Concussion and Vision: Screening and treating persons with persistent post-concussive symptoms

Elizabeth Martori OTL

Learning Objectives

1. Participant will be able to identify common visual deficits that occur related to persistent post-concussive symptoms (PPCS)
2. Participant will be able to assess these visual deficits using standardized screening measures
3. Participant will be able to implement remedial and compensatory treatment techniques to address visual changes and dysfunction.

Concussion Terminology

- The CDC defines concussion as "type of traumatic brain injury – or TBI – caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth. This sudden movement can cause the brain to bounce around or twist in the skull, creating chemical changes in the brain and sometimes stretching and damaging brain cells"
- Symptoms of Concussion
  - Headache
  - Nausea or vomiting
  - Balance problems or dizziness
  - Double vision or blurry vision
  - Light or noise sensitivity
  - Fatigue
  - Feelings of sluggish, haze, foggy, groggy
  - Confusion, concentration or memory problems
  - Changes in mood

Persistent Post-Concussive Symptoms (PPCS)

- Definitions of Persistent Post-Concussive Symptoms
  - Expert consensus-based definition of persistent symptoms following an mTBI from Canada
    - "presence of any symptom that cannot be attributed to a preexisting condition and that appeared within hours of a mTBI, that is still present every day 3 months after the trauma, and that has an impact on at least one sphere of a person's life" (Lagace-Legendre, C. et al. March/April 2021)
  - The Mayo Clinic defines persistent post-concussive symptoms as "occurring when concussion symptoms last beyond the expected recovery period after the initial injury. The usual recovery period is weeks to months"

Persistent Post-Concussive Symptoms (PPCS)

- **Autonomic/Physiological Symptoms**
  - Heart rate variability
  - Cardiovascular dysfunction i.e. orthostatic hypotension with postural change, signs of altered heart rate and blood pressure at rest and during exercise
  - Symptom limited exercise intolerance at low heart rate
- **Mood Related Symptoms**
  - Affective symptoms
  - Cognitive symptoms
- **Vestibulo-ocular and Cervicogenic Symptoms**
  - Blurred vision
  - Dizziness
  - Nausea
  - Balance difficulty
  - Neck pain
  - Headache

Visual Dysfunction Commonly associated with PPCS

- Convergence Insufficiency
  - Ventura et al reports prevalence of vergence dysfunctions ranges from 47%-64% of patients with mild TBI
- Accommodation Insufficiency
  - Hunt et al.'s systematic review also revealed that of the five articles that investigated both convergence and accommodation dysfunction, significant results were reported in mTBI population
- Saccadic Dysfunction
  - Hunt et al. did a systematic review of oculomotor vision based assessment in mild TBI and found 18/20 included articles reported changes in saccadic eye movements in individual with mTBI

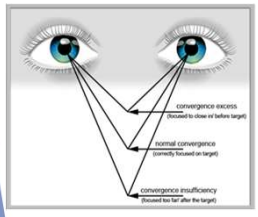
Slide 4

a1 admin, 4/12/2022

Convergence

- **Purpose** – vergence eye movements realign the foveas on a new object at a different depth (viewing distance).
  - Change the depth plane of the foveal object
- Ventura et al. defines convergence as "the simultaneous adduction of the eyes to maintain binocular fusion on near targets"
- Eye Teaming: Near/Close work
  - Reading, device use, eating, managing fasteners/buttons, sewing, typing, and handwriting

Vergence Dysfunction



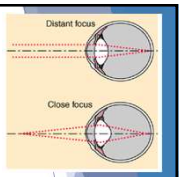
- **Convergence Insufficiency** – condition in which the eyes have the tendency to drift outward when being used for near work such as reading, while at a far distance the eyes work well together
- **Convergence Excess** – is a condition that affects close work as well but in this case the eyes have a tendency to drift inwards
- **Divergence Insufficiency** – is a condition in which a person has difficulty aiming and teaming their eyes together at distant ranges

Convergence Insufficiency can make text look double when trying to read

Some people with Convergence Insufficiency experience a 'halo effect' instead of double vision

https://nvdctherapy.com/vision-learning/convergence-insufficiency/ (image received 1/20/21)

