

# Vision Therapy Rehabilitation of Post-Concussion Visual Impairments

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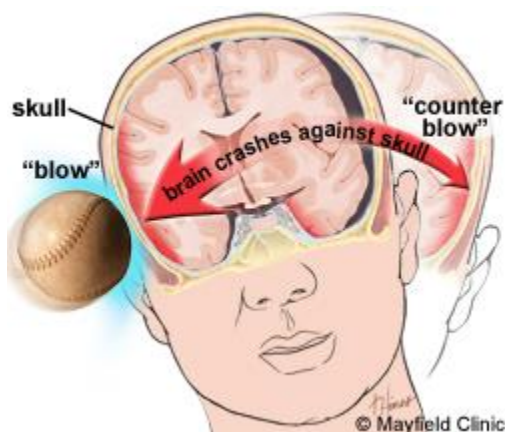
1 Abstract

2 Concussion is a common, mild form of traumatic brain injury that is caused by blunt force  
3 trauma to the head. Concussion can be caused by a wide variety of situation, commonly sports  
4 collisions, automobile accidents, and falls. Signs of concussion include a loss of consciousness,  
5 temporary amnesia, and disorientation. Severe concussion can result in visual impairments such as  
6 blurred vision, light sensitivity, attention deficits, impaired memory, and double vision. Vision therapy  
7 can significantly or completely improve many of these visual impairments. Vision therapy is a series of  
8 procedures monitored by an optometrist that are designed to improve visual movements and  
9 processing. Vision therapy can be used to benefit patients in many different situations from sports vision  
10 training and learning disability improvements to traumatic brain injury rehabilitation and specific visual  
11 condition correction. Many or all of the visual symptoms of concussion respond to vision therapy; vision  
12 therapy programs for concussion typically focus on correcting convergence insufficiency, eye  
13 movements, visual tracking, and gaze stabilization. The case study included at the end of this research  
14 presents the use of vision therapy for the management of post-concussion visual symptoms in a 20 year  
15 old male athlete.

## 16 Concussion and Vision Therapy

17 Concussion is a type of mild traumatic brain injury (TBI) caused by a direct (such as blunt force  
18 trauma) or indirect (such as whiplash) blow to the head; each year in the United States, over 1 million  
19 people suffer from this injury.<sup>3</sup> The signs of this injury are loss of consciousness, temporary amnesia, and  
20 disorientation as well as headaches, nausea, and vision problems.<sup>2</sup> The severity of the concussion is  
21 typically determined by the length of the loss of consciousness and/or amnesia.<sup>3</sup> Severe concussion can  
22 lead to significant visual impairments including blurred vision, light sensitivity, learning and attention  
23 deficits, impaired memory and double vision.<sup>4</sup>

24 Concussion typically occurs as a result of incidents such as sports collisions and injuries,  
25 automobile accidents, and falls.<sup>5</sup> The most common cause of TBI is falls, particularly among children and  
26 older adults.<sup>3</sup> The injury to the brain is due to abrupt acceleration and deceleration of the head during  
27 impact causing the brain to collide with the skull which causes injury in two different places on the brain  
28 (Figure 1).<sup>4</sup> The first injury occurs at the point of impact when the brain initially hits the skull from the  
29 impact; then, there is a rebound effect where the opposite side of the brain hits the skull as well and  
30 causes the second point of injury. After the collision, the injured cells are particularly vulnerable and if a  
31 second concussion occurs the resulting swelling may cause permanent damage.<sup>2</sup>



32

33 *Figure 1. The force of the blow causes the brain to bounce back and forth and coming into contact with the skull and causing*  
34 *injury to the brain.<sup>4</sup>*

35           Diagnosis of concussion is determined by recording the presence of at least one sign and/or  
 36 symptom.<sup>3</sup> Concussion diagnosis can be difficult because the signs and symptoms can change drastically  
 37 within a short period of time after the injury.<sup>2</sup> Often in the context of sports, baseline testing is done on  
 38 athletes before the beginning of the season to quantify and assess the athlete’s typical brain function  
 39 and response; then, when concussion is suspected, the same or a similar test may be done to screen for  
 40 change in brain function post-injury.<sup>3</sup> There are many scales that have been developed to determine the  
 41 presence and severity of concussion. The two primary initial clinical evaluation tools are the Glasgow  
 42 Coma Scale and the Standardized Assessment of Concussion which both have the advantage of the  
 43 ability to be administered at the location of the incident to provide an immediate assessment of the  
 44 injury.<sup>6</sup> This is valuable because the ability to diagnose concussion quickly can allow for earlier, more  
 45 effective treatment and prevent the risk of a second, more detrimental concussion occurring.<sup>4</sup> The  
 46 Glasgow Coma Scale is used to score levels of consciousness (Figure 2) from 3 (most severe) to 15  
 47 (normal); a majority of individuals with concussions score relatively close to normal on this scale hence it

