Vision Vestibular Dysfunction
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• Concussion Clinical Trajectories
• Most commonly reported symptoms
  (Lovell et al 2004)
• Ocular Motor Dysfunction following mTBI
  Capo’-Aponte et. Al Military Medicine 2012
• It’s a brain thang!
  • 70% of our brain is dedicated to vision in some fashion
  • 80% of all sensory function goes through the eyes
  • 90% of individuals that have a concussion will demonstrate 1 or more ocular difficulties
  • If not addressed these ocular difficulties can result in a delayed recovery
  • 40% of individuals will have ocular difficulties longer than 3 months
  • Intervention is helpful in ensuring resolution of ocular complaints and meeting the other trajectories as well

• Three Visual Pathways
  • Parvo-cellular (80%)
    • Occipital Lobe
    • What? Temporal/Ventral
  • Magno-cellular (18%)
    • Midbrain
    • Where? Parietal/Dorsal
  • Konio-cellular (2%)
    • Midbrain

• Central/Focal/Parvo/What?
  • Focal – central – mostly macular function
  • Detail discrimination – visual acuity
  • Attention
  • Concentration
  • Orientation to present consciousness
- **Slow speed** in processing/occipital cortex
- Mostly cortical/higher processing
- Peripheral/Ambient/Magno/Where?
  - Spatial orientation
  - Posture/balance
  - Movement
  - Anticipates change in the preconscious
- **Rapid speed** in processing
  - Fight or Flight – survival mode
- Peripheral/Ambient/Magno/Where?
  - 20% of all nerve fibers of the eye **do not** go to the occipital cortex – go to midbrain
  - Midbrain delivers *SENSORIMOTOR*
  - Spatial visual processes include:
    - Preconscious and proactive
    - Receives feedback from the cortex
    - Brings forward all possibilities for neuro organization
- **Koniocellular**
  - Balances information between parvo and magno
  - Understanding koniocellular may help explain suppression (research is being done)
  - About 2% of nerve fibers go to konio
  - Can operate in closed eye situations
- **Post Trauma Vision Syndrome (PTVS)**
  - Constellation of problems after concussion
  - Signs and symptoms may include:
    - Eyes drifting outward
    - Eyes not working together
    - Double vision
    - Blurred vision
    - Light sensitivity
- Visual field loss
- Concentration difficulties
- Reading problems
- Poor spatial judgment/depth perception
- Possible midline shift

**PTVS and Cognition**
- The balance and interaction between vision and motor is compromised.
- Visual dysfunction causes recovery delays
- Learning interference
- Problems with communication
- Disrupts time and space by “focal binding”
- Affects memory

**PTVS and Motor Skills**
- “Focal binding” compromises preconscious/proactive relationship between ambient system, vestibular and proprioception
- Movement becomes conscious (top down) and isolates function
- No fluency because the system is unable to anticipate (i.e. reading, etc.)

**Over-Focalization of Detail - “Focal Binding”**
- 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 a mass of detail
- Movement of the eyes is projected into the field causing movement of print or ground being walked on

**Think about a grocery store or cafeteria...**
- Abnormal visual processing affects postural tone
- The individual with a concussion has a breakdown in the organization of CNS and automatic responses, which links with the preconscious nature of the visual system: the *ambient process*
- This leads to mal-adaptation and nonfunctional responses
• Common Neurological Sensitivities
  • Light
  • Sound
  • Smell
  • Movement patterns in the visual fields
  • Concussion Clinical Trajectories
• Tools to help
  • Post concussion symptoms survey + questions in the 6 trajectories can provide
  • Brain Localization Form + Vestibular Localization Form
  • VOMS, KD, NSUCO
  • RightEye
• Diagnosis of Concussion – What I look for
  • Start with suspicion/evidence of an injury
  • Mechanism of injury – initial symptoms
  • Get baseline data if available
  • What are their symptoms and provocative activities
  • Changes in balance/motor function
  • History of previous injury - recovery time?
  • Medical history – Mental health, ADHD, Migraines
  • We make our office available to see them immediately.
• Immediate response to TBI
  • The fencing response is a peculiar position of the arms following a concussion. Immediately after moderate forces have been applied to the brainstem, the forearms are held flexed or extended (typically into the air) for a period lasting up to several seconds after the impact. The fencing response is often observed during athletic competition involving contact, such as American football, hockey, rugby and martial arts. It is used as an overt indicator of injury force magnitude and midbrain localization to aid in injury identification and classification for events including, but not limited to, on-field and/or bystander observations of sports-related head injurie
  • Brainstem vestibular nuclei vulnerable to injury forces
• Autonomic nervous system
• The brainstem monitors and regulates the autonomic nervous system; breathing, heart rate, blood pressure and circulation, chewing and swallowing, reflexes of seeing and hearing (startle) sweating, digestion, body temperature, pupil size.

