Knocked for a Loop: Concussion's Impact on Vision

Cheryl Davidson, OD, FOVDR

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Dr. Davidson Financial Disclosure(s)

- No Financial Disclosures

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Course Objectives

- Provide an understanding of the role of vision in concussion and traumatic brain injury (TBI), from acute injury to prolonged symptoms
- Understand how the individual components of the visual system are affected in concussion/TBI
- Recognize when to refer for specialized testing and treatment
- Develop clinical applications for the primary care OD

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Types of Brain Injury

- **Mild Traumatic Brain Injury (mTBI)-ie Concussions**
  - A traumatically-induced transient disturbance of brain function
  - Generally, no loss of consciousness, or less than 30 minutes
- **Moderate TBI**
  - LOC 30 min to 1 day
- **Severe TBI**
  - LOC one day or longer
  - Typical to have MRI/CT changes
- **Penetrating Brain Injury**
- **Anoxic Brain Injury or Nontraumatic**—strokes, drownings, etc.
- **Diffuse Axonal Injury**
  - Shearing of the axons in the brain causing widespread brain injury and usually, coma

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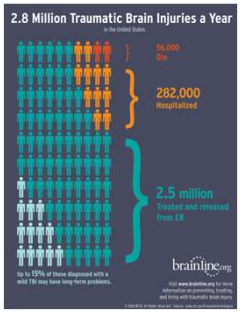

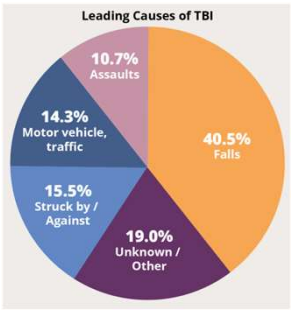

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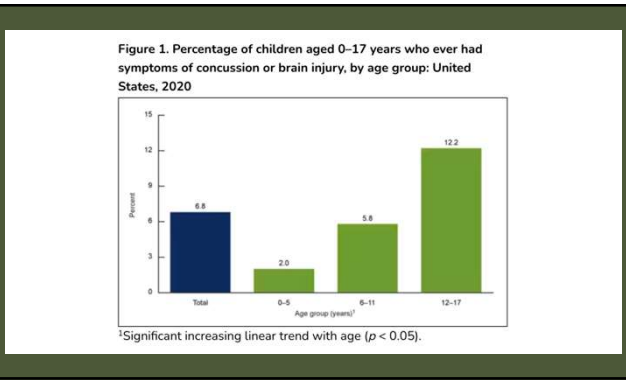

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Slide 4

CD0 3 out of 4 TBI's are mild
Cheryl Davidson, 2023-06-21T23:28:00.412

Slide 5

0 every 21 seconds someone sustains a TBI
Davidson, Alan, 2024-10-13T12:49:02.734

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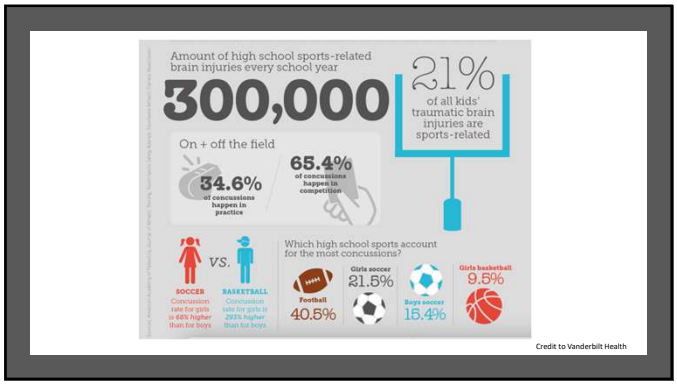

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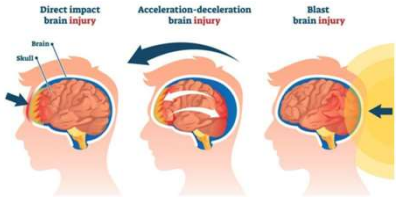
What exactly is happening with concussion in the brain?



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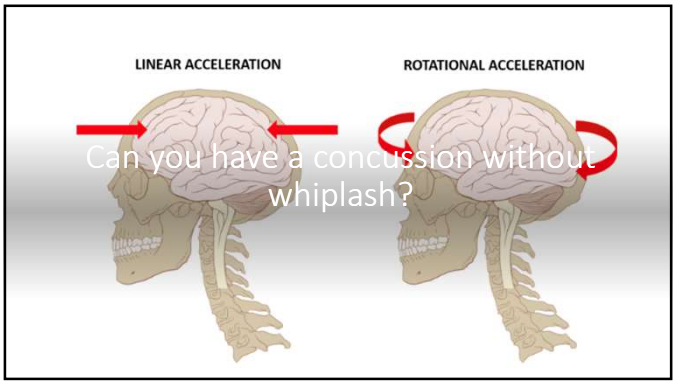

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Neurobiological Changes in Concussions

- Axonal injury—Axons are stretched and damaged
- Ionic shifts—This disrupts the flow of ions into and out of neurons, specifically calcium, potassium and sodium
- Neurotransmitter release—Excitatory neurotransmitters like glutamate are released
- Altered blood flow—The cellular activity alters cerebral blood flow
- Vascular damage—Can lead to proteins and red blood cells leaking into the brain
- **Energy crisis**—The brain's need for energy to restore this disruption is greater than the ability to produce energy

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Four Symptom Categories

(Things reported by the athlete)

Physical Symptoms
- Headache
- Fatigue
- Dizziness
- Sensitivity to light and/or noise
- Nausea
- Balance problems

Emotional Symptoms
- Irritability
- Sadness
- Feeling more emotional
- Nervousness

Cognitive Symptoms
- Difficulty remembering
- Difficulty concentrating
- Feeling slowed down
- Feeling mentally foggy

Sleep Symptoms
- Drowsiness
- Sleeping less than usual
- Sleeping more than usual
- Trouble falling asleep

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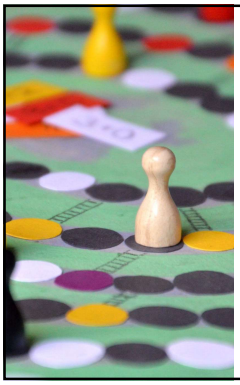

Initial Signs of Concussion

- Appears dazed or stunned
- Confused about instructions/assignments
- Forgets plays
- Is unsure of game, score, or opponent
- Clumsy movements
- Slow response to questions
- Loss of consciousness
- Behavior or personality changes
- Can't recall events prior to hit
- Can't recall events after hit

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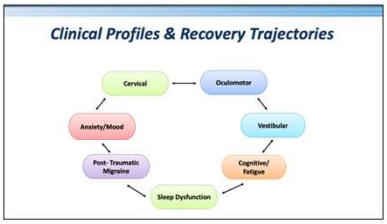
Framework for concussion subtypes out of UPMC