Glasgow Coma Scale		
Response	Scale	Score
<b>Eye Opening Response</b>	Eyes open spontaneously	4 Points
	Eyes open to verbal command, speech, or shout	3 Points
	Eyes open to pain (not applied to face)	2 Points
	No eye opening	1 Point
<b>Verbal Response</b>	Oriented	5 Points
	Confused conversation, but able to answer questions	4 Points
	Inappropriate responses, words discernible	3 Points
	Incomprehensible sounds or speech	2 Points
	No verbal response	1 Point
<b>Motor Response</b>	Obeys commands for movement	6 Points
	Purposeful movement to painful stimulus	5 Points
	Withdraws from pain	4 Points
	Abnormal (spastic) flexion, decorticate posture	3 Points
	Extensor (rigid) response, decerebrate posture	2 Points
	No motor response	1 Point
<b>Minor Brain Injury = 13-15 points; Moderate Brain Injury = 9-12 points; Severe Brain Injury = 3-8 points</b>		

Figure 2. The Glasgow Coma Scale is used to assess the severity of loss of consciousness based upon eye, verbal, and motor responses.<sup>2</sup>



58 duration of amnesia and loss of consciousness suffered by the patient; the different “grades” of  
59 concussion are shown below (Figure 4).<sup>8</sup>

<b>Graded Severity of Concussion</b>
<b>Grade I: no loss of consciousness; amnesia is absent or present for less than 30 minutes.</b>
<b>Grade II: loss of consciousness for less than five minutes or amnesia for between 30 minutes and 24 hours.</b>
<b>Grade III: loss of consciousness for more than five minutes or amnesia for more than 24 hours.</b>

60 *Figure 4. The graded severity of concussion is determined by the length of loss consciousness and amnesia.<sup>8</sup>*

61 In a majority of cases, symptoms will usually resolve within a couple of weeks, but some  
62 symptoms may last upwards of a month.<sup>3</sup> Following the injury, post-concussion evaluation of the  
63 symptoms in a clinical setting needs to be done until all of the symptoms resolve. The most common  
64 symptom of concussion is headaches; headaches usually resolve themselves within a week, but can  
65 sometimes last upwards of a year.<sup>9</sup> Roughly one-fifth of post-traumatic headaches last for greater than  
66 a year.<sup>10</sup> Concussion treatment generally includes rest and over the counter medication such as  
67 acetaminophen to treat headaches, muscle aches, and to reduce the chance of brain bleeding.<sup>4</sup> In the  
68 case of severe concussion, patients can see a variety of specialists to improve or reverse post-concussion  
69 symptoms. In the case of long-lasting visual complications, a vision therapist can be seen to improve  
70 symptoms.

71 Visual disturbances resulting from concussion included blurred vision, double vision, and  
72 abnormal eye movements; these and other symptoms can be resolved through a vision therapy  
73 program.<sup>2,11</sup> Vision therapy is a series of procedures, prescribed and monitored by an optometrist, that  
74 are designed to improve visual skill and perception.<sup>12</sup> Vision therapy is not designed to literally  
75 strengthen the eye muscles, but rather to improve their functioning.<sup>13</sup> Vision Therapy originated from a  
76 group of visual exercises that are now considered orthoptics, a sub-division of modern vision therapy;  
77 orthoptics were first introduced in the late 1800s as a non-surgical treatment for vision disorders caused

78 by uneven eye muscles.<sup>14</sup> These exercises began to develop further as orthoptists, ophthalmologists,  
 79 and optometrists all worked to develop binocular vision (vision where both of the eyes work together  
 80 fluidly) to individuals, especially children, with uncoordinated eye muscles.<sup>15</sup> Outlined below is a chart of  
 81 the major developments in the history of vision therapy. Today, vision therapy has progressed to include  
 82 much more than the movement of the eyes themselves and has broadened its scope to the muscles  
 83 within the eyes as well as the perception and processing of visual information.<sup>14,15</sup> Vision therapy has  
 84 also broadened its application to help improve visual quality in individuals with visual processing  
 85 disorders, under-developed vision, and visual coordination deficits as well as help athletes, individuals  
 86 with learning deficits, and those suffering from traumatic brain injuries.<sup>16</sup>

