Vision Rehabilitation for Traumatic Brain Injury and Post-Traumatic Stress Disorder

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ABSTRACT

Background
The purpose of this single subject design was to determine if vision rehabilitation for traumatic brain injury (TBI) related visual dysfunction improves posttraumatic stress disorder (PTSD) symptoms.

Methods
Three veterans with comorbid PTSD and TBI were selected for a retrospective single-subject A-B study design (i.e., baseline-intervention). A chart review consisted of PTSD checklist (PCL) scores, College of Optometrists in Vision Development – Quality of Life (COVD-QOL) survey scores, and Developmental Eye Movement (DEM) test times. Each outcome measure was analyzed pre- and post-vision rehabilitation. A reliable change index for PCL scores was calculated for each subject.

Results
All veterans undergoing vision rehabilitation for TBI-related visual dysfunctions showed an improvement in COVD-QOL survey scores and DEM test times. The reliable change index for the PCL score of each veteran was significantly lower from the pre- to post-treatment conditions, indicating decreased symptoms of PTSD.

Conclusions
The findings of this single subject design suggest a relationship between vision rehabilitation and PTSD, with decreased symptoms reported on the PCL after treatment. The added benefit of including an eye-movement component in therapy for PTSD, which is utilized in evidence-based treatments such as Eye Movement Desensitization and Reprocessing (EMDR), has long been debated in the literature. Given the encouraging results of this study, further research is needed to investigate the efficacy of eye movements and vision rehabilitation as a component of more comprehensive treatment for PTSD.

Military conflicts have long produced physical and psychological traumatic injuries. The signature injuries of the recent conflicts, Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), include traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD). The prevalence of these often co-morbid diagnoses has increased due to the number of service members surviving traumatic events secondary to advances in
body armor and medical triage. It is estimated that over 330,000 new cases of traumatic brain injury have occurred in service members from the years 2000-2015 and the prevalence of PTSD in OIF/OEF veterans is between 10% and 18%. It is also estimated between 17% and 40% of veterans with TBI will have a dual diagnosis of PTSD.

PTSD and TBI are complex conditions resulting in overlapping signs and symptoms that can greatly impact a veteran’s quality of life. PTSD causes symptoms which are grouped into three categories: re-experiencing symptoms, avoidance symptoms, and hyperarousal symptoms. The current clinical practice guidelines for PTSD treatment recommend cognitive processing therapy (CPT), prolonged exposure therapy (PE), or eye movement desensitization and reprocessing therapy (EMDR).

Visual complaints with associated visual dysfunction is a very common sensory processing deficit that occurs after TBI. It has been reported in up to 75% of patients post-TBI and can disrupt every aspect of the visual system including: accommodation, binocular vision, and eye movement disorders.

Convergence insufficiency, accommodative dysfunction, and deficiency in saccades and pursuits have been noted in 42%, 39% and 30% of TBI patients, respectively.

Vision symptoms and dysfunctions have been studied in relation to comorbid PTSD and TBI. High rates of visual deficits were found in veterans with a history of TBI regardless of whether PTSD was present. While no significant difference in the rate of visual deficits was found in TBI veterans with and without PTSD, veterans with PTSD were found to have more self-reported visual problems than those veterans without PTSD. The complaint rate of reading symptoms and light sensitivity symptoms were particularly higher in the PTSD group.

One area that has not been investigated is the impact of vision rehabilitation for TBI-related visual dysfunction and its impact on PTSD symptoms. Many visual dysfunctions resulting from TBI can be addressed with a program of vision rehabilitation. Vision rehabilitation provides the brain guidance and experience to remediate visual deficits. Utilizing the principles of neuroplasticity, vision rehabilitation is conducted utilizing a specific sequence of repeated activities guided with increasing intensity specific to the veteran’s
The effects of vision rehabilitation on TBI-related visual dysfunction have proven to be effective in laboratory and clinical settings. Several veterans undergoing vision rehabilitation for TBI-related visual dysfunctions have independently reported a subjective improvement in their PTSD symptoms throughout the course of vision rehabilitation. These anecdotal reports warrant further investigation into the relationship between vision rehabilitation for TBI-related visual dysfunction and PTSD. The increasing prevalence of comorbid TBI and PTSD in the veteran population merits study of any treatment modality that can simultaneously address and improve both conditions.

