

Traumatic brain injury (TBI) is the leading cause of morbidity and mortality for children in the United States. With the many different possible interventions available to occupational therapists and the drive for evidence-based practice, there is need for systematic review of interventions. In the United States, the Centers for Disease Control and Prevention (2006) estimated that between 1995 and 2001 children between birth and 14 years old sustained an average of 475,000 head injuries per year. Of those injuries reported, 435,000 were emergency department intakes, 37,000 required hospitalization and 2,685 resulted in death. The most common cause of head injuries in this age range is due to fall-related incidents. At around age 15 vehicle-related collisions are the main cause of head injuries related to TBI. According to a study by Guerrero, Thurman and Sniezek (2000), the rate of traumatic brain injury in the United States is approximately 692 per 100,000 children, between the ages of 0-15.

A recent study looked at the differences between the rates of childhood TBI (as measured by hospital discharges after stay), and found very low numbers in Sweden (37/100,000 children hospitalized) versus the United States (80/100,000 children hospitalized) (Falk, 2007). When the researcher examined the statistical rates for actual incidence of brain injury overall, the numbers increased substantially in both countries, and reported a similar rate per capita of injuries in Sweden (865/100,000) and the United States (692/100,000). This finding was based on data collected during a period from September 2002–September 2003 were a total of 3168 children were documented with head injuries in the emergency of the Astrid Lindgren Children's Hospital (versus the more severe

cases wherein children were hospitalized and discharged after stay) and was compared to the data collected by Guerrero, Thurman and Sniezek (2000). This indicates that much of the discrepancy in rates is based on variability in reporting based on severity of injury, as well as each country's definition of a TBI. Another confounding variable related to incidence of TBI in general is whether children are taken to the hospital or not. Many injuries could be considered mild and therefore the child is not taken to the emergency department. The trend for causes of trauma between the two countries was similar as well: the cause of most injuries early in childhood was falls, and later in childhood was motor vehicle crashes.

Data obtained in New Zealand show lower rates (100-300/100,000 overall incidence of TBI) (McKinlay, 2008), but the study also indicated that the numbers are inconsistent and hard to obtain due to the challenges of definition of TBI and reliance on discharge paperwork for data gathering. The causes of TBI, nevertheless, are similar in New Zealand with some slight differences: contact sports, especially rugby, and assaults are the second and third most common causes after motor vehicle accidents.

When the extent of the trauma does not result in death, the long-term effects of TBI in children are extensive. Many children experience decreased motor control, as well as orthopedic, sensory, cardiopulmonary, cognitive, psychosocial, behavioral, and communication impairments (Cronin, 2001). Mortenson and Harris (2006) investigated another effect that TBI has on children: the diminished participation in the occupation of play. Another recent study looked at how TBI

relates to a reduction in the quantity of friendships that children form (Prigatano & Gupta, 2006). Because of psychosocial and behavioral impairments, many children with TBI have diminished academic performance (Yeates, & Taylor, 2006). Researchers have found the behavioral changes seen in children with TBI negatively affect the behavior of siblings (Sambuco, Brookes, & Lah, 2008). An article review conducted in Australia to find specific intervention methods for children with TBI found that injuries to the frontal lobe had effects on the capabilities to plan, problem-solve and organize (Catroppa, & Anderson, 2006). A recent study conducted in Jerusalem, found that the effects of TBI on balance changed the gait of children who had sustained TBI (Katz-Leurer, Rotem, Lewitus, Keren, & Meyer, 2008). A consistent result noted in a majority of the articles regarding brain injury and children with TBI, was the effect on the children's cognitive function. Cronin (2001) and Mckinlay et al. (2008), found that to be the case even with mild injuries.

Researchers are also examining the long-term effects of TBI from childhood to adulthood (Brenner et al., 2007). A case study of a 56-year-old man who had sustained a TBI at age 5 found that there were many effects that needed to be considered long-term as the man increased in age. Many of these effects did not show up until the individual started to pass through different developmental stages. Another study in Norway tested individuals, who had experienced brain injuries while children, using Minnesota Multiphasic Personality Inventory-2 (MMPI-2). The researchers found that when a simple mild brain injury occurred, it did not have any profound effect on the person; however, when a more

complicated mild traumatic brain injury occurred (e.g. if there was damage to the skull), measurement scores indicated greater pathology (Hessen, Anderson, & Nestvold, 2008).

The interventions available for children who have sustained traumatic brain injuries (TBI) are wide ranging. There are medical interventions including hyperbaric oxygen (Woolley, Lawrence, & Hornyak, 1999), and corticosteroid injections (Rigg, & Zafonte, 2006) that research studies have shown to be ineffective. Botulinum toxin type A (BTX-A) is administered to help children with spasticity in their limbs to be more comfortable; however, this does not rehabilitate the affected limb (van Rhijn, Molenaers, & Ceulemans, 2005). The medical field uses few interventions beyond these in the rehabilitative stage. Physical, occupational, music, art and psychological therapists administer most of the interventions during this phase of the child's recovery.

Physical therapists use a combination of interventions intended to address the physical issues related to gait and ambulation after a TBI. In Switzerland, physical therapists have developed a robotic assisted locomotor training machine adapted from an adult design to help children correct gait issues (Meyer-Heim et al., 2007). In the United States, physical therapists are studying the use of transcranial magnetic stimulation (TMS) to increase brain plasticity in both children and adults to increase retention of skills after therapy (Butler, & Wolf, 2007). Music and art therapies are being more accepted and are taking a greater role in the allied health care rehabilitation setting and are shown to be effective for children who have TBI's and ABI's (Kennelly & Brien-Elliott, 2001;

Mallay, 2002). Psychologists are using behavioral therapy to address the external problematic behaviors expressed by children who have sustained a TBI (Warschausky, Kewman, & Kay, 1999).

Related field applications, used by occupational therapists, have provided the most information regarding treatment of children in the rehabilitative stage after a traumatic brain injury. Most of these are applications from the field of psychology and are applicable through the OT psychosocial framework (Wade, Michaud, & Brown, 2006). The first of these is an online cognitive-behavioral family intervention that allows an indirect approach as well as a direct approach. This program also helps to provide support to the family and allows people who are in a lower socioeconomic status (SES) to be able to access OT related interventions on their own schedule and for a lower cost.

Another study looked at a different online program that used a problem-solving intervention approach to address behavioral problems associated with children with brain injuries (Wade, Carey, & Wolfe, 2006). A study in the UK found that a behavioral intervention program that incorporates rules, a token economy with response cost (e.g. - negative reinforcement by taking away objects), and mystery motivators (incentives that are kept a secret [e.g. "if you finish this task then you will get a surprise"]), has helped reduce behavior problems by an average of 69 percent (Mottram, & Berger-Gross, 2004).

A psychological study on executive function, self-regulation and learned optimism found that children's involvement in the organization of everyday activities was

needed as a part of helping them to recover a sense of optimism and sense of self efficacy during the rehabilitative stage of a TBI; and by involving children in the process there were better outcomes overall in executive function, self-regulation and optimism (Ylvisaker, & Feeney, 2002). An Italian study looked at how a multimodal context-based intervention that used the interplay of parents with children, who had experienced anoxia due to drowning, had positive effects on the children's dyskinetic posture, which had been a result of their brain injuries (Pierro et al., 2005).

Another potential intervention that has recently been employed by psychologists in Cincinnati, Ohio, to help with regular therapy for children is the use of web-based video conferencing and web-based activities to help connect with clients at their homes (Wade, Carey, & Wolfe, 2006; Wade, Wolfe, Brown, & Pestian, 2005). For occupational therapists this would reduce travel and would allow families in rural or remote areas to access consultative services.