1928	OEPF formed. Developed regimens for those visual problems not amenable to conventional lens prescriptions.
1930s	Knowledge shared between various professions involved in vision. Improved understanding of influence of lenses on visual perception. VT techniques circulated to OEPF members. Orthoptic organizations formed in U.S., Europe, and Britain. Optometric community divided on vision models of structural versus functional and hence best management.
1940s	VT program circulation increases. Concept of training in free space & natural environment expanded. Application of VT to child development expands.
1950s	Harmon develops model that relates vision to posture & spatial relations. <sup>6</sup>
1960s	VT applied by optometrists to children with learning-related visual difficulties. Pre- and post-treatment criteria for functional cure of strabismus established. VT credibility falls due to perceptuomotor program resemblance and learning performance achievements not realized. Later models involving understanding of intersensory integration rebuilds credibility.
1966	First extensive vision-training instruction manual for professionals produced.
1971	The College of Optometrists in Vision Development (COVD) formed, which established certification, advocacy, and standards for behavioural optometry.
1976	The first optometric textbook on VT from a major author (Griffin) and publishing house is written.
Late 1970s	Interactive computer screens used in VT.
1980s	Random Dot Stereograms (RDS) produced on monitors; computerised programs for VT evolve.
1987	Australasian College of Behavioural Optometrists (ACBO) formed.
1991	Peachey authors seminal article on minimum attention and automaticity goal of vision therapy.
2005	Computer program internet interaction available for practitioner/patient.
2006-present	Commencement of Convergence Insufficiency Treatment Trials for substantiation and evidence-based criterion. <sup>7,8</sup>

87

88 *Figure 5. Key events in the history of vision therapy.<sup>16</sup>*

89 Currently, vision therapy is being used to treat a wide array of symptoms from blurred or double  
 90 vision to headaches and low reading comprehension. In order to document the presence and severity of  
 91 symptoms, the College of Optometrists in Vision Development (COVD) developed a quality of life  
 92 checklist.<sup>17</sup> This survey is often completed prior to the vision therapy program as a way of indicated the  
 93 need for a comprehensive binocular vision exam as well as during the course of the vision therapy

94 program to indicate an improvement in symptoms. The checklist, shown in full below, includes  
 95 statements such as “holds reading too close” and “does not judge distance accurately”; for each of the  
 96 statements, the patient is to indicate how often they experience that statement from never (0) to  
 97 always (4).<sup>17</sup> For young children, this questionnaire may be completed by their parent or guardian on  
 98 their behalf. Certain statements may only be applicable for specific age groups. A total score lower than  
 99 15 will indicate standard binocularity, while anything higher indicates the need for an exam by a  
 100 developmental optometrist.<sup>17</sup> This checklist is just considered a first step towards vision therapy, a full  
 101 comprehensive eye exam is needed to confirm a visual problem; if the exam confirms the existence of  
 102 an eye movement problem, then a vision therapy program is recommended for the patient.

**QUALITY OF LIFE SYMPTOM CHECKLIST\***

Check the column that best represents the occurrence of each symptom.		Patient's Name: _____ Date: _____				
	0 Never	1 Seldom	2 Occasionally	3 Frequently	4 Always	
1	Blur when looking at near					
2	Double vision					
3	Headaches with near work					
4	Words run together when reading					
5	Burning, itchy, watery eyes					
6	Falls asleep reading					
7	Sees worse at the end of the day					
8	Skips/repeats lines when reading					
9	Dizziness/nausea with near work					
10	Head tilt/closing one eye when reading					
11	Difficulty copying from chalkboard					
12	Avoids near work/reading					
13	Omits small words when reading					
14	Writes uphill/downhill					
15	Misaligns digits/columns of numbers					
16	Reading comprehension down					
17	Poor/inconsistent in sports					
18	Holds reading too close					
19	Trouble keeping attention on reading					
20	Difficulty completing assignments on time					
21	Always says "I can't" before trying					
22	Avoids sports/games					
23	Poor hand-eye (poor handwriting)					
24	Does not judge distance accurately					
25	Clumsy, knocks things over					
26	Does not use his/her time well					
27	Does not make change well					
28	Loses belongings/things					
29	Car/motion sickness					
30	Forgetful/poor memory					
	<b>TOTAL</b>					

Add up the total points: Below 15 routine eye care exam; 16-24 visual functional problem referral needed to a developmental optometrist; >25 refer for developmental vision evaluation.