It affects alertness, tasting, formation of saliva, vomiting, urination, ability to sleep (sleep-wake cycle regulation), sense of balance (vestibular), feeling of gravity and can cause a central sleep apnea (CSAS).

Scattered throughout the brainstem, is the reticular formation that controls consciousness (that distinguishes important and unimportant stimuli)

• Chronic neurological dysfunction emerges when the injured brain repairs itself
  • Definition of concussion is a pathophysiological process that leads to clinical symptoms
  • Acute: neurochemical, metabolic
  • Chronic: microscopic, vascular / glymphatic, structural
  • Recovery must offset complex, neurovascular pathophysiology and redirect circuit repair
  • Rehabilitation and retraining
  • Alternative interventions
  • Pharmacological interventions

• UPMC Recommendations for Baselines
  • Assessment of:
    • Vision – VOMS (pursuits, saccades, NPC)
    • Vestibular – VOMS (VOR & VOR Cancellation)
    • Balance – BESS test
    • Cognition – ImPACT
  • Other tools include SCAT3 & Child SCAT (Age 5-12), King-Devick, other computer NC tests (Vitals Signs, CogState, Headminer)
  • Cognitive issues that linger are showing up as unresolved visual vestibular issues
  • Anxiety trajectory is showing as a consequence of unresolved vision vestibular issues

• Treatment
  • Got to get them sleeping – CALM
• Look at their metabolic state—89% of TBI have thyroid issues, glycemic issues (regulation of glucose)
• Hydration
• Antioxidants

• Common Visual Symptoms

  • **Blurred or fluctuating vision:** Deficits in accommodation or a reduced ability to compensate for a minor prescription can result in blurred or fluctuating vision.

  • **Double vision:** > ½ TBI patients see double. Often, double vision is only present intermittently and patients may not even realize that what they are experiencing is double vision. One major cause of double vision following a concussion is **convergence insufficiency**

  • **Eye tracking deficits:** Difficulties with reading or computer work is extremely common after a concussion. This is one reason why eye tracking tests are used to help diagnose concussions.

  • **Light sensitivity:** Many concussion patients will find that they are bothered by certain types of light, even when indoors.

• Non Visual Symptoms

  • **Reduced cognitive abilities:** Feeling like you are ‘in a fog’? Difficulties with concentration, memory and thinking quickly are very common in concussion patients.

  • **Balance difficulties/dizziness:** The visual system has a strong influence on balance. When vision conditions are present, it can affect your balance and create dizziness and nausea

  • **Headaches:** Evaluation of the eyes should be considered when headaches are present, especially when they occur at the end of the day or after visual activities (reading, computer work, etc).

Our Assessment

• **Eye Tracking:**
  • RightEye
  • KD
  • NSUCO
  • VOMS—covers pursuits, saccades, NPC, VOR, VMS

• **Structure Exam:**
  • VA—refraction when necessary
• Pupils
• Cranial nerve exam
• VF/OCT of the optic nerve/IOP
• Optos
• **Functional Exam:**
  • Dynamic VA (if they are not extremely symptomatic)
  • Balance – BESS/Sway
  • ImPACT
  • Dynavision
  • NeuroTracker

Stats
• KD + BESS + SCAT3 = 100% diagnosis of concussion
• Receded NPC occurs 55%-61% in concussed student athletes
• Decrease in accommodation 65%-69%
• 91% of mTBI will have a prefrontal cortex affect
• Concussion + No solution = Hysteria
• There is a solution—sports vision performance—it can help “hardwire” *(Clark 2015)*
• Our core of sports vision performance is DynaVision + Neurotracker

Early Concussion Management
• Day 0-3 up to 10 days – Rest is still key, but we **cannot** leave them in perpetual rest
• By day 3 -10 we need to get them moving (some evidence shows that earlier than this = better outcomes)
• Identifying the primary trajectory of symptoms allows us to direct treatment and refer appropriately
• Another way of looking at it, the autonomic system is affected. The sympathetic system is “hot” and the parasympathetic system is depressed.
• We have found that craniosacral, photobiomodulation, and compression are some things that can temper the sympathetic system.
• Often, it gives them relief from the headache or dizziness they present with

Concussed Student Athlete
• They have a disconnect between the 80% oculomotor and 20% proprioceptive information

• The concussion causes visual dysfunction that directly influences posture, balance, movement, memory, cognition, attention, and concentration

• Loss of/reduction in sub-cortical processing

• **Mismatch** between visual and sensorimotor information affects balance, posture, movement, and spatial orientation (hallucinations, false sense of movement, dizziness etc.)