Accommodation



- **Purpose** – to change the focus of the eye so that objects at different distances can be seen clearly
- Hunt et al. defines accommodation as "ability to sustain or change focus on an object by adjusting the focal length of the lens using ciliary muscle control"
- Assuming that any refractive error is corrected, the normal human visual system is physiologically focused for objects at distances of 20 feet and greater. If an object is brought closer than 20 feet, a focusing adjustment must be made or the object will appear blurred.
- Common complaints: Interferes with any activity that requires visual concentration on small objects or print at a close distance or transitioning focal distances, blurred vision

Accommodation Dysfunction

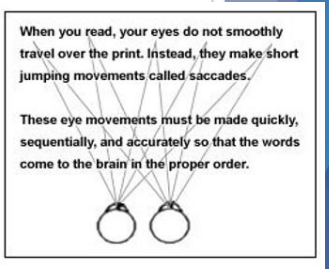
- **Accommodation insufficiency** - condition in which the amount of accommodation available (amplitude of accommodation) is less than expected for the individuals age
  - Presbyopia is a condition in which near visual acuity is decreased because of an age related decline in accommodative ability.
- **Accommodative Excess** - condition in which the amplitude of accommodation in normal, but the ciliary muscle has a tendency to spasm
- **Accommodative Infacility** - condition in which the amplitude of accommodation is normal, but the speed of the response is reduced when transitioning focal points from near<>far

Accommodative Amplitude

- **Accommodative amplitude** - refers to the amount of accommodation available for a particular patient
- The accommodative ability of an individual is inversely related to age
- Young children have very large accommodative amplitudes and this declines with age naturally
- By age 40-45, the decline is significant enough to interfere with the ability to see small print, held at reading distance and is why most people begin to wear reading glasses or bifocals at this age
  - This is referred to as **presbyopia** and is a natural part of the aging process.

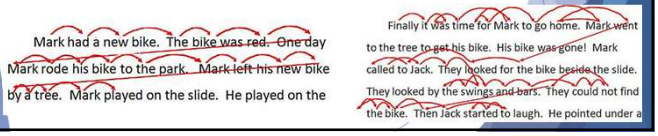
Saccades

- **Purpose** - To shift gaze (the fovea) to a new location in the visual scene
- Hunt defines saccades as "rapid eye movements that enable quick and accurate scanning from one object to another"
- Saccades are accurate, high velocity eye movements used to foveate objects of interest.
- Most prevalent oculomotor skill we use
  - We make about 3 saccades a second and > 150,000 saccadic eye movements a day
- Function - Reading, scanning environment, driving, social interaction and communication



Reading

- Reading requires efficient saccadic eye movements to enable the reader to redirect the line of sight so that the point of information stimulates the fovea
- Eye movements are not random but are guided by information extracted from the visual periphery prior to eye movement.
- Spatial awareness and attention processes appear to the mechanism that provides this guidance
- Master et al reports "reading is a complex higher order integrative function, which requires adequate accommodative, vergence, and saccadic response at the initial stage of gathering visual information"



Vision Assessments

Vision Screening and OT

- Vision problems can interfere with ADLs, IADLs, mobility, community participation/navigation, work, and/or social/leisure activities and quality of life
- Hospital eye exams are limited
- Historically, even traditional hospital and in office exams pay little attention to binocular vision, accommodation, and visual fields.
- **Conditions affecting visual fixation, binocular fusion, and focusing will result in decreased visual function in everyday life**

Suter, P. & Harvey, L. (2011). Vision Rehabilitation: Multidisciplinary Care of the Patient Following Brain Injury. CRC Press: Taylor & Francis Group. Boca Raton, FL p. 71

Vision Screen Considerations

- Premorbid Vision
  - Corrective lenses to be used according to the wearing pattern of the patient
  - If wearing bifocals or progressive lenses, make sure they are looking out of the correct portion of the lens
- History of Visual Dysfunction (even if corrected)
- Cranial Nerve Injuries or Involvement
- Cognitive/Linguistic issues
- Positioning and Posture
- Lighting
- If attention/cognitive issues prevent you from performing the screen, you can still refer to an optometrist – they have equipment to test for these impairments.

Symptom Surveys

- Convergence Insufficiency Symptom Survey
  - Master et al, in their study "the CISS identified patients with vision diagnoses following concussion (compared to the Post Concussion Symptom Survey), and shows promise as a potential screening tool for vision diagnoses following concussion"

ABI/Vision Symptom Survey

Name: ______________________ DOB: ___/___/___ Date ___/___/___

Please read through this list and check items that you have noted to occur along with the frequency.