In the Amsterdam Academic Hospital in the Netherlands a program was developed called the Amsterdam memory and attention training for children (Amat-c), and has been studied by a Swedish OT and found to be effective (van't Hooft et al., 2005; van't Hooft, Andersson, Sejersen, Bartfai, & von Wendt, 2003; van't Hooft et al., 2007). In Cincinnati, researchers conducted a study and found evidence that CIT had a positive effect for pediatric populations (Willis, Morello, Davie, Rice, & Bennett, 2002). Jones, Drummond, and Vella (2007) conducted a survey of occupational therapists in the Trent region of the United Kingdom and found they used many different approaches to help children during the

rehabilitative phase. There were several interventions involved in this study; primarily, the therapists used traditional occupational therapy activities of daily living (ADL) and perceptual retraining activities.

Finally, traditional OT methods of augmenting the environment and providing adaptive technologies (AT) to help reduce distractions and mobility limitations have recently been studied in Canada. A recent study found improved self-reports of ease in navigating the environment by children with TBI because of using the AT (Chau, Eaton, Lamont, Schwellnus, & Tam, 2006). The study did not find a statistical difference. This may, however, have been a result of a small sample. The authors felt that there was enough evidence to warrant the need for further study.

With the lack of intervention in the rehabilitative stages of TBI in the medical field, the onus falls on the therapy fields to help children to cope with the effects of their injury. Due to the nature of the effects of TBI, (physical, cognitive, behavioral and socio-cultural), the fields of occupational therapy, physical therapy and speech therapy are best equipped to help create change for children with TBI. This thesis study took a critical look at different evidence-based practice interventions in occupational therapy for children with TBI, and checked them against a specific minimum of standards of internal and external validity.

METHODS

For this study I adapted the methods established by Cobb, Sample, Alwell and Johns (2006) in their systematic review or articles detailing cognitive-behavioral

interventions used to reduce the high rate of dropout in the population of children with disabilities (See Table 1). In that study, the authors created a rubric for establishing the rigor of between groups designs based on several factors. The first criterion was the study's alignment to commonly held beliefs in the field. The next was whether there was possible implementation replicability. The researchers also based their inclusion criteria on the adequacy of the definition of the outcome measure. Sampling methods for the research design in the individual studies, along with control over external variables also were criteria evaluated to establish rigor. To ensure that the study would be applicable the researchers looked at the generalizability of the study's findings, the breadth of the statistical testing across the important subgroups of students, and the variation within the intervention. Finally, they looked at whether the researchers reported underlying assumptions of the statistical analysis along with the thoroughness of the description of the data. Because this thesis also included quasi-experimental designs, the category pertaining to representation of the sample was modified to look at how the assignment was conducted and the attempts by the author(s) to come as close as possible to random assignment of participants. For the studies which used single subject designs, the category pertaining to representation was marked as *weak*, however, these articles were still included in the review.

SOURCES

In order to have the broadest and most comprehensive literature base possible, I conducted extensive systematic searches of relevant electronic databases,

author searches, and searches of selected reference lists, especially of review articles. The databases I searched included PsychINFO (EBSCOhost), Academic Search Premier (EBSCOhost), CINAHL (EBSCOhost) and PsycARTICLES (EBSCOhost). I conducted a cursory search of OTSeeker and OTCATS to see if these databases would produce any viable sources. I also searched the reference lists of accepted articles for additional articles that might pertain to this study.

SEARCH TERMS

For search terms, I used a combination of "wild cards" (a symbol that stands for one or more unspecified characters used in searches). I used wild card searches to create a more thorough list without the need for finding all permutations of related words (e.g. child, childhood, children can all be searched with child*). Whole words included *brain, head.* Wild card searches will include *child*, injur*, p?ediat*, rehab*, interven*, traum*, occupation*, therap**

Inclusion Criteria:

- Must include between groups with either quasi-experimental or randomized experimental design, or within subject single subject designs.
- Must include people who had experienced traumatic brain injuries between the ages of birth to 21
- Must have received treatment in the form of occupational therapy as the intervention being assessed.

Exclusion Criteria:

- Comparative and associational designs
- Quasi-experimental designs with one group posttest-only, one group pre-test – posttest and posttest-only with nonequivalent groups designs
- Studies that look at interventions within other fields unrelated to occupational therapy
- Studies with interventions used on adult populations over the age of 21.

The search of the databases produced 113 total results. The database sorted the results by date. I excluded all articles older than the year 2000. This limited the results to 71. I then read the titles of each of the articles and excluded any articles that were not clearly within the subject of this review. If an article seemed to fit the criteria of the review, I then read the abstract. I read 20 of the article abstracts that I felt either had potential for review or had potential for including bibliographies that would produce more results. If I felt that the abstract clearly did not fit within the criteria, I excluded them. This reduced the number of total articles to five. From the articles remaining, I read each article to establish whether the study fit within the criteria and removed articles that did not fulfill the requirements. This reduced the number to four articles for review from the database search. Then, I went through the bibliographies of articles, which showed promise for producing more studies to review. To accomplish this, I

used the same methodology reported for the database searches. I looked at and reviewed 85 article titles. This netted another five articles that I searched for individually on the databases. From the review of the abstracts, three articles passed on for review. After reading the articles, I passed two of these articles on for the final review, which made a total of six articles included in this review. I reviewed the final set of articles based on the rubric in Table 1.

For the study conducted by M. Chevignard in French et al. (2008), I used free translation software called Babel Fish, provided by the Yahoo! website. I copy/pasted each section of the article into the translation box then copy/pasted the translation to a word document. If there were words that did not translate in the Babel Fish platform, I would use a Google search to get a translation.

RESULTS

RESEARCH STUDY DESIGNS

The six studies included in this review were all based in the quantitative paradigm. The individual study designs consisted of two randomized control studies; and four single subject designs (a baseline then ABCD design with A being the first experimental phase; a multiple single subject interrupted time series experimental AB design with four sets of data from four subjects; and two single subject pretest-posttest time series design).

PARTICIPANTS

From the six studies in this review, 34 children in total received occupational therapy intervention, and 32 families of children with TBI received problem-solving therapy (Table 2). In the randomized control study conducted by Willis et al. (2000), the inclusion criteria consisted of children with chronic hemiparesis as a result of static brain lesions (13 stroke, six cerebral malformations, two trauma, and four unknown). In the French study conducted by M. Chevignard et al. (2008), the children who were included all had been hospitalized for acquired cerebral lesions. The study included three children who each had right side hemiparesis. The first child had sustained a left cerebral vascular accident (CVA), the second had sustained a head injury, and the last child had a tumor. Miller and Hale (2005) conducted a study in New Zealand that included a single youth who had sustained a severe brain injury as an infant (eight months of age). An Australian study conducted by Corn et al. (2003) included four children, who were split into two groups of two children. The first group included long-term users of the splints. Both of these children were diagnosed with cerebral palsy (CP). The second group included two children with acquired brain injuries, who had no history of splint use. There was no further description of the history of the children, so it is not known what caused the injuries. A study conducted by Pace et al. (2005) included a 10-year-old boy with a severe traumatic brain injury resulting from Shaken Baby Syndrome. A final study conducted by Wade, Michaud, & Brown (2006), included 32 families of children with TBI. In that study,

data were gathered from the children, parents and siblings through multiple surveys.

The ages of the children in these studies ranged from one to 20 years old when the studies were conducted. The child in the Miller and Hale study, who, as already mentioned, had sustained a TBI at the age of eight months was the oldest child included in this review (20 years old).

INTERVENTIONS

(See Tables 3 and 4 for ratings of individual studies, and a synopsis of results.)