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Concussion Clinical Profile Screening Tool-A New Approach to Symptom Evaluation

- A 29-question assessment
- Helps to determine concussion subtype
- Better treatment outcomes with properly focused rehabilitation

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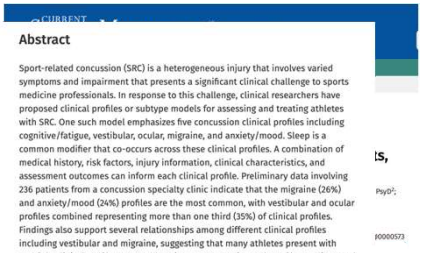

Abstract

Sport-related concussion (SRC) is a heterogeneous injury that involves varied symptoms and impairment that presents a significant clinical challenge to sports medicine professionals. In response to this challenge, clinical researchers have proposed clinical profiles or subtype models for assessing and treating athletes with SRC. One such model emphasizes five concussion clinical profiles including cognitive/fatigue, vestibular, ocular, migraine, and anxiety/mood. Sleep is a common modifier that co-occurs across these clinical profiles. A combination of medical history, risk factors, injury information, clinical characteristics, and assessment outcomes can inform each clinical profile. Preliminary data involving 236 patients from a concussion specialty clinic indicate that the migraine (26%) and anxiety/mood (24%) profiles are the most common, with vestibular and ocular profiles combined representing more than one third (35%) of clinical profiles. Findings also support several relationships among different clinical profiles including vestibular and migraine, suggesting that many athletes present with multiple clinical profiles. Targeted, active treatments for each profile are discussed.

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EDO

- The Current Status
  Concussion Assessme
  A Critical Analysis Rev
- Kaufman MW, Su C
  NN, Lee MK, Nelson G
  SA, Voos JE.
- JBJS Rev. 2021 Jun 8

TABLE II Grades of Recommendation for Concussion Assessment Tools*

Assessment Tool	Grade
Standardized Assessment of Concussion (SAC)	B
Balance Error Scoring System (BESS)	B
King-Devick (KD) test	B
Sport Concussion Assessment Tool (SCAT/child SCAT [cSCAT])	B
Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT/child ImPACT [cImPACT])	B
Vestibular Oculomotor Screening (VOMS)	B
Functional magnetic resonance imaging (fMRI)	I
Diffuse tensor imaging (DTI)	I
Biomarkers	I

*According to Wright[34] grade A indicates good evidence (Level-I studies with consistent findings) for or against recommending intervention; grade B, fair evidence (Level-II or III studies with consistent findings) for or against recommending intervention; grade C, poor-quality evidence (Level-IV or V studies with consistent findings) for or against recommending intervention; and grade I, insufficient or conflicting evidence not allowing a recommendation for or against intervention.

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Clinical evaluation of concussion: the evolving role of oculomotor assessments

Sussman ES, Ho AL, Pendharkar AV, Ghajar J. Neurosurg Focus. 2016 Apr;40(4):E7.

- A review of current concussion screening tools, as available in 2016.
- Standardized Assessment of Concussion (SAC)
- Balance Error Scoring System (BESS)
- Sport Concussion Assessment Tool, 3rd Edition (SCAT-3)
- King Devick Test
- The combination of SAC and BESS, as used in the SCAT-3, had 90% sensitivity for concussion, and this rate increased to 100% with the addition of the KDT.

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Interdisciplinary Team is Essential for Coordinated Care

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Management of Concussion and Persistent Post-Concussive Symptoms For Neurologists

Leddy,J.J., Haider, M.N., Noble, J.M. et al. Curr Neurol Neurosci Rep 21, 72 (2021)

- A summary of management options for the neurologist Based on evidence-based treatments
- If vision impairment persists despite vestibular therapy, Dedicated vision therapy is indicated

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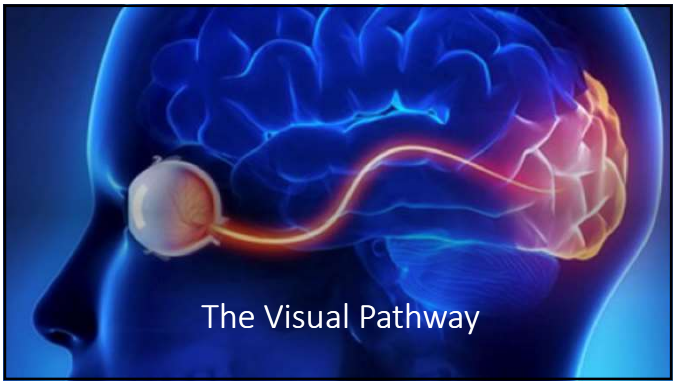

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V1 Primary visual cortex (aka Brodmann area 17) receives Information from the retina and interprets

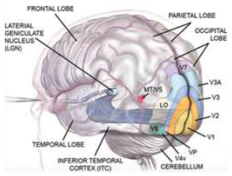
V2 is involved in object recognition and color perception

V3 is not well understood but plays a role in motion processing and color sensitivity

V4 is important for visual attention, processing of color, brightness, texture, shape, motion and depth

V5 (aka middle temporal visual area or MT) is critical In motion processing

V7 is responsible for depth perception, optic flow and spatial attention



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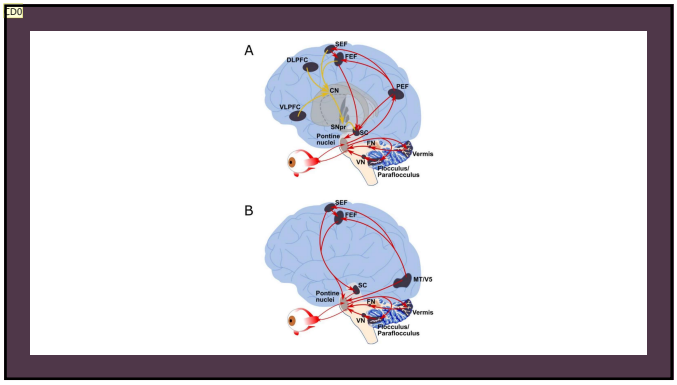
Slide 19