Symptom	Never	Not too Often	Some-Times	Fairly Often	Always
1. Do your eyes feel tired when reading or doing close work?					
2. Do your eyes feel uncomfortable when reading or doing close work?					
3. Do you have headaches when reading or doing close work?					
4. Do you feel sleepy when reading or doing close work?					
5. Do you lose concentration when reading or doing close work?					
6. Do you have trouble remembering what you have read?					
7. Do you have double vision when reading or doing close work?					
8. Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9. Do you feel like you read slowly?					
10. Do your eyes ever hurt when reading or doing close work?					
11. Do your eyes ever feel sore when reading or doing close work?					
12. Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13. Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14. Do you lose your place while reading or doing close work?					
15. Do you have to re-read the same line of words when reading?					
16. Do you have blurred vision at far distance?					
17. Do you have a loss of peripheral vision?					
18. Do you feel dizziness?					
19. Do you have sensitivity to light?					
20. Do you cover or close one eye to see well?					
21. Are you unable to sustain reading or close work for adequate periods?					
22. Are you bothered by movement in the surrounding environment?					
23. Do you notice postural shifts when standing or walking?					

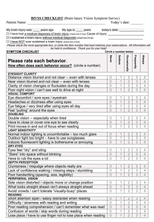
© Scheiman 2011

Score: 0 for never, 1 for Not too Often, 2 for Sometimes, 3 for Fairly Often, and 4 for Always

Investigational only - not validated.

Total ___

Symptom Surveys



- Brain Injury Vision Symptom Survey (BIVSS)
- 28 item scaled questionnaire, 5 point Likert scale
  - 8 Visual symptom categories: eyesight, visual comfort, doubling, light sensitivity, depth perception, peripheral vision complaints, and reading related symptoms
- The BIVSS has good test-retest reliability, and can serve as a suitable tool for assessing and quantifying visual symptoms associated with mild-moderate TBI (Weimer, et al. 2018)

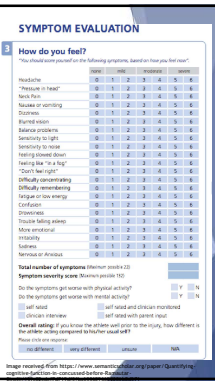
Symptom Surveys


SEVERITY RATING
POST-CONCUSSION SYMPTOM SCALE

- ImPACT: Post concussion symptom survey (PCSS)
- Self report measure consisting of 22 unique symptoms that are each evaluated on a scale from 0-6
  - None - 0
  - Mild - 1-2
  - Moderate - 3-4
  - Severe - 5-6

Symptom Surveys

- Sport Concussion Assessment Tool (SCAT-5)
  - Self report or clinician interview measure of 22 symptoms that are evaluated on a score of 0-6
  - 0 - none
  - 1-2 - mild
  - 3-4 - moderate
  - 5-6 - severe


SYMPTOM EVALUATION

How do you feel?

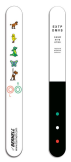
Image received from https://www.semanticscholar.org/paper/Quantifying-cognitive-function-in-concussed-before-Ramachandran-

Convergence Testing

- Near Point of Convergence (NPC) is assessed by moving a target towards a patient (bridge of nose) and measuring the distance at which the patient can no longer maintain fusion or the distance at which the patient develops exotropia (Ventura et al. 2014)
- Normal NPC is 5-10 cm and anything above suggests convergence insufficiency (Ventura et al. 2014)

Amplitude of Accommodation

- Testing is performed **monocularly**
- It is important that the patient does not know the letter on the Gulden Fixation Stick before the test begins
- Hold the fixation stick with the 20/30 target (middle letters) about 1 inch in front of the uncovered eye
- Slowly move the target away from the patient's eye and ask the patient to report as soon as the target comes into focus
- Using a ruler, measure the distance from the eye to the Fixation stick at which the patient was able to identify the stimulus. Record this measurement



Accommodation: Scoring

- Divide 40 by the measurement patient is able to clear the image to determine the amplitude of accommodation.
  - For example, say the patient is able to identify the target at 8 inches. To find the amplitude, divide 40 by 8 which equals 5 D
- Compare the patient's amplitude of accommodation to the expected amplitude for the patients age.

