Effectiveness of Interventions to Address Visual and Visual–Perceptual Impairments to Improve Occupational Performance in Adults With Traumatic Brain Injury: A Systematic Review

Sue Berger, Jennifer Kaldenberg, Romeissa Selmane, Stephanie Carlo

OBJECTIVE. Visual and visual–perceptual impairments occur frequently with traumatic brain injury (TBI) and influence occupational performance. This systematic review examined the effectiveness of interventions within the scope of occupational therapy to improve occupational performance for adults with visual and visual–perceptual impairments as a result of TBI.

METHOD. Medline, PsycINFO, CINAHL, OTseeker, and the Cochrane Database of Systematic Reviews were searched, and 66 full text articles were reviewed. Sixteen articles were included in the review.

RESULTS. Strong evidence supports the use of scanning, limited evidence supports the use of adaptive strategies, and mixed evidence supports the use of cognitive interventions to improve occupational performance for adults with TBI. Evidence related to vision therapy varies on the basis of the specific intervention implemented.

CONCLUSION. Although the strength of the research varied, implications are discussed for practice, education, and research.


Visual and visual–perceptual impairments associated with traumatic brain injury (TBI) are prevalent, with estimates as high as 90% (Jacobson & Marcus, 2011). Physical trauma can damage the visual system, leading to deficits in visual field, visual acuity, oculomotor skills, and visual processing abilities (Cockerham et al., 2009). These deficits can affect a person’s participation in meaningful activities (Greenwald, Kapoor, & Singh, 2012; Warren, 2013).

The objective of this systematic review was threefold: (1) to update information included in the Occupational Therapy Practice Guidelines for Adults With Traumatic Brain Injury (Golisz, 2009) related to interventions that address visual and visual–perceptual functions, (2) to synthesize the literature on interventions within the scope of occupational therapy practice that are effective in improving occupational performance for adults with visual and visual–perceptual impairments as a result of TBI, and (3) to guide the direction of future research that focuses on interventions to address visual and visual–perceptual challenges in people with TBI. The current review answers the question “What is the evidence that interventions to address visual and visual–perceptual impairments and skills improve occupational performance for people with TBI?”

Background

Vision includes three basic functions: visual acuity, visual field, and oculomotor control (Warren, 2013). In this systematic review, visual perception is considered...
an aspect of cognition and is defined as an active processing of visual input that interacts with higher level processing to enable one to interpret the environment (Bowen, Knapp, Gillespie, Nicolson, & Vail, 2011).

Visual and visual–perceptual deficits can significantly influence participation in meaningful activities (Greenwald et al., 2012; Warren, 2013). People with visual impairments may be at increased risk for falls, may be limited in mobility, may have significant reading deficits, and may display a higher prevalence of depression (McCarty, Fu, & Taylor, 2002; West et al., 2002; Zhang et al., 2013). People with TBI frequently experience visual complications as a result of their injury, including visual field deficits (46%), convergence insufficiencies (40%–48%), accommodative insufficiencies (31%–47%), oculomotor deficits (10%–30%), and diplopia (6%–9%; Cockerham et al., 2009; Suchoff et al., 2008). Thirty-one percent of people with severe TBI were found to have visual–perceptual impairments 1 yr postinjury (Kersel, Marsh, Havill, & Sleigh, 2001). A growing body of evidence surrounds veterans with visual and visual–perceptual impairments after service-related TBI. Of veterans of Operation Iraqi Freedom and Operation Enduring Freedom, 10%–20% were diagnosed with a TBI, and 50%–75% of those reported visual complaints (Bulson, Jun, & Hayes, 2012; Cockerham et al., 2009). This systematic review summarizes interventions that address these vision skills.

Method
This systematic review is one of six reviews of the TBI literature relevant to occupational therapy conducted under the auspices of the American Occupational Therapy Association (AOTA) Evidence-Based Practice (EBP) Project. The six review questions were based on the earlier set of reviews that covered the literature from 1986 to 2008 and were updated to reflect present clinical practice. An advisory board consisting of experts in the field and the review authors provided feedback on the development of the questions. This review was carried out through an academic partnership that consisted of two occupational therapy faculty and two occupational therapy graduate students. The methods for the reviews were specified in advance and documented in a protocol for the authors.