Restraint Therapies

Occupational therapists have recently started to study the use of restraint therapies including forced use therapy, constraint-induced movement therapy (CIMT) or constraint-induced therapy (CIT), and modified constraint-induced therapy (mCIT). "Forced Use involves a restraint that results in unstructured practice whenever an activity is performed with the involved hand. Constraint-Induced Therapy involves a restraint and structured practice, which includes shaping and repetitive task practice. In Modified Constraint-induced therapy, structured practice may be provided that does not include the shaping and repetitive task practice" (Charles & Gordon, 2005, p 248). "The treatment is designed to overcome learned non-use in chronic hemiparesis, which is the behavioral suppression of purposive movement of the more affected upper extremity in the life situation, with compensation during daily living activities by the less-affected upper extremity."(Mark et al., 2008, p. 992)

For this study, I located and reviewed three articles that examined the use of CIT or forced use with children who had sustained neurological damage (Willis et al., 2002; M. Chevignard et al., 2008; Miller & Hale, 2005). Within the sample groups in the studies, there were two children included who had sustained traumatic brain injuries. Since the researchers were looking at treating hemiparesis in all of the participating children, they therefore did not separate the data from the children with traumatic brain injuries, from the data of the children with other central nervous system disorders. Each of the three studies looked at different applications of CIT.

The study conducted by Willis et al. (2002) employed forced use therapy by use of plaster casting the unaffected limb to force the use of the affected limb. This study was a randomized control study that looked at a group of 25 children (ages 1-8 years) with chronic hemiparesis, two of whom had sustained a TBI. The assessment used in the study poses a limitation, because it is standardized for a limited age range (birth to 83 months). Following random assignment, the researchers casted the children in the treatment group (n=12) for one month, and had them continue with their routine of occupational and physical therapy. The researchers then reassessed the participants six months later and at that time, the control group (n=13) received the plaster casting and continued with physical therapy only. The researchers performed two rounds of treatment. The first was with a treatment group and a control group. They performed the second round six months later where they administered the treatment to the previous control group, and the previous treatment group received no treatment. The researchers

used only the data from the first treatment and control sessions for their analysis, and not the data collected during the second round. From the data analysis, they found a statistically significant difference in the change scores between the treatment (143.2 before and 155.8 after) and control groups (102.2 before and 104.7 after) on their mean Peabody Developmental Motor Scale (PDMS) scores after the treatment. In a recent critical appraisal by Hoare published in the *Australian Occupational Therapy Journal* (Wallen & Hoare, 2004), the author mentions some of the considerations and limitations regarding the Willis et al. (2002) study. He notes that the study had a high attrition rate for the follow-up, high variability in the groups, and had non-"naïve" (blinded) data collectors. Nevertheless, when combined with other similar research, Hoare felt the Willis et al. study indicated that CIT could be an effective tool for the pediatric population with hemiparesis due to traumatic brain injury.

A second study of a restraint therapy selected for this systematic review, and conducted in France by Chevignard et al. (2008), tested the application of CIT with a Mayo Clinic brace, which is an adjustable splint which immobilizes flexion and extension at the elbow (medcompare website accessed 4/47/2009). This study used a single factor within subjects design with two baseline measurement phases on five physical measures (Nine Hole Peg Test; Box and Blocks Test; and three, one-minute timed tests: displacement of cones and cylinders and the creation of a tower of cubes and a spatial neglect test), and a visiospatial test (batterie de Saint-Maurice) at one week intervals prior to the intervention for each of the five children. The treatment protocol called for each of the five

participating children to wear the brace seven hours each day for two weeks. During those two weeks, the children also were involved in intensive therapy including physical therapy, occupational therapy and psychomotricity. Psychomotricity is "based on a holistic vision of the human being, on the unity of body and mind, psychomotricity integrates the cognitive, emotional, symbolic and physical interactions in the individual's capacity to be and to act in a psychosocial context" (The European Forum of Psychomotricity website accessed 4/27/2009). The study found a significant statistical difference in two of the children's individual scores (cylinders and Nine Hole peg test) both before and after the treatment period. The child who had sustained a traumatic brain injury, identified in the study as Child B, showed an improvement in three of the five measures (cones, cylinders and Nine Hole Peg Test), and showed a statistically significant difference in overall change ($z = -2.816$; $p = 0.005$) (p. 243). The combined effect size for all the children's scores, using Cohen's d was .58 (p. 243). According to the authors of the article, they felt the effect size was broad and not "clinically significant." However, according to Gliner and Morgan (2000) an effect size higher than .5 is a medium to large effect. The researchers did not find any change in visual field neglect before and after the intervention, as measured by the Batterie de Saint-Maurice. The study also collected survey data and found that the therapists, medical team members and parents noted that after the treatment, the children had improved spontaneous use of the affected limb, increased self-awareness, and had increased the integration of the affected limb

into activities. The primary study limitation noted by the authors concerned the small sample size.

The final restraint therapy study included in this systematic review by Miller and Hale (2005), took place in New Zealand, and looked at the application of modified constraint-induced therapy (mCIT), modified to fit within a school-based clinical setting, where the youth are limited in the time they are in the therapy setting. The protocol included four one hour sessions per week for 30 weeks. The participant in this study was the youth mentioned above, who had sustained a TBI when he was eight months old and received the mCIT treatment at 20 years of age. The therapist constrained the participant only during the physiotherapy sessions, by placing her hand over the participant's unaffected hand. The researchers did not report on any statistical analysis of their data, but graphed the data to show the complete non-use of the affected limb in four different sections of the Action Research Arm Test (ARAT) (grasp, grip, pinch and gross movement), in the two baseline measures prior to the intervention, followed by some increase in use in those areas after the 30-week treatment period. The authors reported a number of study limitations, such as the lack of statistical analysis of the data gathered, the lack of any studies to test the validity of the ARAT with youth who have sustained TBI, and the fact that the protocol had potential for allowing confounding variables over the 30-week treatment. Even though the study did not provide the strongest evidence of the effectiveness of mCIT, it did indicate that there were possible gains for an individual who is a number of years post injury. The researchers also

demonstrated the potential for positive outcomes in future studies looking at the use of mCIT for youth with TBI in a clinical situation.

Taken as a whole these three restraint therapy studies show there is evidence that the use of CIT for children with hemiparesis or hemiplegia, due to brain injuries, can have a positive effect. The application of forced use therapy within the field of occupational therapy is as a *preparatory method*, defined in the *Occupational Therapy Practice Framework: Domain and Practice 2nd Edition* as direct methods and techniques that prepare the client for occupational performance. Used in preparation for or concurrently with purposeful and occupation-based activities" (Roley et al., 2008, p. 653). The protocol of both CIT and mCIT specifies the use of functional therapy while the unaffected upper extremity is restrained. In the *Framework*, this is considered an occupation-based intervention: "Client engages in client-directed occupations that match identified goals" (p. 653). Using constraint of the un-affected limb, while doing occupation-based activities, will help occupational therapists use this intervention within their scope of practice.

Second Skin® Lycra Splinting

The claims made supporting Lycra-based dynamic splinting contend that the splints can control tone, assist in trunk control, and increase people's functional abilities after sustaining neurological impairments (Blair, Ballatyne, Horsman, & Chauvel, 1995). The development of the splints came in response to the limitations experienced with static splints (i.e. limitation to range of motion). The

device was designed to "correct deformity, provide joint stability and tone inhibition, and also to re-educate targeted impairments towards more normal function" (p. 544). The splint assessed by Blair and colleagues was the "UPsuit," which is an individually designed, skin tight, Lycra suit with the fabric oriented to create tension in specific directions for dynamic correctional force to targeted body parts.