• Visual impairment causes anxiety, loss of independence, and decreased socialization

What came first? Where can we start?

• **If we have to devote attention to posture we cannot attend to other things**

• Posture should be part of an organizational set that does not require conscious attention

• If the sensorimotor system is out of balance, it will affect visual processing and vestibular and cognition into anxiety

• And conversely, if visual processing is out of balance, it will affect sensorimotor processing, vestibular and cognition into anxiety

• **A mismatch!**

• Priorities for Treatment
  • Visual Issues
  • Double vision
  • Light Sensitivity
  • Vestibular problems
  • Focal/Spatial imbalance
  • Focal visual tasks

Optometry Tools

• 1) BNO – helps with reading

• 2) Tint – 15% blue

• **Vision Training**

• 3) +0.50 – releases focal binding

• 4) Base In Prism – 0.5-2 PD – helps to release focal binding

• Other Treatment Strategies

• Sleep – sleep hygiene, melatonin, amitriptyline, Calm
• Pacing and planning – sub-symptomatic graded activity, ideas for non-provoking activities (audiobooks, podcasts)
• Headaches – medication, acupuncture, craniosacral, C-spine Tx
• Noise sensitivity – musician filter ear plugs, graded exposure, Listening Program
• Anxiety – Mindfulness, craniosacral, easy movement, Tai chi

Non Visual Issues
• Vision vestibular rehab strategies
• Logical order of treatment:
  1) Fixations
  2) Pursuits
  3) Saccades
  4) Vergence/Accommodation
  5) Cognitive load
  6) Vision/vestibular integration
  7) Movement sensitivity/body awareness
     *Often done simultaneously.
• Vision/vestibular integration
• VOR and Gaze stabilization—lots of eye targeting with head movements—changing stance—wide gait, tandem, etc
• Marsden Ball—dodging and catching increase to two
• Percon Saccades with metronome—also trains anticipation
• Brock string—keeping the periphery open
• Cognitive load—add stroop color word exercise
• Vision/vestibular integration—Bean bag toss, infinity walk, chair spins, OKN stimulation
• Dynamic movement and posture—TUG, sit to stand, standing reach,Fukuda stepping,walking, tai chi, yoga, Wii
• Additional interventions
• Compression—weighted vest or tight fitting tee shirt under clothing or could use thera-band
• Proprioceptive retraining—Laser pointer on top of the head helps train eye/head/neck motor control and proprioception
• Principles of Vision Retraining

1) Structure evaluation of the eyes does not provide a complete screening or diagnostic assessment for a comprehensive understanding of the visual system. (It evaluates structure, not function.)

2) **Vision is a skill.** Vision learning and relearning have hierarchies that are fundamental to the development and re-establishment of visual pathways in visual perception and visual behavior.

3) We should not put central vision exercises on a system that has had a potential concussion. Building on an already challenged peripheral system and/or vestibular/proprioceptive system may cause the student athlete to get worse.

Pyramid of Treatment

• Start with exercises that start in the peripheral/ambient vision with vestibular components.

• The patient is in “hyper” focal or focal binding. If we start with fixations, pursuits, saccades, accommodation and vergences, this patient will become more “locked up” and the symptoms may get worse.

• This why vision retraining can have mixed results with healthcare providers who do not understand that the ambient system (Spatial) is the basis for starting therapy.