Search Strategy
The inclusion criteria for this review were as follows: Studies were published in peer-reviewed scientific literature between 2001 and 2013, at least 1 participant in each study sample was an adult with TBI, articles were written in English, and interventions were within the scope of practice of occupational therapy. The original criteria specified that at least 50% of participants in each study have TBI, but we identified only 6 such studies that addressed the review question. Many studies related to vision and brain injury exclude people with TBI because of the multiple challenges accompanying TBI, including impaired cognition. The pathology of visual or visual–perceptual impairment, however, can be similar in people with TBI and those with stroke (Ciuffreda et al., 2007). Therefore, we expanded the search to include relevant studies that focused on people with stroke but also included at least 1 participant with TBI.

Additionally, the previous review of the literature related to occupational therapy interventions and TBI (Golisz, 2009) did not address the complex visual issues associated with TBI but rather addressed vision as a component of cognition and focused on visual attention and visual cognitive skills. Therefore, we expanded the search dates to 2001 or later to include studies specifically related to vision and visual perception that were not included in the most recent Occupational Therapy Practice Guidelines for Adults With Traumatic Brain Injury (Golisz, 2009).

The authors discussed several topics, including apraxia, spatial neglect, facial recognition, and emotion processing, to determine whether they should be considered within the domain of the vision and visual perception review question. After discussion with content experts and AOTA liaisons, we determined that apraxia and spatial neglect would be included in the review addressing cognition, and facial recognition and emotion processing, types of perceptual disorders, would be included in this review.

Using the evidence hierarchy described by Sackett, Rosenberg, Muir Gray, Haynes, and Richardson (1996), descriptive outcome studies such as single-subject and case series designs (Level IV evidence) and case reports, narrative literature reviews, and consensus statements (Level V evidence) were included only when Level I (systematic reviews, meta-analyses, randomized controlled trials [RCTs]), Level II (two-group nonrandomized studies), or Level III (one-group nonrandomized studies) evidence was not found. The reviews excluded qualitative studies and reports from presentations, conference proceedings, non–peer-reviewed research literature, dissertations, and theses.

The EBP methodology consultant to the AOTA EBP Project and AOTA staff identified search terms in consultation with the review authors and the advisory group. The final terms were selected on the basis of the specific thesaurus included in each database. A medical research librarian with experience in completing systematic review
searches further refined the search strategies and conducted all searches. The databases and sites that were searched included Medline, PsycINFO, CINAHL, O’Seeker, and the Cochrane Database of Systematic Reviews. The review teams examined reference lists from articles that were identified for inclusion for additional potential articles, and selected journals were hand searched to ensure that all appropriate articles were included. See Supplemental Appendix 1 (available online at http://otjournal.net; navigate to this article, and click on “Supplemental”) for one of the electronic search strategies for this question.

Study Selection, Data Extraction, and Risk of Bias Assessment

The EBP Project methodology consultant first eliminated references for each question on the basis of citations and abstracts. As the review team, we also reviewed these citations and abstracts and eliminated additional references. We then retrieved the full-text versions of the articles for the remaining references and reviewed them for relevance to the question, study quality, and levels of evidence. Each included article was abstracted using an evidence table that included the level of evidence, a summary of the study methods, and findings relevant to the review question. AOTA staff and the EBP Project consultant reviewed the evidence tables to ensure quality control before we undertook a more in-depth review and summarization.

We assessed the risk of bias of individual studies using the methods described by Higgins, Altman, and Sterne (2011) and of systematic reviews using the measurement tool developed by Shea et al. (2007). Two team members reviewed each article separately to complete the evidence table and determine risk of bias. Whenever there was a difference in opinion, the reviewers discussed their reasoning, and when needed, a third person reviewed the article as well. Risk of bias was considered in determining the strength of evidence for each study.

Data Synthesis Methods

Given the heterogeneity of the included studies, we used a qualitative approach to data synthesis. We examined the studies selected for review for similarities across participants, settings, interventions, and outcomes and grouped related studies into themes.

Designations of the strength of the evidence for each theme were adapted from the system proposed by the Agency for Healthcare Research and Quality, U.S. Preventive Services Task Force (2012). The designation of strong evidence indicates consistent results from well-conducted studies, usually at least 2 RCTs. A designation of moderate evidence was made on the basis of 1 RCT or 2 or more studies with lower levels of evidence. The designation of limited evidence was based on few studies with low levels of evidence. A designation of mixed evidence indicates that the findings were inconsistent across studies in a given category. Finally, a designation of insufficient evidence was used when the number and quality of studies were too limited to make any clear classification.

Results

A total of 584 potential abstracts were screened during the original search, of which 66 were selected for full article review (Figure 1). Sixteen articles met the criteria and were included in the review. Sample sizes ranged from 3 to 40, of which the number of participants with TBI ranged from 1 to 39. Supplemental Table 1 (available online) summarizes the study characteristics, participant characteristics, interventions, and results described in the included articles.