CD0 Journal of Bone and Joint Surgery

Cheryl Davidson, 2023-05-25T02:11:11.170

CD0 0 Recommended using SCAT5 and IMPACT and if needed, the VOMS to confirm

Cheryl Davidson, 2023-05-25T02:18:13.750



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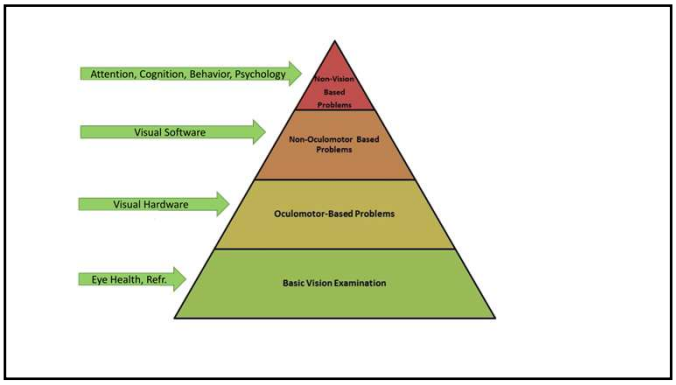

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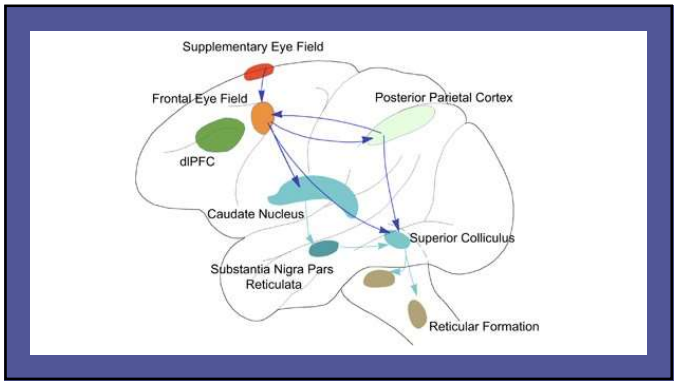

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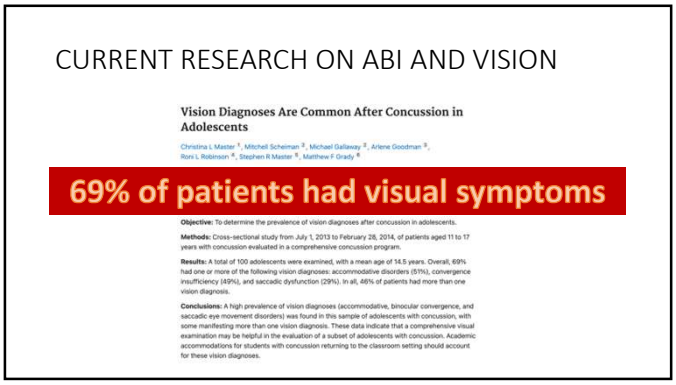

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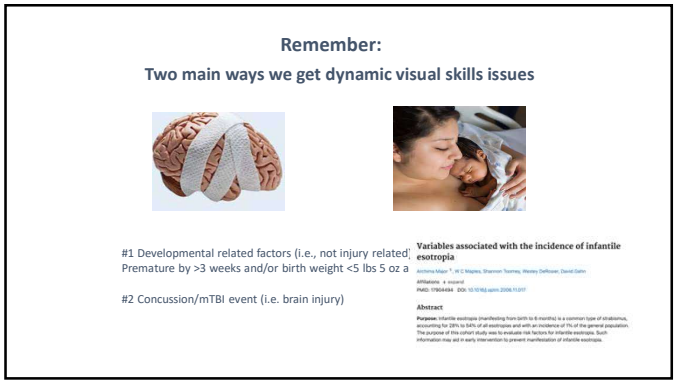

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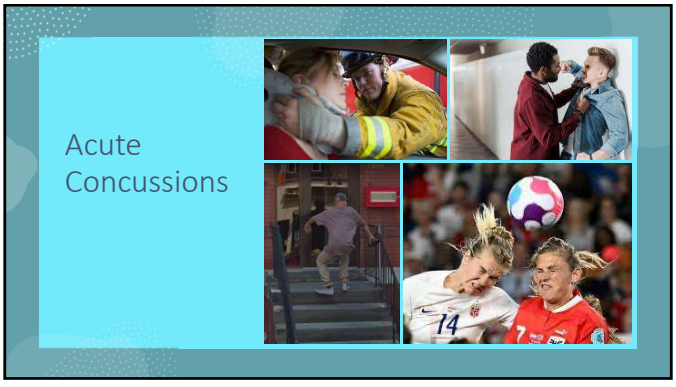

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Slide 25

CD0 Frontal eye fields are responsible for saccadic eye movements, voluntary eye movements, and for visual field perception and awareness.

FEF's communicate with the EOM's through the paramedic pontine reticular formation (PPRF). Damage to the FEF causes deviation to the eyes on the ipsilateral side

Cheryl Davidson, 2023-06-18T21:06:53.513

True or False?

You need to keep the patient awake after sustaining a concussion

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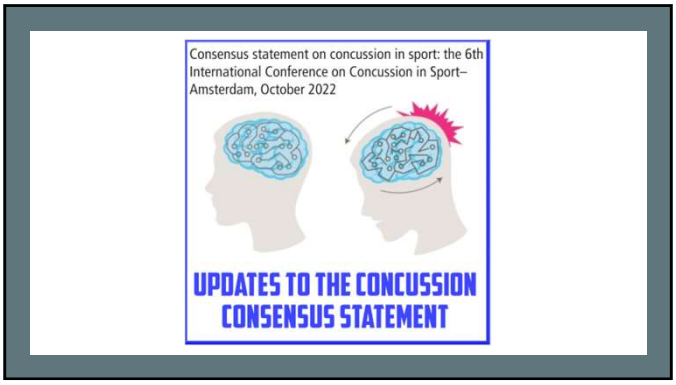

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When to Seek Help After Head Injury/Possible Concussion

- Open wound in the scalp or misshapen shape to the skull
- Severe or progressive worsening headache
- Dilated pupils or anisocoria
- Convulsions or seizures
- Difficulty waking from sleep
- Trouble walking or speaking
- Bleeding or drainage of fluid from the nose or ears
- Unusual sleepiness or decreasing alertness
- Severe, persistent nausea or vomiting more than twice
- Weakness or numbness in the arms or legs

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Treatment Planning: ***Behavioral Regulation***

- **SLEEP**— Regulated sleep schedule with similar bedtime and wake time daily, including weekends. Avoid naps unless napping was part of their typical daily schedule
- **DIET**—Follow a routine eating schedule. No skipping meals, especially breakfast. Emphasize lean proteins and healthy fats
- **HYDRATION**—Dehydration can lead to fatigue, headache, dizziness and weakness
- **PHYSICAL ACTIVITY**—Get some physical activity every day even if it's just a light walk. Take a break if symptoms worsen by more than 3/10 in severity. Also important to remain in social activities, in moderation, while using breaks for symptom management
- **STRESS MANAGEMENT**—Both physical and emotional stress can cause/increase symptoms. Accommodations in place to minimize stress. Be mindful of situational or environmental stressors

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How long to stay in a dark room after a concussion?