An undergraduate research study conducted in Australia at La Trobe University (Corn et al., 2003), which met the criteria for inclusion in this systematic review, examined the use of Second Skin® Lycra splints for children with spasticity due to neurological damage. The Second Skin® Lycra uses the same principle of fabric orientation as the UPsuit mentioned above. The Corn et al. study used a multiple single subject interrupted time series experimental AB design with four sets of data from four subjects (Franklin, Allison, & Gorman, 1996, p. 177). The researchers studied two children who had been long-term users of the Second Skin® splints, and two children who had never used the splints, to see if the splints had an effect on the children's spasticity. The long-term users of the splints had Cerebral Palsy (CP). Both children who were new to the splints had sustained non-specified ABIs. The researchers gathered a series of baseline measures for each child (minimum of 10), using the Melbourne Assessment for upper limb function, and then continued using the same assessment throughout the splint use phase. For the long-term splint users the researchers collected the baseline measurements after the intervention measurements. In all the researchers found there were no significant differences in the spasticity of the

children with the splints. One of the children, a long-term user, showed a decline in the measures of movement, grasp and accuracy while using the splint. The researchers found that the splint actually reduced range of motion when the child was attempting to perform fine motor skills while wearing the splint. They note that the purpose of the splint was to increase finger extension and thumb abduction for gross grasp and control. The only other child to show a statistically significant change while using the splint was a first-time user who showed a short-term change that was not maintained over time.

The researchers discussed possible variables that might have confounded the results of the study: the small sample size, the lack of comparison between the participants, and the absence of the children for a holiday break during the study period. By using a single subject AB design, the researchers left the possibility of threats to internal validity of the results, such as a potential for extraneous events affecting the outcome, and the lack of a comparison group which could have provided an audit of the outcome (Gliner & Morgan, 2000). The results of the Corn et al. study indicate the use of Second Skin® Lycra splints requires further study. Occupational therapists might be cautioned about using the splints for use in reducing spasticity in children with neurological damage, until more outcomes that are positive are determined through evidence-based research.

Family Problem-Solving

D'Zurilla and Nezu (1999) developed a psychology-focused intervention called problem-solving therapy. This therapy involves the identification of *problems*,

defined as situations in life that demand a change in functioning or behavior, and the subsequent identification of solutions to those problems that will enhance the social competence of the individuals experiencing those problems. D'Zurilla and Nezu designed a 5-step process: *Aim, Brainstorm, Choose, Do It and Evaluate* (ABCDE), which was used in the next research article included in this review.

Wade, Michaud and Brown (2006) conducted a study that used the five step family problem-solving intervention to help improve the behavior of children with TBI. The study design was a randomized control trial (RCT) involving the families of 32 school-aged children with moderate to severe TBI, who were divided into two groups. The treatment group received the intervention and the families in both groups continued with psychosocial treatments that they were previously involved in.

The intervention consisted of seven bi-weekly core sessions over a six-month period, and up to four individualized sessions. The sessions consisted of a 30-40 minute didactic portion and a 45-50 minute problem-solving session. The problem-solving skills framework used was adapted from the D'Zurilla and Nezu (1999) 5-step process discussed above. During the didactic portion, the therapist provided the family with information regarding possible effects of TBI on memory, attention, cognition, behavior, and behavioral management strategies.

The researchers used multiple measures for different aspects of this study. They l examined child adjustment, parent psychological distress, parent-child interaction and treatment satisfaction. The between-groups analysis of the pre-

test found that the two groups did not differ significantly except on one measure: the parent-child interaction measure (Conflict Behavior Questionnaire), which showed a trend toward higher levels of internalizing behavior in the treatment group. The researchers compared group differences on three of the measures, the Child Behavior Checklist, Conflict Behavior Questionnaire and the Brief Symptom Inventory, using analysis of covariance (ANCOVA). The pretest assessment was treated as a covariate to minimize the variance in the outcomes based on pre-existing variation.

Following the intervention phase, the parents in the treatment group reported an average 5.81-point decline on the Child Behavior Checklist in the children's internalization symptoms and a 3.86-point decline in the children's anxiety and depression, whereas the control group reported an average 2.07-point increase in internalization symptoms. The corresponding effect sizes reported for this measure were large at 0.17 for internalization and 0.21 for anxiety and depression based on a partial η^2 analysis. According to Cohen's guidelines (1988), a partial η^2 effect size is labeled as small (0.01-0.05), medium (0.05-0.14), or large (>0.14). The researchers found that on average the parents and their children with TBI rated the program as extremely helpful (parents M = 9.0/10 and children M = 8.8/10), and would recommend the program to others.

Some limitations to the study reported by the researchers included: 1. The comparison of the treatment was to standard care, only, and not to alternative treatment. The researchers could conclude only that the intervention is superior to standard care and not to any other intervention. 2. The sample size was small

but was appropriate, considering the specific and limited group they studied. 3. The structure of the study might have limited the researchers' ability to detect significant treatment effects (The researchers noted that they allowed the families to choose goals salient to them, regardless of their relevance to the injury and provided more sessions to families struggling after the initial core sessions). 4. They felt that the level of clinical experience of the therapist (a fifth year clinical psychology graduate student), might have limited the ability to demonstrate the true potential effectiveness of the intervention.

The overall findings of the study indicate that through the effective use of family-problem solving intervention therapists can help families to adjust the behavior of children with TBI. Psychologists conducted this study; however, it can be useful for occupational therapists also to use this intervention within the occupational therapy practice framework (Roley et al., 2008), to address the psychosocial needs of children with TBI and their families.

Antecedent Intervention

A study conducted by Pace, Dunn, Luiselli, Cochran and Skowron (2005), examined how identifying the antecedent events that precede behavior problems, and then mitigating those events, can help in reducing the problem behaviors. The participant was a ten-year-old boy diagnosed with a severe TBI, mild cerebral palsy, and ataxia secondary to Shaken Baby Syndrome. This single subject multiple baseline time series study was comprised of a baseline phase plus four phases of intervention. The intervention phases consisted of: Phase A.

The staff used a traditional consequence-based intervention (negative punishment and positive reinforcement); Phase B. The staff used Phase A procedures with the addition of "transition warnings, a visual schedule, choice for schedule of demands, and modified language for the presentation of demands" (p. 366); Phase C. The staff used Phase B procedures with the addition of non-contingent joint compressions several times per day that lasted approximately 10 minutes for each session; Phase D. The staff used phase C procedures with the addition of a "break program," consisting of an antecedent procedure for postponing tasks when the participant showed increased signs of frustration.

The results indicated that the staff achieved the greatest reduction in the participant's behavior problems in Phase D. The researchers noted a design weakness in their study: they did not conduct a phase that employed only the antecedent interventions (i.e. the transition warnings or the break program), nor did they conduct a phase that did not have a traditional consequence-based intervention. This may have confounded their findings. Overall, with all of the interventions in place in Phase D the participant's incidents of aggression reduced from an average of 6.03 times per day to 3.00. This study does not provide a sample large enough to make a generalized statement about children with TBI who are expressing aggressive behavior. It does, however, provide a possible intervention for therapists who are looking to reduce aggressive behavior associated with children who have sustained a TBI.

DISCUSSION

With the prevalence of brain injury within the pediatric population, occupational therapists need to have a set of evidence-based interventions they can use to assist in rehabilitation. In my structured literature search process, I found that research published on this topic after 1999 is limited. As I reported in the Results section of this thesis, research over the last nine years in occupational therapy focused on interventions for children with TBI and ABI has been concentrated on CIT and physical modalities, and to a lesser degree, behavioral interventions.

There have been phases of changing intervention strategies used over the past few decades by occupational therapists who worked with children with brain injuries. Other recent interventions have concentrated on the use of ADL's and perceptual retraining activities (Jones & Drummond, 2005). In a National Institute of Health Consensus Statement (1998), the types of services offered in the 1990's were cognitive rehabilitation, and behavior modification interventions within the special education system in the school districts. The Statement notes that interventions targeting specific problems within the pediatric population are difficult because there is little information on what unique problems children with TBI experience when compared with adults with TBI. This presented a challenge for this study because the research focus was to find interventions that specifically addressed the sequelae associated with childhood TBI, and fit within the definitions of the *Occupational Therapy Practice Framework* (Roley, et al., 2008). As stated in the introduction of this thesis, the effects are broad so the treatment areas that are required are also broad.