Most of the studies had low attrition and reporting bias, but because the majority (9 of 14) were not RCTs, they had relatively high selection bias (Supplemental Table 2, available online). The 2 included systematic reviews had relatively low risk of bias (Supplemental Table 3, also available online).

Visual Scanning

Visual scanning refers to the eye movements used to locate and identify an object. Strong evidence from 2 Level I systematic reviews and 1 Level I RCT indicates that scanning is an effective intervention to improve search skills when measured with computer search tests (Bouwmeester, Heutink, & Lucas, 2007; Cicerone et al., 2011) and a functional search task (Roth et al., 2009). Insufficient evidence, based on 1 Level I RCT and 1 Level II study, supports scanning as a stand-alone intervention to improve reading (Lane, Smith, Ellison, & Schenk, 2010, Level II; Roth et al., 2009, Level I). The multifactorial nature of reading may require additional skill training (e.g., training with small saccades and directionality in addition to scanning training). All the studies focused on scanning training through structured computer programs.

Adaptive Strategies

Prisms and scrolling text are adaptive strategies. The prescription of prisms can be used with people with hemianopsia to enhance their awareness of the impaired visual field by shifting an image from the nonseeing area into the seeing area. Scrolling text is a computer-based strategy in which the person maintains focus centrally while the text moves right to left. Limited evidence from 1 Level III study
supports the use of Fresnel 40-diopter prisms to improve visual field awareness and functional mobility (Giorgi, Woods, & Peli, 2009). Self-reported improvements were noted in perceived quality of life, visual field awareness, walking, negotiation in crowds, and obstacle avoidance. Limited evidence from 1 Level II study supports the use of scrolling text to improve reading performance for people with reading difficulties resulting from hemianopsia (Spitzyna et al., 2007). Spitzyna and colleagues found that scrolling text right to left improved reading saccades and reading speed after 4 wk of daily sessions.

**Vision Therapy**

*Vision therapy* typically refers to a structured form of visual exercise determined in collaboration with an eye care specialist.

**Vision Therapy for Oculomotor Dysfunction.** Limited evidence from 1 Level II study and 1 Level III study supports the use of vision therapy to remEDIATE oculomotor signs and symptoms in people with TBI (Alvarez et al., 2010, Level II; Ciuffreda et al., 2008, Level III). Evidence to support the use of vision therapy as a means to facilitate change in cortical activity, as measured by functional MRI, in relation to visual function is insufficient (Alvarez et al., 2010, Level II).

**Vision Therapy for Visual Field Deficits.** *Visual restorative therapies* (VRTs), a subset of vision therapy, are remedial interventions that attempt to stimulate the impaired visual field by introducing lights, letters, or objects randomly outside the intact field of view. Evidence to support the use of VRTs to improve visual search skills is insufficient (Roth et al., 2009, Level I). The evidence is also insufficient to support using VRTs to improve visual field deficits (Bouwmeester et al., 2007, Level I systematic review; Cicerone et al., 2011, Level I systematic review; Roth et al., 2009, Level I RCT). A Level I systematic review reported that available studies had too many critical limitations to make any definitive recommendations (Bouwmeester et al., 2007), whereas another found some subjective evidence of improvement with VRTs for reading and visual function (Cicerone et al., 2011).

**Audiovisual Stimulation for Visual Field Deficits or Oculomotor Symptoms.** *Audiovisual stimulation* (AVT) consists of scanning training in which a visual stimulus, typically illumination of light-emitting diodes, is presented accompanied by a white noise auditory stimulus. Moderate evidence from 1 Level I RCT and 2 Level II studies supports AVT as being more effective in improving visual exploration and reading performance in people with visual field deficits or oculomotor symptoms.
than VRT without auditory stimulus (Ciuffreda, Han, Kapoor, & Ficarra, 2006, Level II; Keller & Lefin-Rank, 2010, Level I; Passamonti, Bertini, & Ladavas, 2009, Level II). Limited evidence from 1 Level II study indicates that the improvements with AVT were long lasting, with results maintained 1 yr after the end of training (Passamonti et al., 2009). Limited evidence from 1 Level I RCT supports the use of AVT to improve performance of activities of daily living (Keller & Lefin-Rank, 2010).