This approach is no longer recommended!

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Visual Deficits in Concussion

- The cognitive control of eye movements requires pathways involving fronto-parietal circuits and subcortical nuclei, which are vulnerable in concussion
- In the first 10 days after mTBI, patients have been found to have impaired:
  - Prolonged saccadic latencies
  - Antisaccades (frontal lobe)
  - Higher directional errors
  - Poorer spatial accuracy
  - Impaired memory-guided saccades

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Visual Deficits in Concussion

- 3-5 months after mTBI, patients have been found to perform worse on:
- Saccadic dysfunction present in 30% of patients
  - Anti-saccades
  - Memory-guided saccades
  - Gap Saccade Test—mTBI patients perform poorly when there is shorter temporal gap between a central and peripheral target, but not when there is longer temporal gap.
    - Difficulty with attention?
    - Executive functioning?

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Visual Deficits in Concussion

- Smooth pursuits deficits in the areas of:
  - Target prediction
  - Increased target prediction error
  - Eye position errors
  - Variability of eye position
- Pursuit dysfunction present in 60% of concussion patients

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Visual Deficits in Concussion

- Vergence deficits occur 47-64% of concussed patients
- Accommodative deficits in 65% of patients

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The Predictive Brain State

Point of View: Directions for Research

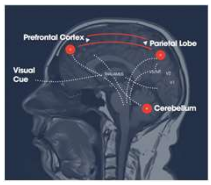
The Predictive Brain State: Timing Deficiency in Traumatic Brain Injury?

Jamshid Ghajar, MD, PhD, Richard B. Ivry, PhD, and the Cognitive and Neurobiological Research Consortium

Dynamic Vision and Attention Require Brain to Predict

Prediction requires Brain to move eyes for orientation

Poor prediction results in attention, focus and memory deficits often seen in central fatigue and mild traumatic brain injury



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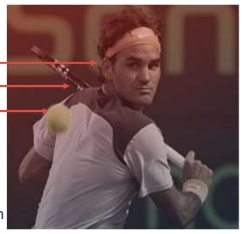
Orientation Requires Predictive Timing

250 msec delay in processing
220 msec delay in swing
100 mph ball velocity



How does the brain do real time interactions (conversation, everyday actions) when it has multiple delays in processing the sensory information and delays in motor output?

Spatial and temporal prediction

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Paying Attention is:

- Spatial and temporal orientation to content
- 80% visual, requiring prediction
- Disruption of spatial or timing prediction produces disorientation and a feeling of being in a "brain fog", "dazed", "out-of-sync"

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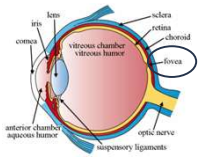
Measuring Orientation

Through Variability in Eye Movements



Need to move eyes to keep image on fovea
prediction needed to maintain focus

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Detecting Eye Movement Abnormalities From Concussion

Maruta J, Ghajar J. Progress in Neurological Surgery. 2014;28:226-33.

- Findings: Concussion patients show difficulty synchronizing their gaze with the target
- They have difficulty with error variability

- Attentional components interact with the visual tracking, suggesting different neurological and physiological conditions can produce identifiable visual tracking characteristics.

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Oculomotor Assessments in Concussion Diagnosis

- VOMS-Vestibular Oculomotor Screening
- King-Devick Test
- Computerized metrics
  - RightEYE
  - EyeSync/NeuroSync
  - Eye Box

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VOMS-Vestibular Oculomotor Screening

VOMS Test	Headache[a]	Dizziness[a]	Nausea[a]	Fogginess[a]	Total Symptom Score[b]
Baseline symptoms					
Smooth pursuit					
Horizontal saccades					
Vertical saccades					
Near point convergence Measure 1: _____ Measure 2: _____ Measure 3: _____					
Horizontal VOR					
Vertical VOR					
Visual motion sensitivity					

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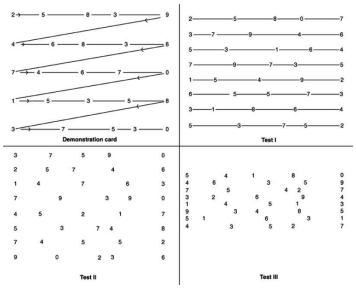
King-Devick Test



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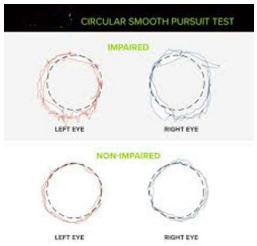

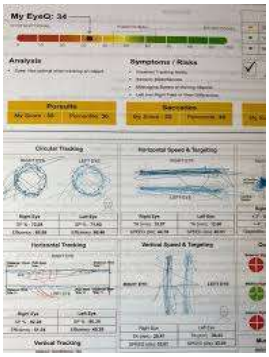

Smooth Pursuit Eye Movements as a Biomarker for Mild Concussion within 7-Days of Injury, Hunfalvay, M et al., Brain Injury. 2021, Dec 11.

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Using Quantitative Eye Tracking Metrics

- Smooth pursuit and eye tracking share similar neural networks - the prefrontal cortex, parietal lobe, and cerebellum
- Damage to white matter in concussion occur in anterior tracks - where the attention and eye tracking networks are located
- Performance variability is a hallmark of concussion, which can be measured by reaction time or assessment of eye movements
- Eye tracking is a more reliable metric than computerized reaction time testing
- Eye tracking testing can be competed in 60 seconds, as opposed to current computerized testing
- A portable eye tracker can be deployed anywhere

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- FDA-cleared, multi-modal software and analytics platform HIPAA compliant
- Supported by $36M DoD funded research
- 20,000+ subject normative clinical trial database with comprehensive eye tracking data
- 30+ peer reviewed publications
- 14 issued patents, 5 pending
- Already in use at top US healthcare, military, and sports organizations

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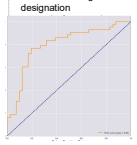
High Performance Diagnostics

World's largest clinical eye tracking Database: 100,000 records

Real-time de-identification

Concussion	Sleep Deprivation	Cannabis
0.9 AUC	Min 0.83 AUC	0.92 AUC
FDA breakthrough designation		Publication Pending



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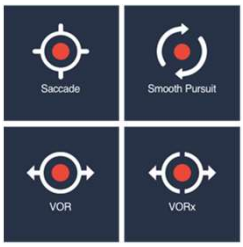
BRAIN PERFORMANCE ANALTYICS ASSESSMENT & TRAINING

Tracking a moving object



Maintaining stable gaze while moving

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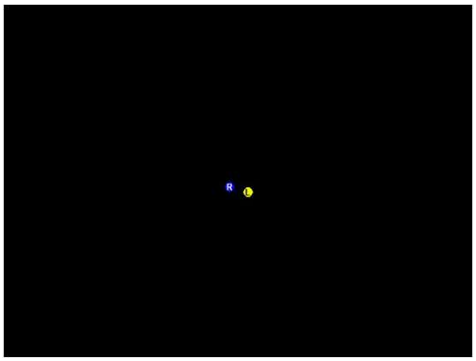

