NO SINGLE TEST CAN DIAGNOSE CONCUSSION
NO SINGLE TEST CAN RELIABLY DETERMINE RECOVERY
WE STILL DO NOT KNOW A LOT ABOUT CONCUSSIONS
BUT WE ARE GETTING CLOSER
DEFINITION

- Neurosurgery journal study reviewed over 5000 studies
- 26 met criteria
- 1st evidence-based criteria for concussion diagnosis
PREVALENT INDICATORS

• Observed and documented disorientation or confusion immediately after the event

• Impaired balance within 1 day after injury

• Slower reaction time within 2 days after injury

• Impaired verbal learning and memory within 2 days after injury
CAUSE

- BIOMECHANICAL FORCES
  - Functional impairments without overt structural damage
  - Rapid acceleration/deceleration
  - Rotational forces considered a “prerequisite” for widespread injury to cause a concussion


ROTATIONAL FORCES

• Stretching and shearing of axonal and cell membranes (i.e., diffuse damage) —>

• Unchecked flux of ions through formerly regulated channels and membranes —>

• Indiscriminate release of excitatory neurotransmitters —>

• Instigates a widespread, and potentially excitotoxic, neuronal depolarization —>

• Adenosine triphosphate (ATP)-dependent Na+/K+ pumps work in overdrive —>

• Increases glucose metabolism = Hyperglycolysis —>

• Overproduction of lactate = disrupts neural function

• Acute hyperglycolysis state lasts minutes to hours—>

• Prolonged hypoglycolysis —mismatch in glucose supply vs. demand

• May produce immediate PCS symptoms, leave brain vulnerable to secondary injuries

**INCIDENCE**

**HIGHEST**

- Rugby 4.18 (per 1000 AE)
- Hockey 1.20
- American football 0.53

INCIDENCE

LOWEST

• Volleyball 0.03
• Baseball 0.06
• Cheerleading 0.07

SYMPTOMS

• Headache (93%)
• Dizziness (75%)
• Difficulty concentrating (57%)
• Confusion (46%)
• Visual disturbance or photosensitivity (38%)

CONCUSSION RATING

• SIMPLE: resolves within 7-10 days (95%)
• COMPLEX: longer than 10 days
CONCUSSION RATING

- COMPLEX concussion not the same as POST-CONCUSSIVE SYNDROME (PCS)
- PCS: > 3 months symptoms
POST-CONCUSSIVE SYNDROME (PCS)

- Recurrent concussion increases odds
- Symptoms most likely to lead to PCS
  - Sensitivity to light
  - Retrograde amnesia
  - Difficulty concentrating
  - Insomnia

SCAT 5
SIDELINE TEST

- Sideline assessment tool
- Baseline testing
- Updated in 2017
- More specific step-wise process
- Still have full-contact practice as a stage to “clear”
CHANGING PERSPECTIVES

Mechanism

Diagnosis

Treatment

Lead author: Michel Rathbone, McMaster University
INFLAMMATION

• Post-concussive syndrome—>post-inflammatory brain syndrome

• Explains numerous types of symptoms in PCS

• Explains concussion-like symptoms in patients with no history of head trauma: systemic inflammatory responses
NEUROINFLAMMATION

- Occurs independently of changes in BBB permeability
- Seen in response to almost all neurological disorders, including concussions
ACUTE RESPONSE

- **Interleukin-1** (pro-inflammatory)
  - Rise in IL-1\(\beta\) precedes secretion of ciliary neurotrophic factor (CNTF) and nerve growth factor (NGF)
    - Promote growth and survival of neurons
  - Aids in defense against injury
- Prolonged exposure could be neurotoxic
ACUTE RESPONSE

• **Tumor necrosis factor-α**
  
  • Early mediator of CNS damage
  
  • Also neuroprotective and neurotoxic
ACUTE RESPONSE

- Interleukin-6 (IL-6)
  - Key regulator during acute phase of inflammatory response
  - Also neuroprotective and neurotoxic
NSAIDS?

- Shown to be not effective
- Targeting this inflammatory cascade has not worked
- Timing:
  - Too soon: interfere with neuroprotective effects of inflammation
  - Too late: damage too great to overcome
OMEGA-3 FFA

- Supplementation with O3FA before a concussion
- Protects against reduced plasticity of neurons and impaired learning
- Normalizing levels of proteins associated with neuronal circuit function, cognitive processing, synaptic facilitation, neuronal excitability, and locomotor control

OMEGA-3 FFA

• Case study of a young boy with sTBI from a motor vehicle accident
• In a persistent vegetative state
• After starting O3FFA supplementation, improved
• Able to walk for HS graduation 3 months later
OMEGA-3 FFA


OMEGA-3 FFA

- No human studies with high evidence
- Two human studies currently ongoing
  - NCAA division 1 athletes with 2200 mg of DHA for 30 days after onset of a concussion
  - 14 to 18 y/o with 2 g of DHA daily for 3 months

CURCUMIN

- Found in turmeric
- Animal supplementation with curcumin before a concussion
  - Improved balance
  - Transduction and monitoring of cellular energy compared with controls
- Promising but no human trials