103 *Figure 6. Vision Quality of Life checklist.<sup>17</sup>*

104 The specific focus of and activities within the vision therapy program will vary depending on the  
 105 specific deficiencies of the individual and their personal goals. In order to get a better understanding of  
 106 the individual's deficits, standardized testing is often done at the beginning of the program. Two  
 107 different types of testing can be done: sensory motor evaluation and developmental/perceptual  
 108 evaluation. The sensory motor evaluation is used to evaluate the movement of the muscles surrounding  
 109 the eyes and how the brain processes visual information. One example of a test (below) done during the  
 110 sensory motor evaluation is the developmental eye movements (DEM) test where the participant is  
 111 timed at they read numbers in a vertical column and then horizontally with irregular spaces; their times  
 112 and errors are then compared to normative data for their age group.<sup>18</sup> The developmental/perceptual

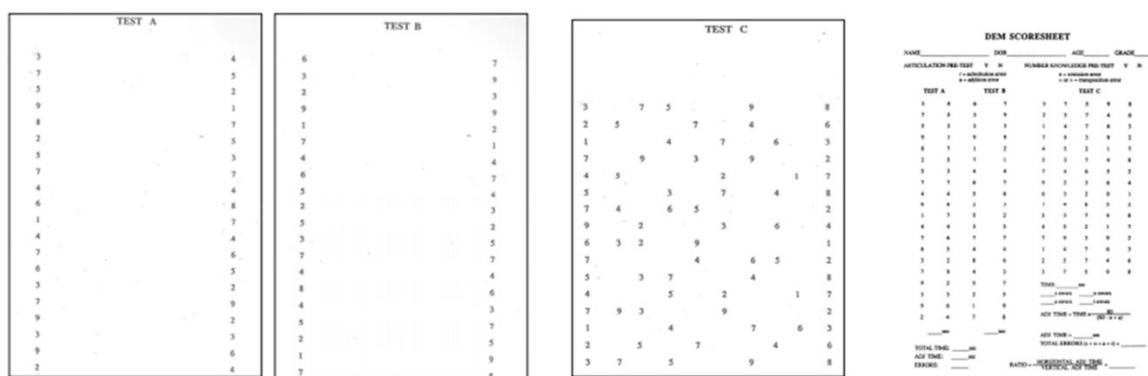


Figure 7. Developmental Eye Movements (DEM) tests and scoresheets.

113 testing evaluates skills such as visual memory, processing speed, and recognition.<sup>1</sup>A Developmental and  
 114 perceptual testing is typically done more frequently in children. A common assessment of many of these  
 115 skills all in one test is the Test of Visual Perceptual Skills (TVPS).<sup>1</sup> TVPS consists of a series of tasks having  
 116 to do with identifying the same and different images in different ways. Two sample pages of the TVPS

117 test are show below. Both types of testing are used to shape the focus of that individual's vision therapy  
118 program.

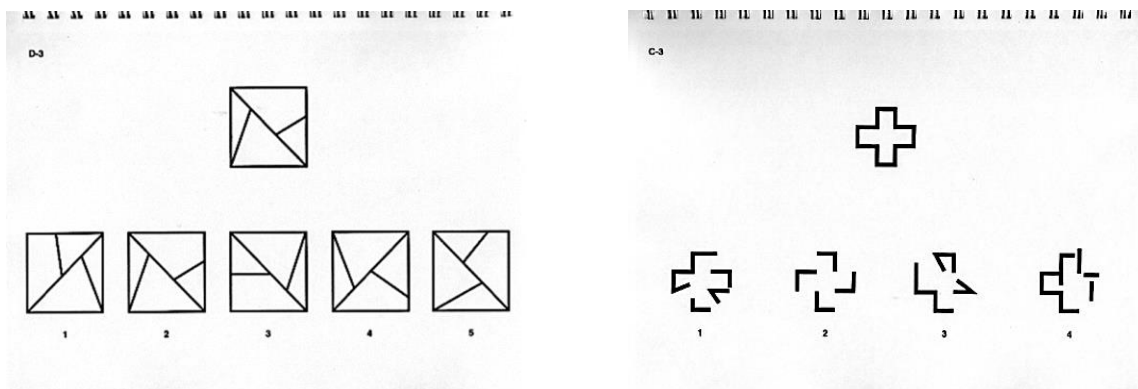


Figure 8. Sample questions from the Test of Perceptual Visual Skills.<sup>1</sup>

119 After the testing is done, a full plan can be made for the individual's vision therapy program and  
120 the types of activities that will be included within it. The length of the program will vary by patient based  
121 on the severity of their diagnosis as well as how often and how frequently they complete their  
122 therapy.<sup>19</sup> These exercises are primarily executed in an office setting, but some activities can also be  
123 done at home for additional therapy.<sup>11</sup> These programs often include the use of equipment such as  
124 specialized lenses, prisms, eye patches, and computer programs. For the rehabilitation of concussion, as  
125 well as most other visual deficiencies, the following groups of activities are commonly included in the  
126 vision therapy programs: anti-suppression, oculomotor, accommodation, vergence, and visual motor  
127 integration.