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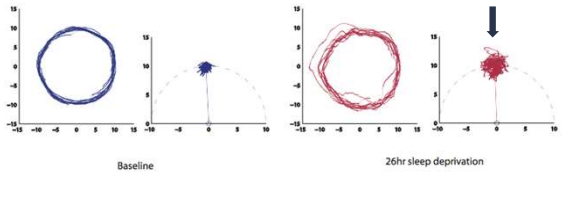
Brain Performance Monitoring

Sleep Deprivation



Predictive Visual Tracking: Specificity in Mild Traumatic Brain Injury and Sleep Deprivation

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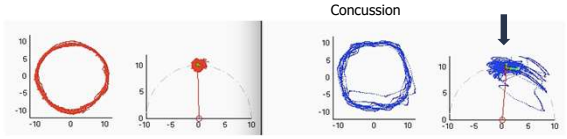
Brain Performance Monitoring

Concussion



Predictive Visual Tracking: Specificity in Mild Traumatic Brain Injury and Sleep Deprivation

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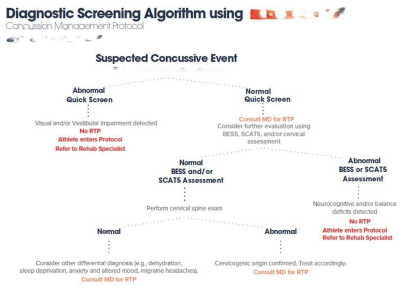
Diagnostic Screening Algorithm using

Concussion Management Protocol



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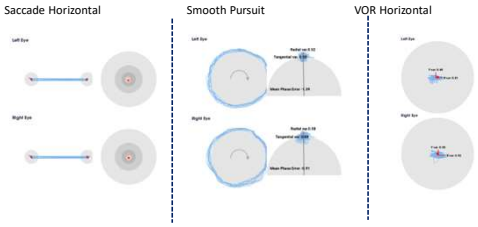
Clinical Scenarios Using EyeSync/NeuroSync

Normal Baseline Test



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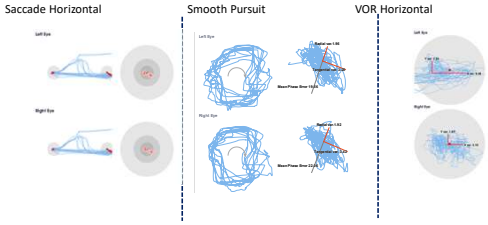
Clinical Scenarios Using EyeSync/NeuroSync

Abnormal Baseline Test



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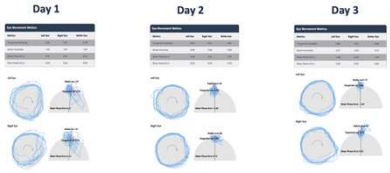
CONCUSSION - QUICK RECOVERY



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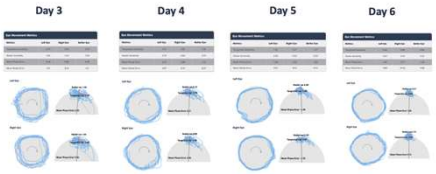
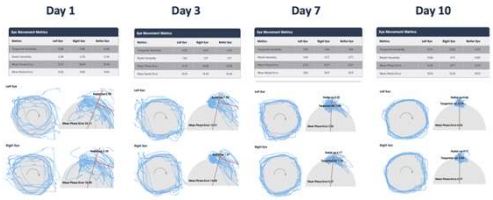
CONCUSSION - NORMAL RECOVERY



61

CONCUSSION - LONGER RECOVERY



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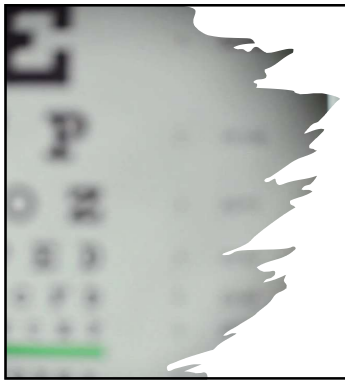


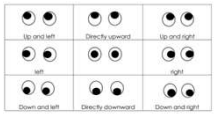
My Examination for Acute Concussion

- Visual acuity
- Basic eye teaming status (Cover Test at distance and near)
- NPC repeated 3 times
- Eye Movements-pursuits and saccades
- Pupils
- Visual field (confrontations)
- NeuroSync with assessment of symptoms

63

Acute Concussion Visual Rehabilitation

- Exercise protocol (under the guidance/blessing of the MD)
- Vitamin supplementation/healthy diet
- Rest and adequate sleep, reduce stimulation and triggers
- Oculomotor rehabilitation



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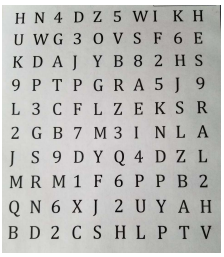
Saccadic Eye Movements



Loading: Add body movement / balance; Auditory: metronome; Cognitive: substituting words

65

Concussive Head Injury in Children and Adolescents Related to Sports and Other Leisure Physical Activities

GJ Browne, LT Lam. Journal of Sports Medicine 2006

- Reviewed almost 600 children aged 6-16 that presented to the ER after participating in sport and/or recreation activity
- 90% of high school athletes will recovery within one week

66

Second Impact Syndrome (SIS)

- SIS is a condition in which an individual experiences a second head injury before completely recovering from a prior head injury
- Athletes who suffer a concussion and return to their sport early are at exceptionally high risk for SIS

When in doubt, sit it out!

67

BJSM
The Journal of Sport & Exercise Medicine

Review

What is the risk of recurrent concussion in children and adolescents aged 5–18 years? A systematic review and meta-analysis

Jacqueline van Iersel, Martin Osmond, Jemila Hamid, Margaret Sampson, Roger Zemek

Conclusion Previously concussed children have four times the risk of sustaining a concussion compared with those with no previous concussion history. This should be a consideration for clinicians in return to sport decision-making. Future studies examining subsequent recurrent concussion in youth sports must consider sex differences.