As noted above, in the 1990's the major focus of intervention research, targeting children with TBI, concerned cognitive retraining (Laatsch et al., 2007). Psychologists conducted much of this work, yet OTs were able to adopt the interventions using the psychosocial framework, as their conceptual model. The systematic review conducted by Laatsch et al. (2007), reviewed an article from 1987 by Light et al., which also examined the efficacy of cognitive reeducation.

The systematic search I conducted for this study produced one article published in 1971 by Calabro, which examined behavior modification for children with brain injury. In a cursory search, I found that in the 1960s a clinician/researcher was trying to differentiate brain injury from mental retardation in the pediatric population (Lewis, 1960). Beyond the attempt to show a differentiation, there were no specific occupational therapy interventions found for children with traumatic brain injuries before the 1970's.

I did not review the studies mentioned in the introduction regarding the use of the AMAT-c (van't Hooft et al., 2005; van't Hooft, Andersson, Sejersen, Bartfai, & von Wendt, 2003; van't Hooft et al., 2007). I attempted to find information on the treatment protocol for this intervention and was unsuccessful. The instruction book for the intervention is out of print and the articles detailing the research of the effectiveness of the intervention did not explain the intervention in enough detail for it to be viable for clinicians to consider implementing.

There were several limitations in this systematic review. The number of articles found through the databases was limited to 113 total articles. Many of these

articles bore little relevance to the field of occupational therapy and, therefore, were not appropriate for this review. The articles, which came directly from the database search, constituted 66 percent of the total reviewed. The articles I included in this review reported on the few occupational therapy intervention studies located through the systematic search protocol I had instituted. The paucity of found research articles may be due to a lack of specific intervention-based research conducted by occupational therapists, a lack of research dealing with interventions specific to children with TBI, or the search protocol I chose to conduct for this systematic review limited my possibilities of finding a greater number of research articles. Due to the broad nature of occupational therapy, much of the evidence used for interventions, however, can come from a variety of different fields, and the boundaries of my study did not allow for searching the research of different disciplines.

An article written by Johnston and Case-Smith (2009) highlights some of the challenges faced by occupational therapy researchers in conducting randomized control trials (RCT). It notes how, within the last eight and a half years, researchers have conducted an increased number of RCT studies, and they continue the call for more evidence-based research to be conducted. Overall, the increase of research conducted by occupational therapy researchers does provide for a greater chance of finding evidence for OT-type interventions, but the authors' call for more such research also means there is still a significant lack of data to examine. When practitioners take this information into the context of interventions for a specific population, such as children with TBI, the chances of

them finding a large quantity of quality research is even lower. As researchers conduct systematic reviews, the need of the researchers to maintain the rigor of the search severely limits the results. The insistence of researchers to maintain a high standard of rigor in systematic reviews is helpful and harmful to the resulting review. It helps to cull out extraneous articles and research studies, and limits the breadth of the study. It also lends to the replicability of the search. Harm for the review can occur, however, because there is the impossibility of finding data that do not contain the specified search keywords. The research databases I used and the search engines that they employ have limitations as well. The search terms need to be specific enough to cull correctly the articles that are not relevant to the search, but need also to be broad enough to capture a large number of the articles that pertain to the subject reviewed. The databases have no way to separate the data by context.

The best intervention studies, yielding the most effective outcomes found in this systematic search indicate that the use of CIT, combined with occupational tasks, shows great promise for helping rehabilitate children who have sustained hemiplegia due to brain injuries (Chevignard et al., 2008; Corn et al., 2003; Page, Levine, Leonard, Szaflarski, & Kissela, 2008; Willis, Morello, Davie, Rice, & Bennett, 2002). Additionally, the results from the other included studies indicate that effective use of family problem-solving, in the form of the five-step problem-solving skills framework (Wade, Michaud, & Brown, 2006), or effective use of antecedent interventions (Pace, Dunn, Luiselli, Cochran, & Skowron,

2005) appear to reduce behavior problems associated with some children who have sustained TBI.

With the large population of children who, every year sustain traumatic brain injury, occupational therapy interventions to help with integration and rehabilitation are necessary. The results this review found, using the systematic protocol outlined earlier in this thesis, indicate that occupational therapists need to do more research into interventions dealing with cognitive, social and behavioral challenges associated with traumatic brain injury in the pediatric population. Because of the broad nature of occupational therapy and the related research, much of what occupational therapy researchers learn can contribute to other therapy fields, as their fields' research can contribute to occupational therapy (Johnston & Case-Smith, 2009).

REFERENCES CITED

Blair, E., Ballantyne, J., Horsman, S., & Chauvel, P. (1995). A study of a dynamic proximal stability splint in the management of children with cerebral palsy. *Developmental Medicine and Child Neurology*, *37*(6), 544-54.

Brenner, L. A., Dise-Lewis, J. E., Bartles, S. K., O'Brien, S. E., Godleski, M., & Selinger, M. (2007). The long-term impact and rehabilitation of pediatric traumatic brain injury: A 50-year follow-up case study. *Journal of Head Trauma Rehabilitation*, *22*(1), 56-64.

Butler, A. J., & Wolf, S. L. (2007). Putting the brain on the map: Use of transcranial magnetic stimulation to assess and induce cortical plasticity of upper-extremity movement. *Physical Therapy*, *87*(6), 719-736.

Catroppa, C., & Anderson, V. (2006). Planning, problem-solving and organizational abilities in children following traumatic brain injury: Intervention techniques. *Pediatric Rehabilitation*, *9*(2), 89-97.

Charles, J., & Gordon, A. M. (2005). A critical review of constraint-induced movement therapy and forced use in children with hemiplegia. *Neural Plasticity*, *12*(2-3), 245–261.

Chau, T., Eaton, C., Lamont, A., Schwellnus, H., & Tam, C. (2006). Augmented environments for pediatric rehabilitation. *Technology & Disability*, *18*(4), 167-171.

Chevignard, M., Azzi, V., Abada, G., Lemesle, C., Bur, S., Toure, H., et al. (2008). Intérêt de la thérapie par contrainte induite chez l'enfant hémiplégique après lésion cérébrale acquise. (French). *Annales de Readaptation et de Medecine Physique*, *51*(4), 238-247.

Cobb, B., Sample, P. L., Alwell, M., & Johns, N. R. (2006). Cognitive-Behavioral Interventions, Dropout, and Youth With Disabilities: A Systematic Review. *Remedial & Special Education*, *27*(5), 259-275.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed., p. 567). Hillsdale, N.J: L. Erlbaum Associates.

Corn, K., Imms, C., Timewell, G., Carter, C., Collins, L., Dubbeld, S., et al. (2003). Impact of second skin lycra splinting on the quality of upper limb movement in children. *British Journal of Occupational Therapy*, *66*(10), 464-472.

Cronin, A. (2001). Traumatic brain injury in children: Issues in community function. *American Journal of Occupational Therapy*, *55*(4), 377-384.

D'Zurilla, T. J., Nezu, A. M. (1999). *Problem-solving therapy: A social competence approach to clinical intervention* (2nd ed., p. 260). New York, NY: Springer Pub.

European Forum of Psychomotricity Forum Européen de la Psychomotricité. (n.d.). . Retrieved April 27, 2009, from http://www.psychomot.org/bachelor-programme.htm.

Falk, A. (2007). Current incidence and management of children with traumatic head injuries: The Stockholm experience. *Developmental Neurorehabilitation*, *10*(1), 49-55.