128 Suppression refers to the brain shutting down the visual input from one of the eyes. In some  
129 cases, it also loses control over the motor alignment of that eye.<sup>20</sup> Anti-suppression activities are  
130 designed to make sure that the patient is using both of their eyes at the same time. Many of these are  
131 red/green or red/blue activities. In these activities, letter charts, games, or activities are done in red and  
132 either blue or green. While completing the activity, the participant wears specific glasses with one lens  
133 that is red and the other that is either blue or green. These lenses work to cancel out the colors of the  
134 activity so that only one eye can only see the red and the other eye can only see the blue or green. In

135 order to see the entire activity, both eyes must be working at the same time. If one of the eyes is  
136 experiencing suppression then parts of the activity will black out and the participant will not be able to



Figure 9. Red/Green anti-suppression chart <https://www.bernell.com/product/RGC/862>

137 see them.

138 Oculomotor exercises help to improve the movement of the muscles surrounding the eyes.<sup>13</sup>

139 Oculomotor dysfunction is one of the most common visual impairments resulting from brain injuries.<sup>21</sup>

140 These exercises typically start with monocular motility which involves the movement of each individual

141 eye. This is achieved through the use of patching to work with the eyes one at a time. A classic activity to

142 address this is a flat, wooden stick with letters listed down it; one eye at a time, the patient must read

143 the letters down the stick while it is moved up and down and in circles a few inches from their face.

144 After seeing improvements in the monocular motility, the therapy shifts to binocular saccades which is

145 the side to side movement of the eyes together. Typically, this is improved in with a wall saccade activity

146 where there are two or more letter charts placed apart on a wall; the participant stands many feet away

147 from the wall and must keep their head still and move only their eyes to alternate reading the letters in

148 order from each chart.<sup>22</sup> Of individuals with traumatic brain injury who complete a vision therapy

149 program, 90% have been shown to successfully treat one or more of their oculomotor symptoms.<sup>21</sup>

150



Figure 10 Child completing a monocular motility exercise. <https://www.webmd.com/children/video/vision-therapy-children>

151

Accommodation is the ability of the eyes to change focus from near to far to make images

152

clear.<sup>13</sup> These exercises help to work the muscles inside of the eyes that contract and relax the lens to

153

change the focus of the eye. The classic accommodation exercise is the use of an accommodative rock,



Figure 11. Child using accommodative rock while reading. <https://www.bernell.com/product/2901/Miscellaneous>

154

or flipper.<sup>22</sup> A flipper is two different sets of lenses that are attached to the same handle. One side has a

155

set of plus lenses which will shorten the focal length and make the participant to converge, or bring their

156

eyes in, to make it clear; the other side has a set of minus lenses which will lengthen the focal length and

157

make the participant diverge, or relax their eyes outward, to make the image clear.<sup>23</sup> This device can be

158

used for any number of activities, most commonly for reading, where the individual will periodically

159

switch back and forth between which set of lenses they are looking through.

160 Vergence is the ability of the eyes to move in opposite directions (coming together or moving  
161 apart) to maintain binocular vision.<sup>23</sup> Vergence is an important function of stereopsis which is the  
162 perception of depth that is produced from the combination of visual stimulus from both eyes. Double  
163 vision is often the result of a vergence deficiency. There are two dimensions of vergence: convergence  
164 (the eyes coming inward together and focusing at near) and divergence (the eyes moving outward from  
165 each other and focusing at a distance).<sup>23</sup> The most commonly used vision therapy vergence exercise is  
166 the vectogram.<sup>22</sup> A vectogram consists of two pieces of clear plastic with very similar images printed on  
167 them that are overlaid on top of each other. The individual then wears polarized lenses so that one eye  
168 is seeing one of the images and the other eye is seeing the other; this creates a three dimensional  
169 image. The sheets are then slowly pulled apart and the direction that they are pulled will force the  
170 patient to either converge or diverge their eyes in order to keep it in a single, three dimensional image.  
171 When converging, the image appears to come closer and get smaller; when diverging, the image



Figure 12. Vectogram exercise and child demonstrating seeing change in depth/size of image.  
<https://www.reviewofoptometry.com/article/you-can-help-your-patients-see-3-d>

172 appears to move further away and get larger. These size and distance relationships are opposite of what  
173 is experienced in the real world in order to ensure that the individual is actually seeing the change in  
174 depth and not just determining the depth based on the change in size cues. Another common vergence  
175 exercise is the Brock String.<sup>22</sup> This is just a string with few beads on it; one end of the string is secured to  
176 a stationary object such as a doorknob, while the other end is help up to the individual's nose. The

177 individual is then instructed to look directly at one of the beads. If both of their eyes are successfully  
178 focusing on that bead, then an “X” is seen in the strings where it appears that there are two strings  
179 going into the bead and two strings leaving the bead. If one of the eyes is being suppressed or not

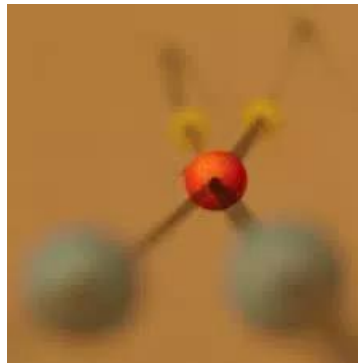


Figure 13. Woman using Brock String and view of what it should look like from the participant's perspective.  
<https://www.bernell.com/product/BC109/Brock-String-Devices>

180 looking at the same place as the other, then a “Y” or even just a single string will be seen instead.