PROGESTERONE

• Neuroprotective and neuroregenerative abilities and reduces inflammation

• Effects improved with Vitamin D

• Cochrane Review did not find it helps but not enough data, studies inconsistently done
OTHER SUPPLEMENTS

• Resveratrol

• Melatonin

• Creatine

• Vitamin C, D, and E

• Scutellaria baicalensis (Chinese herb)
NEUROINFLAMMATION

• Not quite the same as general inflammation

• Manipulating neuroinflammation key to treating long-term symptoms of concussion
WHEN IS A CONCUSSION GONE?
CURRENT METHOD

• Symptoms must resolve

• No symptoms return during exercise protocol
COMPUTERIZED NEUROPSYCH TESTING

- Insufficient validity and test–retest reliability
- Can have metabolic changes from concussion even when ImPACT returns to baseline
- 17% of concussions had normal ImPACT
- 20-40% of nonconcussed athletes showed cognitive impairment
PET SCAN

• Uses radio-labeled metabolic analogs to measure brain glucose metabolism

• Lower glucose metabolism in concussed patients correlate with cognitive disturbances

• Very promising but more research needed to determine potential clinical utility and validate
FUNCTIONAL MRI

- Blood-oxygen-level-dependent (BOLD) fMRI
- Detects changes in oxygenation state of hemoglobin
- Changes in concussed brain activation detected acutely and months after injury
- Hard to interpret, expensive, not always covered
MAGNETIC RESONANCE SPECTROSCOPY

- Measures the concentrations of molecules associated with brain metabolism
- Concussion significantly lowers gray matter glutamine and N-acetylaspartate (NAA) levels
- Increases white matter creatine and choline levels
- May help determine metabolic recovery from concussion and determine return to play
MAGNETIC RESONANCE SPECTROSCOPY

- Study: One cohort of patients with concussion
- Symptoms resolved in about 3 days
- Took 30 days for the NAA level and NAA/Cr ratio to return to baseline

TREATMENT
APPROACH TO TREATMENT

- Comprehensive
- Active
- Proactive
- Engagement
FOUR DOMAINS OF SYMPTOMS

- Physical
- Cognitive
- Emotional
- Sleep
TREATMENT

• Acute
• School
• Cognitive
• Visual
• Auditory
• Psych

• Endocrine
• Vestibular
• Rehabilitation
• Exercise
• Sleep
ACUTE: COGNITIVE REST

- Concussion: Neuroinflammatory concept
- Similar approach to an acute ankle sprain
- 72-hour inflammatory phase
- Treatment goal—calm down inflammation
COGNITIVE REST

• No **reading, video games, computer screens** longer than 30 minutes (or when symptoms are provoked)

• Minimal **texting**

• Avoid loud **music**

• Avoid activities requiring **focus**
Cognitive Rest

- May do light physical activity that does not cause symptoms or risk further injury
- Frequent naps allowed (no longer than 30 minutes)
COGNITIVE REST—SCHOOL

- No school first post-concussive day
- Strongly consider no school for 1st 3 days
- Communication with school officials is key
- Understand athlete’s stress
RETURN TO LEARN

• Can tolerate 30-45 minutes of concentrated activity without symptoms

• Gradual return: half days, then full day

• Give athlete detailed accommodations

SCHOOL ACCOMMODATIONS

- Rest during school day
- Reduction in workload
- Shorter assignments
- More time to complete work
- Wear hat to block fluorescent lights
SCHOOL ACCOMMODATIONS

• Shortened school days (alternate half-days)
• Shortened classes
• Fewer activities requiring exertion
• Breaks during school day (quiet location)
• Line guide (bookmark or index card) when reading to reduce the work involved for the eyes to scan
SCHOOL ACCOMMODATIONS

• Quiet room to complete assignments or tests
• Avoid noisy events or areas (cafeteria, pep rally, sporting events)
• Tutoring or peer helper
• Tests reduced or postponed
BRAIN ACTIVITY

• Changes in alpha, beta, theta, delta brain wave activity

• Gray and white matter can suffer injury

• As gray matter recovers, may not be re-integrated into neural network function—>”not working”

• White matter: high speed relay system connecting to cortex

• Gray matter highly plastic, white matter is not
BRAIN MAPPING—QEEG

• qEEG: Quantitative Electroencephalography

• Multiple EEG electrodes measuring activity (32 leads) and digitally processed

• Assess changes in brain wave frequency bands

• “Map” areas of brain with slower brain wave activity

• Assess coherence
COHERENCE

- Correlation between regions: high connectivity
- Connectivity reflects amount of processing brain devotes to a certain activity
- Changes in coherence can reflect difficulties in processing
**SPECT Findings:**
- Traumatic Brain Injury
- Atypical Mood Disorder (Bipolar)
- Anxiety Disorder

**qEEG Findings:**
- Patient No Evidence of TBI
- TBI Signature Pattern
- Bipolar Disorder

Over activity in the “fight or flight” region of the brain as a result of Bipolar
NEUROFEEDBACK

- Guided by qEEG
- Helps to improve brain wave activities
- Computer games
- NF can treat ADHD, depression, anxiety, addictions
- Improve connectivity and coherence
USE IN CONCUSSION/PCS