Franklin, R. D., Allison, D. B., Gorman, B. S. (1997). *Design and Analysis of Single-Case Research*. (p. 391). Mahwah, N.J: L. Erlbaum Associates.

Gliner, J. A., & Morgan, G. A. (2000). *Research Methods in Applied Settings: An Integrated Approach to Design and Analysis* (p. 465). Mahwah, N.J: Lawrence Erlbaum.

Guerrero, J. L., Thurman, D. J., & Sniezek, J. E. (2000). Emergency department visits associated with traumatic brain injury: United States, 1995-1996. *Brain Injury*, *14*(2), 181-186.

Hessen, E., Anderson, V., & Nestvold, K. (2008). MMPI-2 profiles 23 years after paediatric mild traumatic brain injury. *Brain Injury*, *22*(1), 39-50.

van't Hooft, I., Andersson, K., Bergman, B., Sejersen, T., von Wendt, L., & Bartfai, A. (2005). Beneficial effect from a cognitive training programme on children with acquired brain injuries demonstrated in a controlled study. *Brain Injury*, *19*(7), 511-518.

van't Hooft, I., Andersson, K., T. Sejersen, Bartfai, A., & von Wendt, L. (2003). Attention and memory training in children with acquired brain injuries. *Acta Paediatrica*, *92*(8), 935.

van't Hooft, I., Andersson, K., Bergman, B., Sejersen, T., von Wendt, L., & Bartfai, A. (2007). Sustained favorable effects of cognitive training in children with acquired brain injuries. *NeuroRehabilitation*, *22*(2), 109-116.

Johnston, M., & Case-Smith, J. (2009). Development and testing of interventions in occupational therapy: toward a new generation of research in occupational therapy. *OTJR: Occupation, Participation & Health*, *29*(1), 4-13.

Jones, P., & Drummond, A. (2005). Occupational therapy for children with acquired brain injury: A review of the literature. *British Journal of Occupational Therapy*, *68*(7), 324-330.

Jones, P., Drummond, A., & Vella, K. (2007). Occupational therapy for children with acquired brain injury: A survey of current practice. *British Journal of Occupational Therapy*, *70*(4), 154-160.

Katz-Leurer, M., Rotem, H., Lewitus, H., Keren, O., & Meyer, S. (2008). Relationship between balance abilities and gait characteristics in children with post-traumatic brain injury. *Brain Injury*, *22*(2), 153-159.

Kennelly, J., & Brien-Elliott, K. (2001). The role of music therapy in paediatric rehabilitation. *Pediatric Rehabilitation*, *4*(3), 137-143.

Laatsch, L., Harrington, D., Hotz, G., Marcantuono, J., Mozzoni, M. P., Walsh, V., et al. (2007). An evidence-based review of cognitive and behavioral rehabilitation treatment studies in children with acquired brain injury. *Journal of Head Trauma Rehabilitation*, *22*(4), 248-256.

Langlois J. A., Rutland-Brown, W., Thomas, K. E. (2006) *Traumatic brain injury in the United States: Emergency department visits, hospitalizations, and deaths.* Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Lewis, R. S. (1960). *The other child; the brain-injured child, a book for parents and laymen* (2nd ed., p. 148). New York: Grune & Stratton.

Mallay, J. N. (2002). Art therapy, an effective outreach intervention with traumatized children with suspected acquired brain injury. *The Arts in Psychotherapy*, Reflections on 9/11 and other catastrophes, *29*(3), 159-172.

Mark, V., Taub, E., Bashir, K., Uswatte, G., Delgado, A., Bowman, M., et al. (2008). Constraint-Induced Movement therapy can improve hemiparetic progressive multiple sclerosis. Preliminary findings. *Multiple Sclerosis*, *14*(7), 992-994.

Mayo Clinic Elbow Brace from Aircast - Orthopedics Product Showcase - Medcompare. (n.d.). . Retrieved April 27, 2009, from http://www.medcompare.com/showcase.asp?showcaseid=183.

McKinlay, A., Grace, R. C., Horwood, L. J., Fergusson, D. M., Ridder, E. M., & MacFarlane, M. R. (2008). Prevalence of traumatic brain injury among children, adolescents and young adults: Prospective evidence from a birth cohort. *Brain Injury*, *22*(2), 175-181.

Meyer-Heim, A., Borggraefe, I., Ammann-Reiffer, C., St Berweck, Sennhauser, F. H., Colombo, G., et al. (2007). Feasibility of robotic-assisted locomotor training in children with central gait impairment. *Developmental Medicine & Child Neurology*, *49*(12), 900-906.

Miller, R., & Hale, L. (2005). Constraint-induced movement therapy for a youth with a chronic traumatic brain injury. *New Zealand Journal of Physiotherapy*, *33*(3), 85-90.

Mortenson, P. A., & Harris, S. R. (2006). Playfulness in children with traumatic brain injury: A preliminary study. *Physical & Occupational Therapy in Pediatrics*, *26*(1/2), 181-198.

Mottram, L., & Berger-Gross, P. (2004). An intervention to reduce disruptive behaviours in children with brain injury. *Pediatric Rehabilitation*, *7*(2), 133-143.

Pace, G., Dunn, E., Luiselli, J., Cochran, C., & Skowron, J. (2005). Antecedent interventions in the management of maladaptive behaviours in a child with brain injury. *Brain Injury*, *19*(5), 365-369.

Page, S. J., Levine, P., Leonard, A., Szaflarski, J. P., & Kissela, B. M. (2008). Modified constraint-induced therapy in chronic stroke: Results of a single-blinded randomized controlled trial. *Physical Therapy*, *88*(3), 333-340.

Pierro, M. M., Bollea, L., Di Rosa, G., Gisondi, A., Cassarino, P., Giannarelli, P., et al. (2005). Anoxic brain injury following near-drowning in children. Rehabilitation outcome: Three case reports. *Brain Injury*, *19*(13), 1147-1155.

Prigatano, G. P., & Gupta, S. (2006). Friends after traumatic brain injury in children. *Journal of Head Trauma Rehabilitation*, *21*(6), 505-513.

Rehabilitation of persons with traumatic brain injury. (1998) NIH consensus statement. Volume 8, number 4, October 26-28, 1998, 41 p.

van Rhijn, J., Molenaers, G., & Ceulemans, B. (2005). Botulinum toxin type A in the treatment of children and adolescents with an acquired brain injury. *Brain Injury*, *19*(5), 331-335.

Rigg, J. L., & Zafonte, R. D. (2006). Corticosteroids in TBI is the story closed? *Journal of Head Trauma Rehabilitation*, *21*(3), 285-288.

Roley, S. S. M., DeLany, J. V. D., Barrows, C. J. M., Brownrigg, S., Honaker, D., Sava, D. I. M., et al. (2008). Occupational therapy practice: Framework: Domain & Process 2nd Edition. [Miscellaneous Article]. *Journal of Occupational Therapy November*, *62*(6), 625-683.

Sambuco, M., Brookes, N., & Lah, S. (2008). Paediatric traumatic brain injury: A review of siblings' outcome. *Brain Injury*, *22*(1), 7-17.

Wade, S. L., Carey, J., & Wolfe, C. R. (2006). The efficacy of an online cognitive-behavioral family intervention in improving child behavior and social competence following pediatric brain injury. *Rehabilitation Psychology, 51*(3), 179-189.

Wade, S. L., Michaud, L., & Brown, T. M. (2006). Putting the pieces together: Preliminary efficacy of a family problem-solving intervention for children with traumatic brain injury. *Journal of Head Trauma Rehabilitation, 21*(1), 57-67.

Wade, S. L., Wolfe, C. R., Brown, T. M., & Pestian, J. P. (2005). Can a web-based family problem-solving intervention work for children with traumatic brain injury?. *Rehabilitation Psychology, 50*(4), 337-345.