181 Visual motor integration is the ability to coordinate the perceptions of the visual system with  
182 the fine and gross motor skills. This is an important step in translating the skills acquired in vision  
183 therapy and being able to use them in real world applications. Fine motor integration can be achieved



Figure 14. Child wearing yoked prism glasses while walking on balance beam.  
<http://www.cdispatch.com/lifestyles/article.asp?aid=13084>

184 through any of the near activities that involves the participants to move objects, use a touch screen, etc.

185 Gross motor integration is usually improved using yoked prism glasses; yoked prism glasses are a set of  
186 prism lenses that can be rotated to change the perception of space when they are looked through by  
187 the participant. These glasses can be used during a wide variety of activities, most commonly a low  
188 balance beam. This can be especially helpful in improving the balance of concussion patients who have  
189 had a disturbance in their vestibular system.<sup>24</sup> Prism lenses can also be used to specifically help people  
190 with head injuries who have suffered from a midline shift and prevent excessive weight bearing on one  
191 side of their body.<sup>25</sup>

192 Typically, vision therapy rehabilitation of post-concussion visual impairments consists of  
193 carefully planned exercises from each of these categories to target the symptoms and specific deficits of  
194 that individual. Vision therapy has been shown to be a very successful treatment for vision disorders  
195 resulting from concussion. A study recently published in *Optometry and Vision Science* found clinically  
196 and statistically significant improvements in convergence, vergence, and accommodation in concussion  
197 patients who completed a vision therapy program.<sup>26</sup> All around, vision therapy is a relatively simple and  
198 effective method for treating the visual dysfunctions that are associated with concussion.

## Case Study

### 199 Initial Evaluation

200 SW, a 20-year-old male athlete, was seen 8 days post-concussion for an evaluation of his  
201 recurrent visual symptoms. The patient reported poor convergence and pressure behind the eyes.  
202 Difficulty reading and swimming or jumping words were also reported. Overall concussion recovery had  
203 been going well with minimal headaches and light sensitivity as well as good balance and no diplopia  
204 (double vision). The patient reported that visual symptoms were severe and have been worsening since  
205 the injury.

206           At the end of the evaluation, four diagnoses were made: convergence insufficiency (difficulty of  
207 the eyes to work together), spasm of accommodation (prolonged contraction of the muscles  
208 surrounding the lens), exophoria in both eyes (tendency of eyes to drift outward), and hypermetropia  
209 (farsightedness) in both eyes. Convergence insufficiency was the primary diagnosis and improvement of  
210 SW's accommodation would also improve his convergence.

211           The recommended course of action for the convergence insufficiency, spasm of  
212 accommodation, and exophoria was active vision therapy and rehabilitation. The goal of the therapy  
213 was to improve SW's visual skills and aide with overall concussion recovery. Because SW is an athlete, a  
214 focus in sports vision enhancement would also be included in his program. For the hypermetropia,  
215 recommended trying plus lenses at near to see if that would help to improve his convergence. Eye  
216 glasses were not recommended for the time being.

#### 217 Vision Therapy Testing

218           SW was seen again for sensorimotor testing 14 days after his injury and 6 days since his initial  
219 exam. At this time, he reported an increase in symptoms since the last exam, particularly the addition of  
220 frequent double vision. During this appointment, SW filled out a Quality of Life questionnaire and  
221 indicated the following symptoms: blurred vision, double vision, headaches with near vision work, words  
222 running together when reading, dizziness, head tilts when reading, avoiding near vision work, trouble  
223 keeping attention on reading, and poor memory. During his sensorimotor exam, SW was given the DEM  
224 test. He fell within the normal ranges for the vertical tests but was unable to do the horizontal part of  
225 the test because it was too doubled and the numbers were running together. This evaluation confirmed  
226 the presence of physiological diplopia (double vision) with an inability to converge at near and unstable  
227 diverging at near.