• Motor Skills, Vestibular, Peripheral Awareness

• Primitive Reflexes, Gross Motor Skills, Balance/Vestibular, Peripheral

• Primitive Reflex Integration Protocol - we focus on: Moro, TLR, Spinal Galant, ATNR, STNR, Palmar, Head Righting

• Multisensory Systems Therapy / Syntonsics

• Balance board/Bosu ball work /Balance Master /Balance Beam/Walking Rail

• Platform swing work

• DynaVision emphasizing peripheral

• Circle jumping

• Kirschner Arrows

• VO Star

• McDonald/Lora’s Card

• Body Awareness

• Infinity Walk

• Fine Motor Skills, Eye Hand Coordination

• Pencil Olympics

• Masgutova Hand Exercises/Sign Language Alphabet
• Stringing Beads, Lacing Cards
• Tweezer activities
• DynaVision
• Makoto Arena
• Pegboards
• Bean Bag/Scarf Toss
• Flashlight Tag
• Clothespin Drop
• Marsden ball bunting
• Peripheral finger touch
• McDonald Card/Lora’s Card

Central Vision/Eye Alignment

• Eye Alignment, Near Equal Acuity (active patching, binasals, sector occlusion)
• *Often this does not need to be a separate step, other procedures help to improve alignment and/or acuity
• MIT

Vision Skills

• Monocular skills (acuity, fixation, pursuits, saccades, accommodation, central/peripheral)
• Stick/Straw
• Flippers
• Marsden Ball
• Hart charts
• Prism jumps (emphasize JND)
• Lens sorting
• Ann Arbor Tracking
• Split bifocal rock
• Rotating pegboard
• After Image
• Eye stretches - Close & Closed Eye Movements
• MFBF
• SVI with R/B glasses
• DynaVision with R/G glasses
• NVR
• Dissociated prisms
• Bar Reader/TV Trainer activities

Vision Skills
• 1st degree fusion
• Stereoscope
• Cheiroscope
• Quoits
• 2nd degree fusion
• Vectograms/Tranaglyphs
• Brock String
• Aperture Rule

Vision Skills
• Vergence Ranges
• Wheatstone stereoscope
• Vectograms/Tranaglyphs
• HTS Computer system
• Jump Ductions
• Two vectograms split on stand
• Prism flippers
• Other treatments
• Vibration—power plate or vibrating insoles
• Binasal Occlusion—works about 79% of the time to relieve symptoms and help with more fluent reading
• Micro-prism
• Yoked prisms—used a lot with motor activities
• Clearance for Return to Learn/ Play
• Role of Exertion
• Vision & vestibular tasks in space with hand/eye coordination
• Sport specific visual tasks – need to be fast & multidirectional
• Should include multiple systems: balance, vestibular, cognitive & vision
• Need to get heart rate up while doing tasks

Case Study
• 15 year old female sustained a concussion in volleyball
• Dove for a ball rotated and hit back of head on the floor
• Therapy for poor accommodation, extreme symptoms with near work
• 10 sessions later, can do Brock string, NPC to nose with good control, pursuits with good eye teaming, +/- 1.50 flippers with ease
  • BUT – VERY symptomatic!!!
• Should be an “easy” case, what is wrong?
• Peripheral work was missing!
  • What to do with a 15 year old?
    • DynaVision, peripheral identification, scan board, reminders to keep vision “open”
    • Scanning and walking with head movement and hand coordination
• After starting session with peripheral work – student athlete ended session without complaint of eyestrain for the first time!
• And on follow up remained symptom free
• Started exertion protocol and finished with releasing her back to full play—they did not have an AT so we did the work

Case study
• 13 year old had a clavicle injury 5 months ago, recovered started playing in soccer
• Reports no real incident of concussion but was having a lot of difficulty in school
• VOMS confirmed receded NPC and increase in symptoms with the screening
• Described most all the symptoms of PTVS and IMPACT scores were not to baseline

Vision retraining
• Initiated Peripheral vision work with vestibular
• Saw him 3 times for 45 minutes for 2 weeks
• Reported feeling better the first session continued increasing levels of training—increasing heart rate and exertion doing cognitive load with dynavision and neurotracker
• After the last session, had him come in the next day and do the IMPACT
• All scores were at or above baseline
• Returned him to the AT who did the RTP protocol with exertion and heart rate for his school protocol
• Played football this year without incident

Summary
• The Eye tracking is an excellent screening tool that helps identify a potential problem in the vestibular and ocular motor issues

RightEye, VOMS, KD, NSUCO
• Vision is learned. Vision is bi-modal. Ambient visual system disconnects.
• Always start with peripheral vision exercises first so as not to “bind” or further lock up the visual system

Dynavision/Senaptec are the cornerstone of our concussion protocol
with NeuroTracker as the finisher
• Concussion management requires a “TEAM”—you do not have to offer therapy to be a great source for the recovery team—Rehab OD, OT, PT, AT—need your input