Accommodation Norms

Age	Expected Number	Age	Expected Number
3	17 D	30	8 D
6	16 D	33	7 D
9	15 D	36	6 D
12	14 D	39	5 D
15	13 D	42	4 D
18	12 D	45	3 D
21	11 D	48	2 D
24	10 D	51	1 D
27	9 D	54	0 D

The amplitude for accommodation should be within 2 D of the expected findings

Saccades

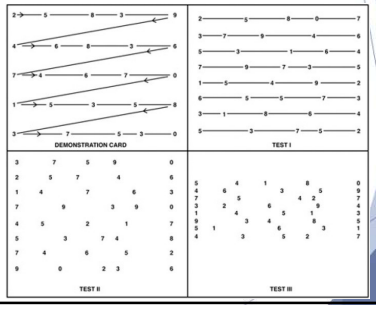
King Devick Test (K-D Test)

- Is a 2 minute rapid number naming assessment in which a patient reads numbers aloud quickly from test cards or a computer based application
- K-D Test requires eye movements (saccades, convergence and accommodation), attention and language function.
- The meta-analysis performed by Galetta, K et. Al demonstrates that the K-D test detects concussion with high degrees of sensitivity and specificity with any worsening of timed score from baseline.

Developmental Eye Movement Test (DEM)

- Determine saccadic eye movement efficiency based on the speed and accuracy that a series of single digit numbers can be located, recognized, and verbalized rapidly.
- The DEM (unlike previously similar tests) attempts to control for the automaticity factor, by adding a subtest where the stimuli are arranged vertically

King Devick Test



Saccades: DEM

- Consists of 2 subtests and 4 scores are generated from completion of the 2 tests
  - Vertical Time: below average score represents a deficiency in the ability to rapidly name aloud printed numbers
  - Horizontal (adjusted) time: accounts for errors of omission or addition (time is rounded up if numbers are omited and time is rounded down if numbers are added)
  - Ratio: below average score indicates a deficiency of oculomotor skill and is supportive of a diagnosis of oculomotor dysfunction

Saccades: DEM

- **Substitution errors** (s errors): cross out the number with a / if an error in naming occurs. Immediate correction of naming errors should be accepted as a correct answer.
- **Omission errors** (o errors): circle a number if it is omitted (circle all numbers if the entire line is missed)
- **Addition errors** (a errors): place a cross (+) when a number has been added or a number has been repeated. When whole lines are repeated, count as 5 addition (a) errors
- **Transposition errors** (t errors): place an arrow when a number is read out of sequence

Saccades: DEM

- Pre test is only given to children 6 years or younger to ensure knowledge and articulation of numbers
- This may also be used for patients with dysarthria or mild aphasia
- Vertical Test
  - Have the patient read template A aloud
  - Instruct the patient to only use their eyes
  - Record the time in the space provided
  - Immediately continue onto template B and give the same directions
- Horizontal Test
  - Proceed to test C
  - The patient should read all the numbers from left to right until completion

Saccades: DEM

- Vertical Test
  - Test A
    - "I want you to read the numbers down the two columns like this as quickly and carefully as you can. Do not use your finger. Use your eyes only"
    - Recording - record time taken to complete Test A
  - Test B
    - "I want you read the numbers down the columns like this as quickly and carefully as you can, just as you did before. Do not use your finger. Use your eyes only."
    - Record the time taken to complete Test B
- Horizontal Test
  - Test C
    - "I want you to read the numbers across the rows like this as quickly and as carefully as you can."

Saccades: DEM Scoring

- Vertical time is scored by adding the time to complete test A and test B
  - Test A + Test B = Vertical Time
- Horizontal time is determined by compensating for the time to complete test C in the presence of errors
  - The **adjusted horizontal time** reflects the amount of time it would have required to read 80 numbers
  - Adjusted Horizontal Time = Test C time [80/(80-o+a)]
  - Example: Total time = 55 seconds; there were 2 lines missed (10 numbers) and one line repeated (5 numbers). Therefore, the adjusted horizontal time = Test C time x [80/(80-10+5)] or 55 seconds x 1.06. The adjusted horizontal time is 58.6 seconds
- Ratio
  - Ratio = (Adjusted horizontal time/vertical time)

Saccades: DEM Scoring

- Vertical time score - determines the automaticity of number naming ability.
  - Serves as a baseline assessment of naming speed
  - Correlates with reading and academic performance.
- Horizontal time score - evaluates number naming in a reading-like task that depends on a challenging oculomotor component.
- By comparing the Vertical Test and Horizontal test time scores, the core oculomotor, or eye movement, function can be isolated.
- Ratio score - used to compare the vertical (automaticity) and horizontal (automaticity plus oculomotor control) test performance levels.
  - The comparison allows isolation of oculomotor function.
  - Is an indicator of the actual eye movement performance factor
  - Tassinari, J. & DeLand, P., (2005) report that a below expected score on Ratio indicates a deficiency of oculomotor skill and is supportive of a diagnosis of oculomotor dysfunction.