70

Double Vision and Light Sensitivity Symptoms are Associated With Return-to-School Timing After Pediatric Concussion

Schmitz, B, Smulligan, K.L., Wingerson, M.J., Walker, G.A., Wilson, J.C., Howell, D.R. *Clinical Journal of Sport Medicine* 33(3)264-269, May 2023

Study of 212 students; Missing more than 5 days of school was associated with double vision and light sensitivity but not associated with dizziness or blurred vision

68

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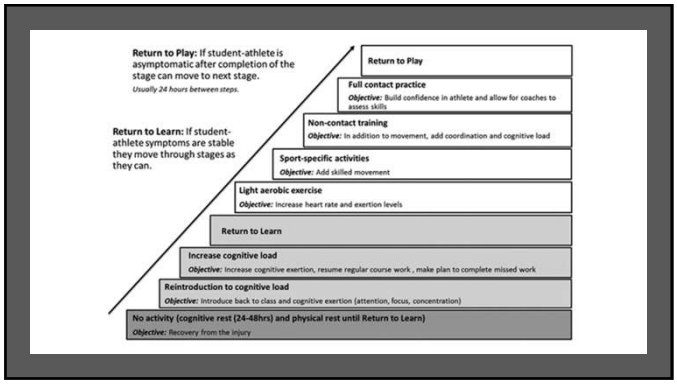

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Prolonged Recovery in Concussion

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Post Concussion Syndrome Definition and Symptoms

- Prolonged recovery is described as symptoms lasting more than 3 months from injury
- Common symptoms usually fall into four categories:
  - Cognitive
  - Sleep
  - Mood/Behavioral
  - Physical
- Occurs in roughly 10% of concussion cases of high school athletes but recent data suggests PCS is under-diagnosed in children and the rates may be 25% or higher

Persistent post-concussive syndrome in children after mild traumatic brain injury is prevalent and vastly underdiagnosed. Fried, E. Balla, U., Catalogna, M. et al. Scientific Reports 12, 4364 (2022)

73

What's the most common symptom indicating prolonged recovery from concussion?

On-field **dizziness** is associated with a 6.3-fold increase in the odds of a prolonged recovery

74

Post Trauma Vision Syndrome

- Defined by William Padula, OD in 1988
- "Dysfunction of the ambient vision process"
- Symptoms include:
  - Dizziness
  - Diplopia
  - Blurred vision at near
  - Perceived movement of print
  - Eyestrain (asthenopia)
  - Headaches
  - Photophobia

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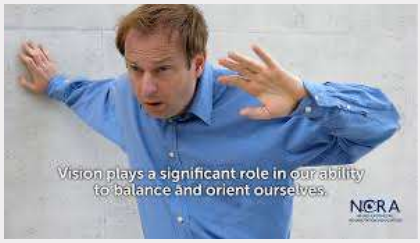

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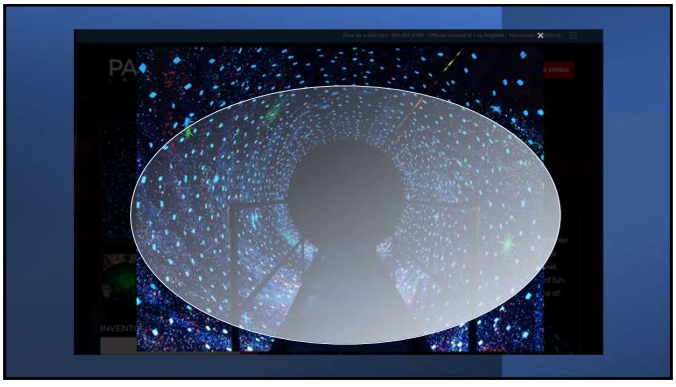
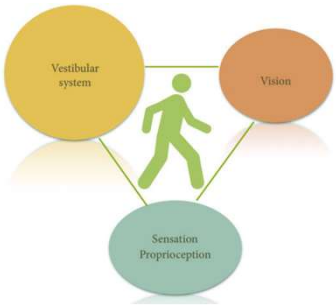


78

What can the vortex tunnel teach us?

Vision can "overpower" the other two systems (even when vision is malfunctioning!)



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How does this happen?

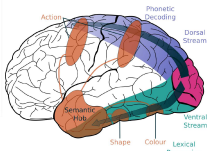
- The PERIPHERAL vision is the dominant aspect of vision
- NOT the central vision, which is largely the focus in optometric/ophthalmologic exams
- Visual acuity of 20/30 or better only occupies the central 6% of the retina

Over 90% of our visual system is devoted to peripheral vision processing!

80

A Tale of Two Systems: Dorsal and Ventral Streams

Factor	Ventral system	Dorsal system
Function	Recognition/identification	Visually guided behaviour
Sensitivity	High spatial frequencies - details	High temporal frequencies - motion
Memory	Long term stored representations	Only very short-term storage
Speed	Relatively slow	Relatively fast
Consciousness	Typically high	Typically low
Frame of reference	Allocentric or object-centered	Egocentric or viewer-centered
Visual input	Mainly foveal or parafoveal	Across retina
Monocular vision	Generally reasonably small effects	Often large effects e.g. motion parallax



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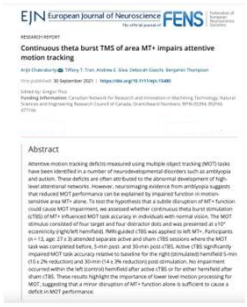
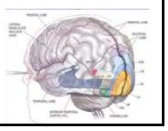
EDO



Abstract

Area MT is the only visual area fully myelinated at birth and the vestibular system is fully formed at 48 days gestation. Hebb's law states nerves that fire together, wire together.

Vision develops from the periphery inwards and "locks" with the vestibular system at birth to establish the VOR relationship—KEY!



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Use of Virtual Reality in Peripheral Awareness Testing-Emerging

- Early studies using VR to test for visual efficiency in peripheral vision awareness show that concussion patients have functional peripheral vision processing problems

Central and Peripheral Attention in Virtual Reality: Test of Visual Efficiency For Concussion Detection. Reneker JC, Pruett WA, Pannell WC, Brown M, Babi RM, Shirley HL, Zhang Y. Journal of Medical Extended Reality Volume 1.1, 2024

84

Slide 83

CD0 Area MT is the middle temporal part of cortex, responsible for the processing of visual motion

Cheryl Davidson, 2023-05-25T01:54:51.052

Unstable Ambient Vision (Magnocellular)

- Decoupling of the focal and ambient processes, which affects function and performance.
  - Deficits in posture, balance, movement, preconscious
  - Loss in speed of ambient visual processing
- M-cells have larger diameter axons and are more susceptible to damage.

85

Unstable Ambient Vision leads to "Focal Binding"

- Difficulty processing peripheral vision will often result in a tendency to "tunnel in" and pay attention only to central or focal objects.
- Causes inability to release detail.
- Environment becomes over-stimulating.
- Movement in the environment (busy, crowded) becomes chaos to the visual system.
- Print on page becomes mass of detail.