Wallen, M., Hoare, B. (2004). There is weak evidence that forced-use therapy provided for 1–month without additional therapy improved the fine motor function of children with hemiparesis. *Australian Occupational Therapy Journal, 51*(2), 110-111.

Warschausky, S., Kewman, D., & Kay, J. (1999). Empirically supported psychological and behavioral therapies in pediatric rehabilitation of TBI. *Journal of Head Trauma Rehabilitation, 14*(4), 373-383.

Willis, J. K., Morello, A., Davie, A., Rice, J. C., & Bennett, J. T. (2002). Forced use treatment of childhood hemiparesis. *Pediatrics, 110*(1), 94-96.

Woolley, S. M., Lawrence, J. A., & Hornyak, J. (1999). The effect of hyperbaric oxygen treatment on postural stability and gait of a brain injured patient: Single case study. *Pediatric Rehabilitation, 3*(3).

Yeates, K. O., & Taylor, H. G. (2006). Behavior problems in school and their educational correlates among children with traumatic brain injury. *Exceptionality, 14*(3), 141-154.

Ylvisaker, M., & Feeney, T. (2002). Executive functions, self-regulation, and learned optimism in paediatric rehabilitation: a review and implications for intervention. *Pediatric Rehabilitation, 5*(2), 51-70.

APPENDIX A

Table 1. Design standards and evaluative rubric adapted from Cobb, Sample, Alwell, & Johns (2006).

	Evidence for a rating of			
	Strong	**Moderately Strong**	**Moderately Weak**	**Weak**
Design Standard				
A. How would you rate the implementation and replicability of the intervention or approach?	The intervention or approach was sufficiently described at a level that would allow relatively easy and thorough replication by other implementers, and the description of the implementation of the intervention was fully consistent with its defined characteristics.	The intervention or approach was adequately described to allow replication of the most essential elements by other implementers, and the description of the implementation was largely consistent with its defined characteristics.	The authors of the study omitted important descriptive information concerning the essential elements of the intervention, such that its replication would be impossible, OR it is plausible that the implementation of the intervention may have been inconsistent with its defined characteristics.	The authors of the study omitted important descriptive information concerning the essential elements of the intervention, such that its replication would be impossible, AND it is plausible that the implementation of the intervention may have been inconsistent with its defined characteristics.
B. How would you rate the adequacy with which the outcome measure was defined?	The study provided adequate evidence that the outcome measure was properly defined and appropriate for the context of the study.	Although the study did not present adequate evidence that the outcome measure was properly defined, the measure did appear to be appropriate to the content of the outcome and the context of the study.	The outcome or the measure used to assess the outcome were only described conceptually as a member of a broader class of outcomes/ measures, across which significant variation exists as to their specific content.	It is unclear what the outcome was and how it was measured.
C. How would you rate the adequacy with which participants in the comparison or alternative treatment groups were made comparable to those in the treatment group?	Participants were randomly assigned to conditions, and there does, not appear to have been any serious differential attrition within groups or severe attrition across groups.	Randomized assignment was used. In this single subject design the authors used adequate baseline data to compare the time series data to be able to make inferences about change.	Randomized assignment was not used. In this single subject design at least one baseline study was observed.	Randomized assignment was not used. In this single subject design there were no baseline measurements

D. How would you rate the adequacy with which the study controlled events that happened concurrently with the intervention or approach that might have confounded its effects?	Concurrent processes and events that might offer alternative explanations to a treatment effect have been ruled out, either explicitly or implicitly.	No processes or events that could be alternative explanations for a treatment effect were identified, but some alternative explanations could not be explicitly ruled out, either because there was some evidence that alternative explanations might exist, or because no attention was given to ruling out an alternative explanation and it is reasonable to expect that one or more alternative explanations might exist.	There was no maybe no rating for this standard.	Identifiable processes or events that were described to be occurring simultaneously with the treatment or approach may have caused the observed effect.
E. How would you rate the adequacy with which the actual sample, setting, outcomes, and measurement processes reflected the theoretical population and typical norms for settings, outcomes, and measurement processes?	The actual sample generalized well to the theoretical population, and the setting, outcomes, and measurement processes generalized well to common variations in settings, classes of outcomes, and processes and timing of data collection.	Most aspects of the theoretical population and common variations of settings, classes of outcomes, and data collection processes and timing were represented in the study.	Although some important characteristics of the theoretical population and typical settings, outcomes, and data collection processes and timing were represented by the study, many important characteristics were not.	Generalization to the theoretical population could not be made because the sample population was not representative or the study was a single subject designs.
F. Did the researchers thoroughly interrogate the data and describe the data in a way that coincided with the conclusions in which they arrived?	The analyses in the study interrogated the data completely AND arrived at an appropriate conclusion based on the reported data.	Some interrogation was performed on the data and the researchers reported an appropriate conclusion based on the reported data.	Only descriptive statistics were presented and the conclusions were appropriate to the data.	Only descriptive data were presented or the data did not support the conclusion in which the researchers arrived.

G. How adequately were the data described, analyzed, and depicted such that effect sizes for the outcomes in this extraction could be calculated?	Either the effect sizes were reported by the authors, or they provided sufficient data to allow the precise calculation of effect sizes.	Sufficient statistical information was reported to allow, at a minimum, an imprecise effect size to be calculated for the outcome of this extraction.	There was no *moderately weak* for this standard.	Neither sample sizes nor effect sizes were reported, and insufficient data were provided to allow effect sizes to be calculated.
H. How closely is this intervention aligned to the field of occupational therapy?	This intervention is occupational in nature or can be utilized by an occupational therapist in a way that is specific to OT.	This intervention can be used with another intervention that is occupational in nature or can be used by an occupational therapist.	There was no *moderately weak* for this standard.	This intervention is not based on occupation and cannot be used with any other method or is broadly defined and cannot be defined as occupational therapy.

Table 2. Participant demographics.

Article	Number of Participants	Number of children with TBI	Number of Children with diagnosis other than TBI	Age range
Pace et al. 2005	1 Child	1		10 years
Corn et al. 2003	4 Children	2	2 with CP	8-16 years
M. Chevignard et al. 2008 (French)	3 Children	1	1 with CVA, and 1 with a tumor	5 years
Miller & Hale 2005	1 Youth	1		20 years
Willis et al. 2002	25 Children	2	13 CVA, 6 cerebral malformation, and 4 unknown	1-8 years
Wade, Michaud and Brown 2006	32 Families	32		5-16 years
Total	66	39	27	1-20 years

Table 3. Rating table for reviewed studies

Article	A. Implementation and replicability	B. Definition of outcome measures	C. Comparison of the treatment group to the control	D. Controlled for outside variables	E. Representation of the participants	F. Thorough interrogation of the data	G. Data well described and the effect size reported	H. Alignment to the field of occupational therapy
Restraint Therapy (CIT)								
Chevignard et al. 2008	Strong – Good description of CIT	Moderately Strong – Used several measures with good validity	Moderately Strong – ABA design with two baseline measures	Moderately Strong – Multiple outcome measures with intervention and no change in other therapy	Weak – Limited to three children only one has TBI	Strong – Reported both quantitative and qualitative data and thoroughly interrogated data	Strong – Reported effect size of d=0.58	Moderately Strong – Technique used in OT in conjunction with occupation-based activities
Miller & Hale 2005	Strong – Good thorough description of the protocol used and how it was modified	Strong – Action Research Arm Test, high validity and reliability	Moderately Strong – Single subject test-retest design with two pretests	Moderately Weak – The protocol had opening for confounding variables	Weak – Single subject design with a protocol that would be difficult to reproduce in a clinic	Weak – No interrogation was done on the data, the data are shown in a table	Moderately Weak – The change noted appeared large but the authors did not perform statistical analysis	Moderately Strong – Technique used in OT in conjunction with occupation-based activities