METHODS

This research study was reviewed and approved by the facility's affiliate Institutional Review Board (IRB), as well as the local Research and Development Committee (RDC). A thorough review of the research protocol and design was conducted by the IRB and RDC with full consideration for protections of human subjects. Waiver of informed consent was granted from the IRB due to the retrospective nature of the study.

The Medical Center where this study was conducted has a Polytrauma Support Clinic Team. This outpatient clinic provides comprehensive traumatic brain injury evaluations for veterans of post 09/11/2001 combat missions. Veterans are referred to the Polytrauma team by their primary medical or mental health provider if they screen positive for a TBI during their combat deployment. The TBI evaluation is completed by a Physiatrist who conducts a targeted history, physical exam, and reviews a veteran self-report measure of neurobehavioral symptoms. Referrals to subspecialty areas are completed depending on the veteran's individual complaints. The typical veteran seen by the Polytrauma clinic has a history of concussion, or mild traumatic brain injury that occurred months or years prior, often due to blast exposure or blunt trauma.

Participants

Three veterans with diagnoses of PTSD and TBI were selected for this retrospective study. Table 1 provides a general description of the participants. All veterans met criteria for PTSD according to the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition, Text Revision (DSM-IV-TR). Diagnosis of PTSD was made by one or more mental health professionals (e.g., licensed psychologist, licensed clinical social worker, and/or psychiatrist). All veterans in this study met criteria of mTBI as defined by the American Congress of Rehabilitation Medicine (ACRM). Diagnosis of mTBI consists of trauma that produces changes in at least one or more areas including: 1) loss of consciousness (LOC) for less than 30 minutes; 2) any loss of memory of events that occurred within 24 hours before or after (i.e., posttraumatic amnesia (PTA)) the incident; 3) alteration of consciousness/mental state immediately following the incident (e.g., feeling confused, dazed, or disoriented); and/or 4) presence of focal neurological deficits. Participants were excluded if they met criteria for other major mental illness (e.g., major depressive disorder, bipolar disorder).

Intervention Design

Individuals participated in an A-B (baseline-intervention) single-subject design.

Table 1. Description of Participants.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Race</th>
<th>Injury</th>
<th>Year of Injury</th>
<th>Year of Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>44</td>
<td>White</td>
<td>Blunt trauma</td>
<td>2003</td>
<td>2012</td>
</tr>
<tr>
<td>C</td>
<td>23</td>
<td>Hispanic</td>
<td>Blunt trauma/Blast wave</td>
<td>2012</td>
<td>2015</td>
</tr>
</tbody>
</table>
Single-subject designs have been widely used in rehabilitation research as a means for demonstrating evidenced-based practice.\textsuperscript{14} Single-subject designs have also been used to demonstrate clinical treatment effectiveness for various conditions including akinesia in Parkinson’s disease,\textsuperscript{15} speech-language conditions,\textsuperscript{16} and PTSD.\textsuperscript{17} Further, researchers in the area of vision science have demonstrated use of single-subject designs in areas of optometry/ophthalmology.\textsuperscript{18,19} For this A-B research design, baseline phases consisted of scores from PTSD Checklists administered during mental health appointments prior to implementation of vision rehabilitation.\textsuperscript{20} The in-office vision rehabilitation program was prescribed weekly or bi-weekly for 12 weeks, however due to scheduling conflicts, travel distance, and extenuating circumstances, each veteran only completed 8 therapy sessions. Home exercises were assigned daily between in-office sessions. The treatment protocol was designed and directed by the Optometrist and conducted by the Occupational Therapist. The Optometrist reviewed progress after each in-office session and case discussion between the Optometrist and Occupational Therapist occurred frequently. Each therapy program was individually planned to address the veteran’s specific visual dysfunction while utilizing the common hierarchy in visual rehabilitation. Veterans initially worked on visual and binocular stability with monocular oculomotor control and progressed into higher levels of binocular functioning including fusional skills, visual motor integration, and visual processing activities.