DEM Interpretation

- Raw scores - On the DEM is the total time in seconds taken by the examinee to name all of the stimulus items
- Percentile rank - Represents the percentage of those tested in the sample population whose scores were below that score.

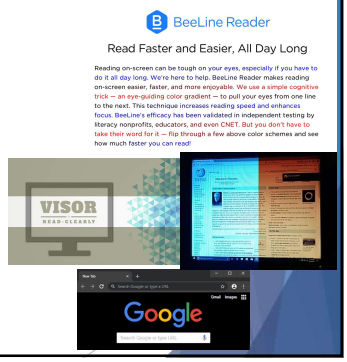
DEM Videos

DEM Videos

Vision Treatment

Compensatory

- Device Modifications
  - Settings: Brightness, Font Size, Ergonomics
  - Software and Extensions
    - BeeLine Reader
    - Google Chrome Visor
    - Google Chrome Read & Write
    - Google Chrome High Contrast
    - Google Chrome Dictation for Gmail
    - F.lux
    - Siri
    - Speech to Text



Compensatory

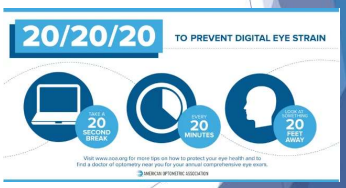
- Low Tech Solutions
  - Blue Blocker lenses
  - Tinted glasses
  - NSRI Tinted overlays
  - Anti-glare screen covers
  - Livescribe echo pen
  - Line guide

Compensatory Strategies for Reading/Return to School (Master et. Al)

- Frequent visual breaks
- Oral teaching
- Audio books
- Large-font print material (vs. small font electronically displayed material)
- Pre-printed notes

Compensatory

- Palming
- Focusing in distance
- 20/20/20 rule
- Rest breaks
- Blinking/Eye drops



General Principles for Eye Movement Rehabilitation

- Consider optical correction first
- Accommodative and binocular vision disorders should be treated before beginning therapy for eye movement problems (or treat simultaneously).
- Fixation is integral in maintaining steady foveation on an object in space
  - It is also a measure of global attention
- Accuracy first, then speed
- Saccades (gross) large to fine (small) eye movements
- Add metronome, simple cognitive tasks, or balance during any eye movement task to increase complexity
- In order for visual skills to stick, we must challenge it under multiple demands. Load visual skills to make sure it is integrated and automatic

Components for Effective Vision Rehabilitation

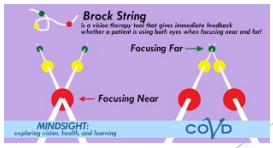
- Motivation and ACTIVE participation
- Repetition
  - Necessary for neuro-plastic changes to occur as repeated stimulation of a neuron results in increased synaptic strength (Chang, et al., 2016)
- Feedback
  - For example, the normal physiological diplopia response on brock string, auditory feedback of NVR or Vision Coach, Pegboard
- Multi-sensory integration
  - Systematically loading vision rehabilitation procedures with balance, vision, motor, and auditory inputs, results in the speed of visual information processing being enhanced

Convergence Functional Modifications

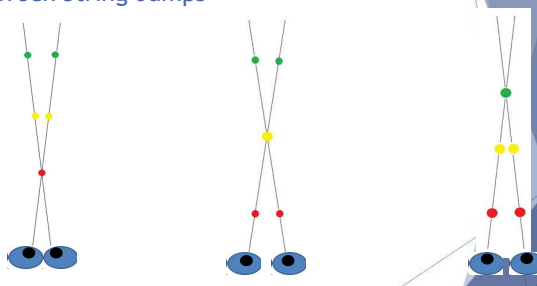
- Allow more time for visual near tasks
- Increase frequency of rest breaks
- Increase print size for near work
- Move working distance away until comfortable or increase tolerance

Remedial Convergence

- Progression
  - Eye teaming on static targets
  - Eye teaming jumps at various focal distances
  - Eye teaming movement
- Convergence Activities
  - Thumb and post it
  - Brock string
  - Pencil push ups