**Cognitive Interventions**

Cognitive retraining strategies include graduated practice of increasingly complex tasks, a focus on increasing attention to contextual cues, errorless learning, self-talk, pacing, social skills training, and home practice. Strong evidence from 2 Level I RCTs and 2 Level II studies indicates that participation in cognitive rehabilitation can improve participants’ performance in neuropsychological measures focused on visual perception (Bornhofen & McDonald, 2008, Level I; Laatsch & Krisky, 2006, Level II; Powell, Letson, Davidoff, Valentine, & Greenwood, 2008, Level II; Radice-Neumann, Zupan, Tomita, & Willer, 2009, Level I). Insufficient evidence based on 1 Level I RCT supports the use of cognitive strategies focusing on social skills training to improve the ability to name basic emotions, interpret comments, and determine whether a person is lying or being sarcastic (McDonald et al., 2008).

**Discussion**

Overall, the literature addressing interventions within the scope of occupational therapy practice for people with visual and visual–perceptual deficits from a TBI is limited. The studies reviewed provide strong evidence to support the use of scanning as a compensatory strategy to improve computer visual search skills in people with visual field deficits but limited evidence of functional improvements after intervention (Bouwmeester et al., 2007; Cicerone et al., 2011; Lane et al., 2010; Roth et al., 2009). Moderate evidence supports audiovisual stimulation for people with visual field deficits or oculomotor symptoms (Alvarez et al., 2010; Ciuffreda et al., 2006, 2008; Keller & Lefin-Rank, 2010; Passamonti et al., 2009). Research supporting the use of prisms and scrolling text for people with impaired visual field is limited (Giorgi et al., 2009; Spitzyna et al., 2007). Finally, strong evidence supports the use of a cognitive retraining approach for people with visual–perceptual deficits in improving test scores, but there is insufficient evidence that these test improvements generalize to function (Bornhofen & Mcdonald, 2008; Laatsch & Krisky, 2006; Powell et al., 2008; Radice-Neumann et al., 2009).

Limitations present in many of the studies in this systematic review include small samples, lack of control for unilateral inattention, outcomes that were not functional, interventions that might be considered outside of the scope of occupational therapy practice, and lack of control for other therapies participants received during the study. Variability in participant characteristics across studies (e.g., severity of injury, length of time since injury) may limit the generalizability of the interventions. It is worth noting that it can be difficult to recruit large numbers of people with TBI with visual or visual–perceptual impairment, and therefore many studies did not include a control group but instead used a within-subjects design. Given the potential for selection, performance, and detection bias in several studies, we considered these challenges in the results of this systematic review.

**Implications for Occupational Therapy Research**

Occupational therapy practitioners often use interventions to address the myriad of visual deficits associated with TBI that have been found to be effective with other populations, such as people with stroke or low vision diagnoses, but that have not been studied in people with TBI (e.g., optical devices, compensatory strategies; Kaldeberg & Smallfield, 2013; Niemeier, Cifu, & Kishore, 2001). People with TBI present with multiple challenges beyond impaired vision, including cognitive and motor limitations. These additional limitations might influence the effectiveness of interventions typically used with other populations.

More research is needed regarding interventions that include occupational performance outcomes for people with vision and visual–perceptual impairments from TBI. More studies are needed that use rigorous research designs, include larger sample sizes, explore dosage of intervention, and determine characteristics of clients most likely to benefit from specific interventions.

**Implications for Occupational Therapy Education**

Academic curricula should provide coursework addressing the unique needs of adults with visual impairments as a result of TBI, providing opportunities to practice the interventions that have been found effective for this population, and discussing the limitations in the available evidence. In addition, providing continuing education to occupational therapy practitioners working with adults who have visual deficits as a result of TBI can promote evidence-based practice and advance current practice.
Implications for Occupational Therapy Practice

Occupational therapy practitioners working with adults with TBI must understand the implications of visual and visual–perceptual deficits for occupational performance and choose interventions based on their reasoning and available evidence. Preliminary support is available for the following interventions to address vision and visual perception in people with TBI:

- Scanning training for people with impaired visual field
- Audiovisual stimulation for people with impaired visual field or oculomotor symptoms
- Adaptive strategies such as prisms and scrolling text for people with impaired visual field
- Application of a cognitive retraining approach for people with visual–perceptual impairments.

Occupational therapy practitioners should always use these techniques in conjunction with occupations to support carryover of improved vision and visual perception to daily activities. In addition, practitioners should review the evidence related to stroke and low vision and use clinical reasoning to determine whether any of the strategies used for other populations might be appropriate for clients with TBI. ▲

Acknowledgments

We thank Deborah Lieberman and Marian Arbesman for their support and guidance in the methodology of this review and Janet Powell for her helpful feedback on initial drafts of this article.

References


*Indicates studies that were systematically reviewed for this article.