**Measures and Data Collection**

The PTSD Checklist (PCL) is a self-report screening measure consisting of 17 items that correspond with the DSM-IV-TR symptoms of PTSD.\textsuperscript{12,20} Each of the 17 items on the checklist have a 5-point Likert scale ranging from 1 to 5, with higher scores suggesting more severe symptoms. The total symptom severity score ranges from 17-85 with a cut-off score of 50 considered positive for military populations. It is recommended that a 5-point minimum threshold is used for determining whether a patient has responded favorably to treatment and a 10-point minimum threshold is used to determine if the improvement was clinically meaningful.\textsuperscript{21} An updated version of the PCL has been developed for the Diagnostic and Statistical Manual of Mental Disorders- 5th Edition (DSM-5).\textsuperscript{22} The newest version of the PCL, the PCL-5, consists of 20 items with a 5-point Likert scale ranging from 0 to 4. Given the changes in number of items and Likert score rankings for the PCL-5, a score of 38 or higher is considered significant for symptoms of PTSD.\textsuperscript{23}

The College of Optometrists in Vision Development Quality of Life (COVD-QOL) symptom survey is a 30 question self-response survey that probes the impact of impaired visual skills and visual perception difficulties. Studies have established the reliability and accuracy of the survey in accurately portraying visual symptoms and improvement in symptoms post vision rehabilitation.\textsuperscript{24} Symptoms are graded on a scale of never (zero) to always (4) with a cut off score of 20 considered positive.

The Developmental Eye Movement Test (DEM) is a widely used visual skill test administered in the context of vision rehabilitation and is commonly used in the VA Health Care System. It is a functional visual-verbal timed standardized test of saccadic eye movement and assesses oculomotor function on the basis of speed with which a series of numbers can be seen, recognized, and verbalized accurately. The normative data for the DEM only goes up to age 14, so results for adults are extrapolated.\textsuperscript{25} The DEM has good reliability indices when administered in an office setting and correlates well with visual symptoms.\textsuperscript{26} The test is scored based on time accounting for errors and omissions. Assessment of the vertical time score
determines the automaticity of number calling ability and represents a baseline performance of oculomotor control. The horizontal time determines the number calling ability in a spatial array that requires a more sophisticated level of oculomotor control like that needed during reading.\textsuperscript{27}

**Interobserver Agreement**

Since this study used scores from self-report measures of the individuals participating in the study, reliability checks were conducted by two of the authors for select sessions during baseline and treatment phases. The rate of interobserver agreement was calculated by the number of agreements between raters regarding PCL scores divided by the number of observations. Agreement between raters was 100\%, indicating excellent interrater reliability.

**Methods of Analysis**

For the baseline and treatment conditions, visual inspections as well as statistical analyses were conducted between treatment phases. As recommended in previous research with single-subject designs, a reliable change index (RCI) was calculated for each subject.\textsuperscript{14,28} In single-subject designs, the RCI can be used as a method of determining if a treatment and/or therapy has produced a significant change in performance.\textsuperscript{28} A change is considered significant if the patient moves from impaired/symptomatic to functional/asymptomatic during the course of therapy.\textsuperscript{29} In this study, the decrease in PCL scores indicates movement from symptomatic to asymptomatic.

**RESULTS**

**Vision Rehabilitation Outcome Measures**

Vision rehabilitation scores for the COVD-QOL survey and DEM are presented in Table 2. All three patients reported improvements on both scores from pre- to post-test. Subjects A, B, and C showed a 22\%, 76\%, and 72\% reduction in visual symptoms, respectively. In addition, subjects A, B, and C improved 41\%, 22\%, and 45\% on the vertical DEM time and 35\%, 27\%, and 51\% on the horizontal DEM time, respectively.

**Post-Traumatic Stress Disorder Outcome Measures**

The RCI was significantly lower for each patient from the pre- to posttreatment conditions. For Case A, the patient reported an 8-point decrease in his PCL score (RCI = 2.06, P < .05). The veteran’s posttreatment score on the PCL was below the cutoff score for significant symptomatology on the PCL (i.e., below a cutoff score of 50). Case B reported similar results, and his PCL score decreased by 12-points (RCI = 3.1, P < .05). His score was only slightly above the cutoff score for PTSD symptomatology on the PCL. Finally, Case C demonstrated the greatest improvement with a 28-point reduction in symptoms as reported on the PCL-5, (RCI = 7.24, P < .05). The veteran was well below the cutoff score on the PCL-5 (i.e., below a score of 38) for significant symptoms of PTSD.