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Focal Binding & Motor Skills

- Movement becomes conscious and isolates function…**lack of automaticity.**
- No fluency because system is **unable to anticipate.**
- May have intact peripheral field, but **no peripheral awareness.**
- Lack of peripheral awareness makes them more **susceptible for re-injury.**

87

Oculomotor Dysfunction in PTVS

- Fixational control
- Saccadic latency and accuracy
- Anti-saccades or saccadic inhibition
- Pursuit deficits in both accuracy and timing
- Likely need computerized assessment to evaluate the timing/latency/accuracy deficits

88

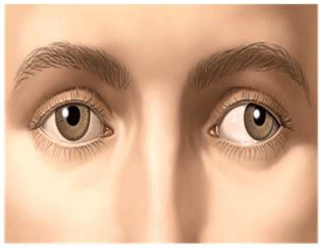
Double Vision is common in PTVS and typically Thought to be driven from Exotropia or Exophoria (Convergence Insufficiency). However, up to 1/3 of concussion patients may have Esophoria or Convergence Excess

It's easy to see how patients with binocular dysfunction might report "blurred vision" as a common symptom

89

High Exophoria / Exotropia

Eye Teaming Problem???



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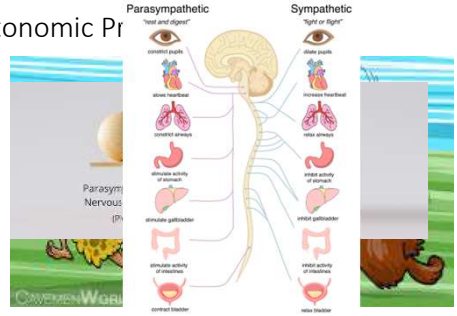
Autonomic Pr



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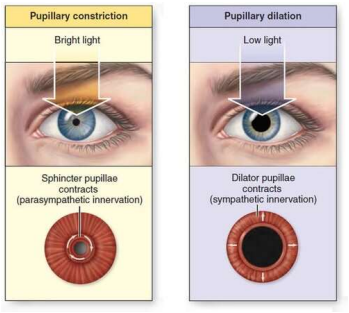
The Pupillary Light Reflex

- The Pupillary Light Reflex (PLR) has been studied as a biomarker for concussion.
- Pros: Objective, quick, and inexpensive to measure in a hospital or other clinical setting
- Cons: Variability by gender and age, need to control ambient light
- Research indicates lack of symptoms after concussion does not represent a return to typical PLR metrics



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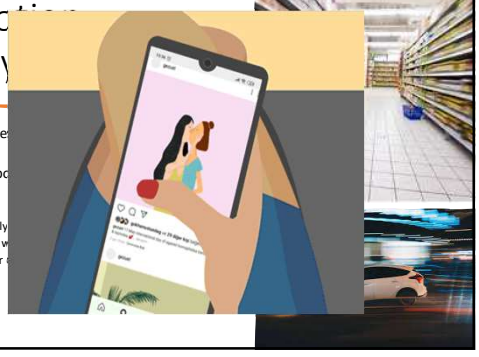
Visual Mo Sensitivity

- Common in PTVS, come dysfunction
- Patients commonly repo
  - The grocery store
  - The mall
  - When driving, especially
  - Watching tv or movies w
  - When scrolling on their



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Binasal Occlusion

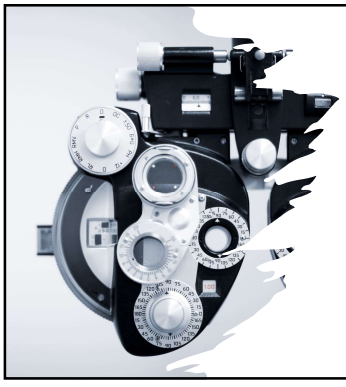
- A technique using tape to block out the nasal portion of the visual field
- Reduces confusion between right eye field and left eye field and decrease focal binding

94

Photophobia

- Extremely common, outdoors and indoors
- Sensitivity to fluorescent flicker as well as LED lights
- Diagnosis is by history and observation
- Treatments include tints, syntonics, binasal occlusion

95



My Examination for Prolonged Concussions

- Complete exam with dilation
- Eye movement testing including RightEYE/King Devick and/or EyeSync
- Binocular vision workup
- Second visit may include:
  - VEP
  - Syntonic color fields
  - Traditional visual fields
  - Tint, binasal or Prism evaluation

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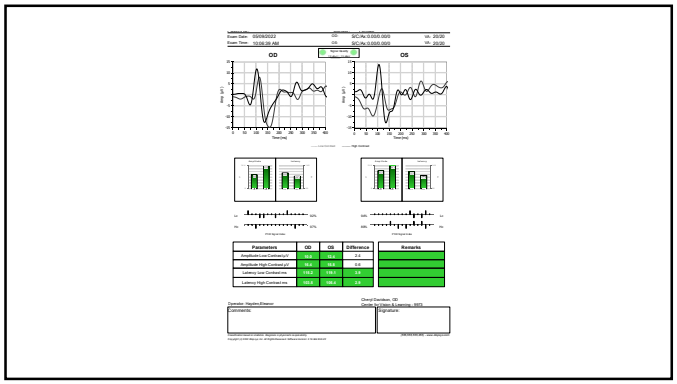
Assessing Ambient Visual Function: Visual Evoked Potential (VEP)

- VEP is a test that records the electrical potential of the brain
- Relatively quick
- Can help us with RX prescribing
- Objective
- Unbiased
- Malingerers?

Visual evoked potentials (VEP) evaluating treatment for post-trauma vision syndrome (PTVS) in patients with traumatic Brain injuries (TBI) Padula, W.V., Argyris, S, Ray, J. *Brain Injury*, 8(2), 125-133.

97



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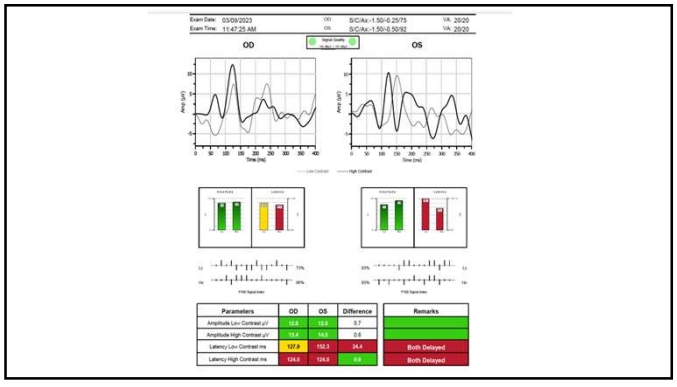