Brock String Jumps



Brock String

Jumps

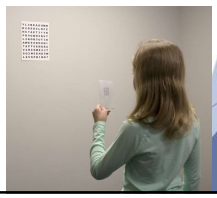
Slides

Accommodative Functional Modifications

- Increase rest breaks
- Increase font size, reduce use of small print
- Improve quality of print
- Classroom or meeting: sit closer to projection to decrease distance of transitioning focal points from near<>far

Remedial Accommodation

- Progression
  - Monocular progress to Binocular
  - Larger near chart and progress to smaller charts
  - Start with near and far chart closer together and then progressively move further away from distant chart
  - Moving target on small target
- Accommodation Activities
  - Rocker Charts
  - Gulden fixation rod with movement



Near<>Far Charts

Saccades Functional Modifications

- Provide more time for visual tasks
- Use finger or line guide to keep place
- Block out text to reduce visual stimulation on page

Remedial Saccades

- Progression
  - Provide visual anchors or tactile cues
    - Dynavision, color coded columns on letter charts
  - Single letter chart to double letter charts
  - Increase distance and then move closer to challenge near work tasks
  - Large angle to small angle
  - Increase speed demand i.e. use of metronome
- Saccade Activities
  - Letter charts
  - Four square saccade charts
  - Petrosyan worksheets
  - Reading/Word cancellation

Letter Charts

Oculomotor Function

- In order to be functional:
  - Should be automatic and effortless
  - Should be stable and both eyes should work equally or close to equally
  - Should be stable with head movement
  - Should be stable in different body positions
  - Should be stable in complex environments
  - Should be able to switch from near<>far without difficulty

References

- Chang, A., Ritter, S., & Xi Yu, Xi. (2016). Neurovision Rehabilitation Guide. CRC Press Taylor and Francis Group LLC, Boca Raton, FL
- Fraser, C. (2021). *Visual Effects of Concussion: A Review.* Clinical and Experimental Ophthalmology 1-6
- Gallaway, M., Scheiman, M., & Mitchell, G. L. (2017). Vision Therapy for Post-Concussion Vision Disorders. Optometry and Vision Science. Vol. 94, No. 1
- Gentile, M. (1997). Functional Visual Behavior: A Therapist's Guide to Evaluation and Treatment Options. AOTA, Bethesda, MD
- Hunt, A., Mah, K., Reed, N., Engel, L., & Keightley M. (2016). *Oculomotor-Based Vision Assessment in Mild Traumatic Brain Injury: A Systematic Review.* Journal of Head Trauma Rehabilitation. Vol 31(4): 252-261
- Lagace-Legendre, C. et al. (March/April 2021). Persistent Postconcussion Symptoms: An Expert Consensus-Based Definition Using Delphi Method. *Journal of Head Trauma Rehabilitation. 36*(2), 96-102. doi: 10.1097/HTR.0000000000000613
- Laukkanen, H., Scheiman, M., & Hayes, J. (2016). *Brain Injury Vision Symptoms Survey (BIVSS) Questionnaire*. Optometry and Vision Science. Vol 93(00)

References

- Master, C., Scheiman, M., Gallaway, M., Goodman, A., Robinson, R., Master, S., & Grady, M. (2016). *Vision Diagnoses Are Common After Concussion in Adolescents.* Clinical Pediatrics. Vol 55(3): 260-267
- Scheiman, M. (2011). Understanding and Managing Vision Deficits: A Guide for Occupational Therapists. SLACK Inc, Thorofare, NJ
- Suter, P. & Harvey, L. (2011). Vision Rehabilitation: Multidisciplinary Care of the Patient Following Brain Injury, CRC Press Taylor and Francis Group LLC, Boca Raton, FL
- Tassinari, J. & DeLand, P. (2005). *Developmental Eye Movement Test: reliability and symptomology.* Optometry Vol. 76:7
- Ventura, R., Balcer, L. & Galetta, S. (2014). *The neuro-ophthalmology of head trauma.* Lancet Neurology. Vol 13:1006-16.
- Weimer, A., Laukkanen, H., Hayes, J. & Saxerud, M. (2018). *Test-Retest Reliability of the Brain Injury Vision Symptom Survey.* Vision Development & Rehabilitation. Vol 4(4)
- Wilbur, C., Leddy, J., Bezherano, I., Bromley, L., Edwards, A., Willer, B., and Haider, M. (2021). *Rehabilitation of Concussion and Persistent Postconcussive Symptoms.* Seminars in Neurology. Volume 41: 124-131