Figure 1 shows reported PCL scores for the three cases throughout the course of treatment. Two of three veterans’ PCL

<table>
<thead>
<tr>
<th>Subject</th>
<th>COVD-QOL Score</th>
<th>DEM Vertical</th>
<th>DEM Horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Deficiency of Saccades/Visual Perceptual Deficits</td>
<td>Pre Therapy 45</td>
<td>52.42 seconds</td>
</tr>
<tr>
<td></td>
<td>Post Therapy 35</td>
<td>30.10 seconds</td>
<td>36.13 seconds</td>
</tr>
<tr>
<td>B</td>
<td>Convergence Insufficiency</td>
<td>Pre Therapy 51</td>
<td>42.43 seconds</td>
</tr>
<tr>
<td></td>
<td>Post Therapy 12</td>
<td>33.11 seconds</td>
<td>35.20 seconds</td>
</tr>
<tr>
<td>C</td>
<td>Deficiency of Saccades/Binocular Vision Disorder</td>
<td>Pre Therapy 68</td>
<td>49.92 seconds</td>
</tr>
<tr>
<td></td>
<td>Post Therapy 19</td>
<td>27.51 seconds</td>
<td>29.63 seconds</td>
</tr>
</tbody>
</table>
scores were below cutoff scores for PTSD symptomatology at posttreatment. All of the three veterans demonstrated significant improvements on PCL scores when compared to pretreatment scores.

DISCUSSION

Our study documented improvement in PCL scores for veterans undergoing vision rehabilitation for TBI related visual dysfunctions. In addition, vision rehabilitation outcome measures, including the COVD-QOL survey and DEM scores improved after vision rehabilitation. As a retrospective study with a small sample size, we are unable to draw conclusions about the causative nature of this correlation.

Vision rehabilitation involves the use of structured and appropriately sequenced sensorimotor activities administered repetitively with feedback monitors that modify visual behavior. Through the dual interactions of top-down controls and bottom-up processes, the entire visual system continually monitors sensory input and accuracy of oculomotor responses in relation to prescribed visual tasks. These repetitive processes remEDIATE visual deficiencies through the concepts of neuroplasticity. The major types of functional neuroplastic changes that occur in adults supports the concept that an anatomical area in the brain has the ability to perform different functions and redundant neural systems are able to operate under abnormal conditions. It is thought these mechanisms may be the basis for many neurological recoveries including psychiatric disorders.

The importance of pursuit eye movements in eye movement desensitization and reprocessing therapy (EMDR) for PTSD has been debated in the literature. EMDR is an evidence-based treatment for PTSD. It was proposed in 1987 from the observation that eye movements can calm negative emotions. During EMDR, patients perform slowed pursuit eye movements under the guidance of their therapist’s hand while focusing on traumatic events. It is hypothesized that the focus of attention on the traumatic memory and repeated movement increases communication between brain hemispheres, consequently decreasing the emotionality of the negative memory, increasing cognitive flexibility, and allowing memory of the event without arousal.

Although meta-analytic studies have been published demonstrating the effectiveness of EMDR in treatment for PTSD, there has been significant debate over whether the eye-movement component of EMDR provides any additional benefit to the processing of trauma. In fact, there have been some studies to suggest that eye-movements do not provide additional benefit for treatment of PTSD. However, it is quite likely that insufficient sample sizes could account for findings in previous research, resulting in limited power for analysis. When conducting comparative research for different components of the same treatment, larger sample sizes are needed due to subtle differences in treatment components.

Others have discounted the use of eye movements with EMDR by pointing out that the mechanism of action has not been adequately explained in the literature. Our authors would argue that although understanding the mechanism of action is an important factor for any treatment, therapeutic
benefit to the patient should be of higher importance. Veterans’ perceptions of the use of vision rehabilitation in treatment of PTSD were positive and presented as an unexpected benefit for this therapy.

This study is limited by its small retrospective design, but the results are significant. This is the first study to look at the relationship between vision rehabilitation and PTSD. Given the encouraging findings of this study, additional research is needed to further investigate the efficacy of comprehensive vision rehabilitation as a component of more complete treatment for PTSD. Comprehensive vision rehabilitation may have an additional benefit to the treatment of PTSD, likened to the value of pursuit eye movements in EMDR. While our authors do not wish to portray that vision rehabilitation or use of the eye-movement component with EMDR in and of themselves provide a “cure” for PTSD, they do contend that use of these procedures should not be discounted or dismissed. Further research that incorporates use of randomized control trials and sufficient sample sizes to adequately investigate specific components (i.e., eye movements) and duration of therapy are needed.

No follow-up data was available for this study. Therefore, long-term effects of the treatment are unknown at this point. Further research would be helpful to determine if vision rehabilitation might alleviate symptoms for longer periods of time, or if vision rehabilitation conducted in conjunction with other therapies might improve long-term outcomes for patients suffering from PTSD.

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REFERENCES


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