Article	A. Implementation and replicability	B. Definition of outcome measures	C. Comparison of the treatment group to the control	D. Controlled for outside variables	E. Representation of the participants	F. Thorough interrogation of the data	G. Data well described and the effect size reported	H. Alignment to the field of occupational therapy
Constrain-induced Therapy (CIT)								
Willis et al. 2002	Moderately Strong – Some knowledge of CIT is assumed sparse description of the protocol	Moderately Weak – Peabody Developmental Motor Scale outside of the population the test is normative for	Moderately Strong – The groups were randomly assigned but disproportionate and no attempt was made to correct that.	Strong – Pretest-posttest control group design with randomized assignment (Gliner & Morgan, 2000)	Moderately Strong – Sample only contained two children with TBI however the treatment is for a specific associated condition	Strong – Data were analyzed several different ways to assess variability within groups and means between groups were compared	Moderately Strong – No effect size was given	Moderately Strong – Technique used in OT in conjunction with occupation-based activities
Lycra splinting								
Corn et al. 2003	Moderately Strong – Requires knowledge of the intervention	Strong – Melbourne Assessment, good validity and reliability	Moderately Weak – Did not compare data between participants	Moderately Weak – AB Design leaves the study open to confounding variables	Weak – Four children, two had TBI	Strong – Good statistical analysis of the data	Moderately Strong – No effect size reported, good description of the findings	Moderately Strong – Related to hand therapy

Article	A. Implementation and replicability	B. Definition of outcome measures	C. Comparison of the treatment group to the control	D. Controlled for outside variables	E. Representation of the participants	F. Thorough interrogation of the data	G. Data well described and the effect size reported	H. Alignment to the field of occupational therapy
Antecedent behavioral intervention								
Pace et al. 2005	Strong – Requires some knowledge about some of the techniques but is replicable.	Strong – Used quantitative clinical observation of self-injurious behavior	Moderately Strong – Single subject test-retest with a baseline and addition of interventions	Moderately Strong – Two week long baseline phase possibility of confounding variables with multiple interventions	Weak – Single subject with a multitude of interventions	Moderately Weak – Limited interrogation, visual analysis of data on a graph	Moderately Weak – Good description of the data, no effect size	Moderately Strong – Common preparatory methods for OT, modification of the environment is direct service
Family problem-solving								
Wade, Michaud and Brown 2006	Strong – Good description of method refer to D'Zurilla and Nezu	Strong – Five different measures, self-report with satisfaction surveys and behavior description	Moderately Strong – Use of between group analysis to test for discrepancy in groups	Strong – Randomized assignment with 16 families in each group full description of attrition	Moderately Strong – Moderately large sample of families all had children with TBI	Strong – Strong statistical analysis with multiple tests	Strong – Effect sizes reported with large effects	Moderately Strong – Related through psychosocial intervention techniques

Table 4. Synopsis of results

Article	Study design	Outcome measures	Results	Reported effect size	Conclusion
Restraint Therapy					Overall found to be effective
Chevignard et al. 2008	Single factor within subjects design	Nine Hole Peg Test, Box and Blocks Test, and three, one-minute timed tests: displacement of cones and cylinders and the creation of a tower of cubes	Two of the children showed significant difference on the cylinders and Nine Hole peg test; however, did not show significant change overall (Z=-0.256, p=0.798). Child B, showed an improvement in three of the five tests (cones, cylinders and Nine Hole Peg Test), and showed a statistically significant difference in overall change ($z = -2.816$; p = 0.005).	Overall effect size was d=.58 which is considered to be large	The researchers found the CIT intervention to be effective for children with hemiparesis due to brain injuries. The small sample size in this study makes it hard to generalize these findings alone. Taken with the other studies the treatment may be effective for this group.
Miller & Hale 2005	Single subject pretest posttest AB	Action Research Arm Test (ARAT)	The authors presented descriptive statistics. Grasp went from 0-8, Grip from 0-2, Pinch from 0-2, and Gross movement from 0-6 out of a possible score of 57	None reported	With the lack of statistical analysis and the single subject design, generalization cannot be inferred from this study. However, it does add to the growing list of evidence that modified constraint induced therapy can be effective for some individuals.

Article	Study design	Outcome measures	Results	Reported effect size	Conclusion
Willis et al. 2002	Randomized control trial, Pretest posttest control group design with reversal of subjects	Peabody Developmental Motor Scale (PDMS) and parent report of functionality	Treatment Group change from 143.2 to 155.8 (n=12) Control Group change from 102.2 to 104.7 (n=13) ($F=29.17$, $df=1,23$, $p<0.0001$) Parents all reported increase in function	None reported	The study had some limitations in the randomization but overall the findings were positive and the researchers found the forced use therapy treatment to be effective for children with hemiparesis.
Lycra splinting					Mixed results
Corn et al. 2003	Multiple single subject interrupted time series experimental AB	Melbourne Assessment	Child 1 Acquired brain injury (ABI) new user: No improvement long-term slope ($t_{16}=-2.01$), improvement on the short-term effect ($t_{16}=-2.50$). Child 2 ABI new user: No significant change in slope ($t_{18}=-1.05$) or effect (($t_{18}=0.60$). Child 3 CP long-term user: No significant change in slope ($t_{16}=0.46$) or effect (($t_{16}=2.09$). Child 4 CP long-term user: No significant change in the slope ($t_{13}=0.11$) and showed decrease in the quality in overall effect ($t_{13}=3.35$) with the splint.	None reported	This was a small study with a limited number of subjects. The study produced mixed results indicating that some caution needs to be taken with this intervention for spasticity associated with brain injury.

Article	Study design	Outcome measures	Results	Reported effect size	Conclusion
Antecedent behavioral intervention					Possibly effective
Pace et al. 2005	Single subject multiple baseline across settings time series with a baseline then an ABCD intervention with each step containing elements from the previous step	Clinical observation of self-injurious behavior and aggression	Mean incidence of self-injurious behavior overall went from a baseline of 2.29(6.05) to 2.22(4.68) in phase A; 0.93(2.58) in phase B; 0.48(0.75) in phase C; 0.14(0.44) in phase D. The researchers did not report aggression in the baseline and phase A. Mean incidence of aggression started at 9.94(9.40) in phase B; 6.03(6.22) in phase C; and 3.00(3.57) in phase D.	None reported	The researchers did not do any statistical analysis of the data to establish significance of the change in behaviors during this study. The reduction in the level of self-injurious behavior may be attributed to the increased attention being given to the child. The intervention needs further study but overall appears to have promise to reduce maladaptive behavior.

Article	Study design	Outcome measures	Results	Reported effect size	Conclusion
Family problem-solving					Shown to be effective
Wade, Michaud and Brown 2006	Randomized control trial, pretest posttest control group	Child Behavior Checklist (CBCL), Brief Symptom Inventory (BSI), Conflict Behavior Questionnaire (CBQ), and a two-part satisfaction survey	5.81-point decline on the CBCL in the children's internalization symptoms and a 3.86-point decline in the children's anxiety and depression; Control group reported an average 2.07-point increase in internalization symptoms. The therapist rated families' success at implementation at moderate to good (M=3.75; SD=0.88). Most of the family members indicated an increased knowledge of the effects of TBI (83-90 percent). Overall, the families and children were satisfied with the treatment and would recommend it.	0.17 for internalization and 0.21 for anxiety and depression based on a partial η^2 analysis	Within the field of occupational therapy, this intervention has potential for helping families with children who have sustained TBI. The effect size is large and the satisfaction was high. The intervention is client centered and can be used in a broad fashion that would be applicable on several levels.