228

229 Vision Therapy Program

230 The initial stage of vision therapy focused on improving simple, smooth converging and  
 231 diverging at near as well as both monocular motility and binocular saccades. The oculomotor exercises  
 232 were difficult for SW, but manageable. The vergence exercises were extremely difficult due to the  
 233 frequency and intensity of his double vision. At his 9<sup>th</sup> vision therapy session, SW was able to converge  
 234 and diverge with effort. By the 12<sup>th</sup> session, SW was able to complete all of his vergence activities with  
 235 significantly less effort. Accommodation activities were also included throughout the program. Later in  
 236 the program as visual skills improved, visual motor integration activities were added as well.

System	Visits 1-19
Anti-Suppression	<ul style="list-style-type: none"> <li>• <b>Diplopia awareness</b> Diplopia dot Red/Green Toybox Red/Green playing cards</li> </ul>
Oculomotor	<ul style="list-style-type: none"> <li>• <b>Monocular motility</b> Near-to-far Hart chart Wach's Rotations Multimatrix</li> <li>• <b>Binocular Saccades</b> SVI Program Wall Saccades</li> </ul>
Accommodation	<ul style="list-style-type: none"> <li>• <b>Monocular facility</b> Plus/minus flippers</li> <li>• <b>Binocular facility</b> Plus/minus flippers</li> </ul>
Vergence	<ul style="list-style-type: none"> <li>• <b>Smooth fusional vergence at near</b> Mini red/green tranaglyph Vectogram Eccentric rings</li> <li>• <b>Smooth/step vergence at distance</b> VTS4 Program</li> <li>• <b>Smooth/step vergence at near</b> Vision Builder Program Randot iPad Vison Tap Program</li> <li>• <b>Gross Convergence</b> Brock String</li> </ul>
Visual Motor Integration	<ul style="list-style-type: none"> <li>• <b>Fine motor accuracy</b> Vision Tap iPad program Multmatrix</li> <li>• <b>Gross Motor Coordination</b> SVI Program Yoked prism balance beam Yoked prism pitchback</li> </ul>
Visual Field	<ul style="list-style-type: none"> <li>• <b>Peripheral awareness</b> Form Field</li> </ul>

237 Progress Check

238 91 days after his injury (approximately 11 weeks after beginning vision therapy), SW was seen for a  
 239 progress evaluation by the optometrist. SW self-reported improvement in his symptom quality,  
 240 particularly less frequent double vision; he was still struggling with low computer stamina and pressure  
 241 around the eyes after 15 minutes of computer work. The exam revealed significant improvements in  
 242 SW's visual functioning, but still difficulties with gross convergence and remaining symptoms. SW was  
 243 responding well to therapy so continued therapy was recommended. The optometrist recommended  
 244 roughly ten more sessions of vision therapy treatment.

System	Visits 20-34
Anti-Suppression	<ul style="list-style-type: none"> <li>• <b>Suppression monitored during accommodative and vergence training</b>            RRR Perceptive            Vision Tap iPad program            Polaroid bar reading</li> </ul>
Oculomotor	<ul style="list-style-type: none"> <li>• <b>Monocular motility</b>            Multimatrix            Wach's rotations</li> <li>• <b>Binocular Saccades</b>            Wall saccades            Marsden ball            Dynamic reader</li> </ul>
Accommodation	<ul style="list-style-type: none"> <li>• <b>Monocular facility</b>            Plus/minus flippers            Distance Clear            Blur Clear</li> <li>• <b>Binocular facility</b>            Plus/minus flippers            RRR Perceptive</li> </ul>
Vergence	<ul style="list-style-type: none"> <li>• <b>Smooth fusional vergence at near</b>            Eccentric rings            Vectogram            Aperture ruler</li> <li>• <b>Smooth/step vergence at distance</b>            VTS4 program</li> <li>• <b>Smooth/step vergence at near</b>            Vision Builder Randot program</li> </ul>
Visual Motor Integration	<ul style="list-style-type: none"> <li>• <b>Fine motor accuracy</b>            Multimatrix            Vision Tap iPad program</li> <li>• <b>Gross Motor Coordination</b>            Yoked prism balance beam            Yoked prism pitchback            Marsden ball</li> </ul>
Visual Field	<ul style="list-style-type: none"> <li>• <b>Peripheral awareness</b>            TV letter strips</li> </ul>

245 Conclusion

246 SW was a 20 year old male athlete suffering from post-concussion visual impairments. When beginning  
247 his vision therapy program, SW's primary complaints were double vision and headaches in addition to  
248 blurred vision, poor visual work, dizziness, decreased attention, and poor memory. His visual therapy  
249 program primarily consisted of vergence and accommodation exercises in order to reduce his double  
250 vision and headaches. He was also given oculomotor activities to improve his eye movements. SW was a  
251 very motivated patient and had high compliance to his program. SW responded very well to therapy and  
252 at the conclusion of his program had complete or nearly complete elimination of all of his visual  
253 impairment symptoms.