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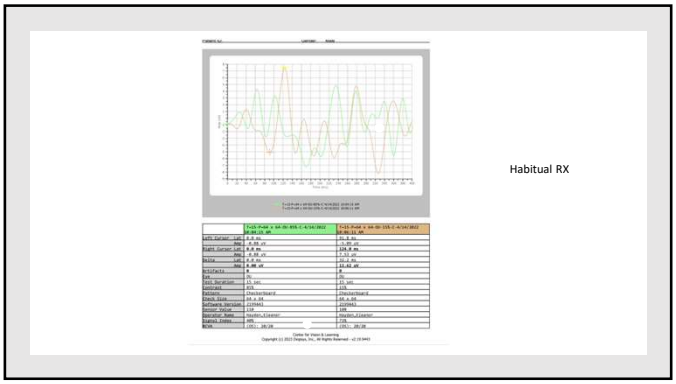
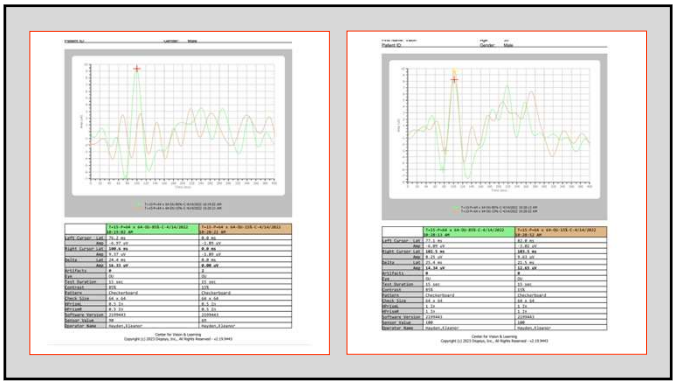


Habitual RX

100



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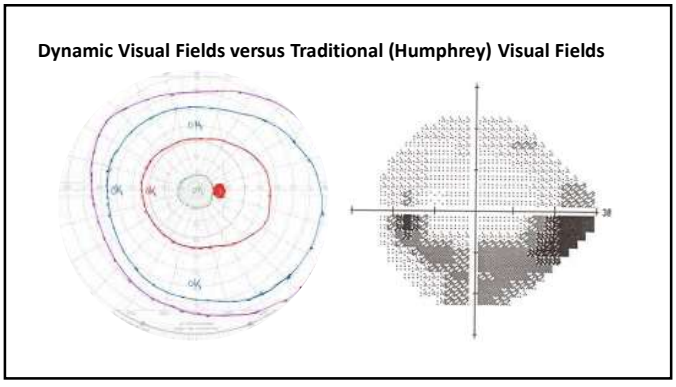
Dynamic Visual Fields versus Traditional (Humphrey) Visual Fields



Treatment Options in PTVS

- Change to RX or new RX
  - Small changes may make a big difference to your patient
  - May need 2 pairs of glasses if dizziness/fall risk is prominent
  - Prism
- Binasal occlusion
- Tinted lenses or photochromic (Transitions)
- Vision Therapy
- Referral/consultation with sports medicine/neurologist/PT or OT, as appropriate
- Optometric Multisensory Therapy
- Red light therapy

103

Effect of vision therapy on measures of oculomotor function of patients presenting with post-concussion syndrome.
Rollet, P and Morandi, G. Canadian Journal of Optometry. Vol 81 (4) 2019.

In general, improvements in measures of oculomotor functioning were greatest for near point of convergence, vergence facility and accommodative facility. Patients receiving 20 sessions of VT had improved and less variable outcomes when compared to those receiving 5-10 sessions of VT. In addition, VT was found to improve symptoms of visual discomfort in patients presenting with PCS. Results of this retrospective analysis demonstrate significant improvements in measured outcomes for all patients receiving VT and support VT as a treatment option for symptoms of PCS.

104

Receded Near Point of Convergence Is Not Diagnostic of Convergence Insufficiency
Raghuram, A, et al. *American Journal of Ophthalmology*. May 2019.

- **Retrospective analysis of 83 patients <21 yo, >28 days post-concussion, with chronic symptoms**
- **Conclusions**
  - 89% had receded NPC
  - Of these, 95% had oculomotor dysfunction
  - 41% had disorders of accommodation
  - 28% had convergence insufficiency AND accommodative dysfunction
  - Only 8% had convergence insufficiency only

YOU NEED TO LOOK AT THE WHOLE VISUAL SYSTEM!

105

Options for Photophobia

- TINTS AND COATINGS
  - FL41-Rose tint
  - Light blue or omega (purple) – calming
  - BluTech – computer

106

Syntonic Phototherapy

- **Application of selected light frequencies through the eyes**
- **Based on autonomic principles to restore homeostasis to the neurologic system**
- **Diagnosed by symptoms, clinical findings and peripheral vision sensitivity**
- **Treated daily for up to 20 minutes per session**

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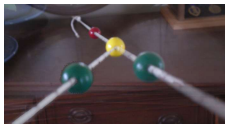
Brock String—Friend or Foe?

- Brock string is an EXCELLENT technique to work eye teaming
- Brock string is NOT an excellent technique to work eye teaming if it's caused by autonomic dysfunction
  - You run the risk of further reinforcing the focal binding that is already present in your patients
- If you choose to use brock string with your concussion patients, always pay attention to the periphery!



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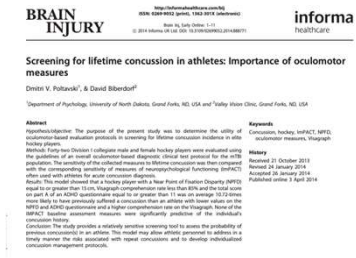

Screening for lifetime concussion in athletes: Importance of oculomotor measures

"presence of oculomotor dysfunction…on average 10.72x more likely to have previously suffered a concussion…

112

Sequelae of Concussions

110

When To Refer For a Functional OD Evaluation

- Double vision or other visual symptoms limiting progress in OT/PT
- 4 weeks post-injury and still having visual symptoms (or 4 weeks after treatment begins)
- Depending on patient's stamina/symptom level could be a 2 hour evaluation

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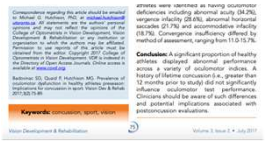
Prevalence of Oculomotor Dysfunction in Healthy Athletes Preseason: Implications for Concussion in Sport

On average, approximately 1 in 5 varsity athletes had significant dynamic visual issues at BASELINE



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Referral Resources

- Referring to a vision therapy provider:
  - Work with area professionals, get to know them
  - Explain to them what services you provide and conditions you enjoy treating
  - Send information along regarding the patient you wish to refer

OVDRA Optometric Vision Development & Rehabilitation Association

NORA NEURO-OPTOMETRIC REHABILITATION ASSOCIATION

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"The difference between an average healthcare professional & an excellent one is that **the excellent one knows when to get others involved.**"

--Eric Singman, MD, PhD--

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Thank you!

Cheryl Davidson, OD, FOVDR

DrDavidson@cvlstl.com

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