## References

1. D'Angelo O.D. ML. Vision and Development: What's Old is New Again Within Vision Therapy Part II - NewGradOptometry.com. 2015; <https://newgradoptometry.com/vision-development-whats-old-is-new-again-within-vision-therapy-part-ii/>. Accessed April 38, 2018, 2018.
2. Mann A, Tator CH, Carson JD. Concussion diagnosis and management. *Canadian Family Physician*. 2017;6(63):460-466.
3. What Is a Concussion? *HEADS UP* 2018; [https://www.cdc.gov/headsup/basics/concussion\\_what.html](https://www.cdc.gov/headsup/basics/concussion_what.html). Accessed March 6, 2018.
4. Andaluz N. Concussion (mild traumatic brain injury). 2016; <https://www.mayfieldclinic.com/PE-Concussion.htm>. Accessed March 6, 2018.
5. Holmes B. Policy getting good grades: Concussion law aids monitoring - ProQuest. *Boston Globe*2012.
6. Graham R, Rivara F, Arbogast K, et al. *Sports-Related Concussions in Youth: Improving the Science, Changing the Culture*. Washington, DC: Institute of Medicine and National Research Council; 2014.
7. Nell V, Yates DW, Kruger J. An extended Glasgow Coma Scale (GCS-E) with enhanced sensitivity to mild brain injury. *Archives of Physical Medicine and Rehabilitation*. 2000;81(5):614-617.
8. Concussion grades. *Star-Gazette*2011.
9. Chronic post-traumatic headache: Associations with mild traumatic brain injury, concussion, and post-concussive disorder | SpringerLink. *Current Pain and Headache Reports*. 2008;12(1):67-73.
10. Lucas S. Headache Management in Concussion and Mild Traumatic Brain Injury. *PM&R*. 2011;3(10):S406-S412.
11. Shin H, Park S, Maples W. Effectiveness of vision therapy for convergence dysfunctions and long-term stability after vision therapy. *Ophthalmic & Psychological Optics*. 2011;31:180-189.
12. Piñero DP. Science-based vision therapy. *Journal of Optometry*. 2016;9(4):203-204.
13. Association AO. The Effectiveness of Vision Therapy in Improving Visual Function - Vision Help. 2014. <https://visionhelp.com/the-effectiveness-of-vision-therapy-in-improving-visual-function/>. Accessed 2014-10-30.
14. Doyle M. Vision Therapy In The Modern Behavioural Optometry Practice: The History of Vision Therapy and Contemporary Approaches to Case Selection, Case Management, and the Delivery of Treatment. *Optometry & Visual Performance*. 2016;4(1):15-22.
15. Helveston E. Visual Training: Current Status in Ophthalmology. *American Journal of Ophthalmology*. 2005;140(5):903-910.
16. Birnbaum MH. Behavioral optometry: a historical perspective. *Journal of the American Optometry Association*. 1994;65(4):255-264.
17. Maples WC, Bither M. Efficacy of vision therapy as assessed by the COVD quality of life checklist. *Optometry*. 2002;73(8):492-498.
18. Facchin A, Maffioletti S, Carnevali T. The Developmental Eye Movement (DEM) Test: Normative Data for Italian Population. *Optometry and Vision Development*. 2012;43:162-179.
19. Peachey G, Peachey P. Optometric Vision Therapy for Visual Deficits and Dysfunctions: A Suggested Model for Evidence-Based Practice. *Vision Development & Rehabilitation*. 2015;1(4):289-338.
20. Volkman F. Human visual suppression. *Vision Research*. 1986;26(9):1401-1416.
21. Ciuffreda KJ, Rutner D, Kapoor N, Suchoff IB, Craig S, Han ME. Vision therapy for oculomotor dysfunctions in acquired brain injury: a retrospective analysis. *Optometry*. 2008;79(1):18-22.
22. Phases of optometric vision therapy. *Review of Optometry*. 2011;148(10):62-63.

23. Association AO. Care of the Patient with Accomodative and Vergence Dysfunction. In: Association AO, ed. St. Louis, MO: American Optometric Association; 2001.
24. Ryan C. The Connection Between Vision & Balance. 2016. <https://vestibular.org/news/12-23-2016/connection-between-vision-balance>. Accessed 2016-12-23.
25. Appelbaum OD S. Head Injury and Stroke Vision Rehabilitation - Vision Help. 2014. <https://visionhelp.com/head-injury-and-stroke-vision-rehabilitation/>. Accessed 2014-10-06.
26. Gallaway M, Scheiman M, Mitchell GL. Vision Therapy for Post-Concussion Vision Disorders. *Optometry and Vision Science*. 2016;93(00).