• Active treatment for various cognitive PCS symptoms
  • Concentration
  • Memory
  • Headaches

• Proactive method of treating acute symptoms
• Pituitary protected by sella turcica but stalk vulnerable to TBI forces
• Stalk connected to anterior pituitary and hypothalamus
• TBI can lead to stalk rupture, hypothalamic abnormalities and hypopituitarism
Endocrine

- 4% of patients with TBI sustained an associated neuroendocrine disorder of the hypothalamic-pituitary axis

- 40-63% of fatal cases of TBI reveal postmortem pathologic findings of the hypothalamus/anterior pituitary
PITUITARY GLAND

- Anterior lobe: growth hormone [GH], thyrotropin, corticotropin, gonadotropins
  - Released by neuropeptide-releasing hormones from the hypothalamus
- Posterior lobe: vasopressin, oxytocin
  - Produced by hypothalamus, stored in lobe for release
  - Not affected by pituitary stalk trauma
PITUITARY GLAND

- 5-90% incidence (Endocrine Feb 2014)
- 27.5% hypopituitarism in some form out of 1000+ TBI cases
Most common endocrine complications after TBI:

- Decreased ADH (SIADH/dilutional hyponatremia)
- Decreased Growth Hormone

GROWTH HORMONE

- Fatigue
- Growth problems
- Weight gain
- Low blood pressure
- Low libido
- Loss of muscle mass
- Amenorrhea
OTHER ENDOCRINE EFFECTS

• Hypothyroidism: fatigue, constipation, weight gain, irregular menstrual periods, cold intolerance

• Hyperprolactinemia: irregular menstrual periods, nipple discharge, and erectile dysfunction

• Screen for hormonal disorders (lab tests)

• Refer for appropriate treatment
HEARING

• Loud or numerous noises provoke symptoms
• Temporary threshold shift
• Symptoms can last long time
TREATMENT

• Lower constant decibel exposure
• Avoid situations with loud or numerous noises
• Educate patient
VISUAL
• Visual testing newer trend in sideline eval

• 50% of brain “circuits” linked through vision

• Many susceptible to disruption from head injury
• Visual testing newer trend in sideline eval

• 50% of brain “circuits” linked through vision

• Many susceptible to disruption from head injury
KING-DEVICK TEST

- Assesses visual function and attention integrity
- 1-2 minutes to perform
- Track saccadic eye movements
- Athlete rapidly reads numbers on 3 test cards
- Score = total time required (seconds)
SACCADIC EYE MOVEMENT

Rapid, ballistic movements of the eyes that abruptly change the point of fixation.
**KING-DEVICK TEST**

- KD 75% sensitive in detecting concussion


- SAC + BESS: miss 10% of concussions (n=20)

- SAC + BESS + KD: all concussions detected

VISUAL DISRUPTION

- Headache
- Loss of balance
- Blurred vision
- Inattention
- Poor memory
- Vertigo
- Dizziness
- Anxiety
- TMJ
- Neck pain
BINOCULAR VISION DYSFUNCTION

- Eyes not aligned after TBI
- Muscles in and around eyes overwork when focusing
- Increased tension
- Treatment goals: progressive relaxation
Binocular Vision Dysfunction Questionnaire (BVDQ) For ages 14 & older

Name: _______________________________ Email: _______________________________ Date: __________

Best Phone Number: ___________________ Back-Up Phone Number: ___________________

How did you hear about Vision Specialists of Michigan?

Directions: For each of the following questions, please check the answer that best describes your situation. If you wear glasses or contact lenses, answer the questions assuming that you are wearing them.

Always = Every day
Frequently = At least 1 time / week
Occasionally = Less than 1 time / week
Never = Never

1. Do you have headaches and / or facial pain?
   - Draw in location of discomfort
   - (Scale 1-10: 1=extremely mild, 10=extremely severe)
     - FACE
     - BACK OF HEAD

2. Do you have pain in your eyes with eye movement?
   - _______________________________
<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
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</thead>
<tbody>
<tr>
<td>2.</td>
<td>Do you have pain in your eyes with eye movement?</td>
</tr>
<tr>
<td>3.</td>
<td>Do you experience neck or shoulder discomfort?</td>
</tr>
<tr>
<td>4.</td>
<td>Do you have dizziness and / or light headedness?</td>
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<tr>
<td>5.</td>
<td>Do you experience dizziness, light headedness, or nausea while performing close-up activities (computer work, reading, writing, etc.)?</td>
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<tr>
<td>6.</td>
<td>Do you experience dizziness, light headedness, or nausea while performing far-distance activities (driving, television, movies, etc.)?</td>
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<tr>
<td>7.</td>
<td>Do you experience dizziness, light headedness, or nausea when bending down and standing back up, or when getting up quickly from a seated position?</td>
</tr>
<tr>
<td>8.</td>
<td>Do you feel unsteady with walking, or drift to one side while walking?</td>
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<tr>
<td>9.</td>
<td>Do you feel overwhelmed or anxious while walking in a large department store (Target, Wal-Mart, Meijer, etc.)?</td>
</tr>
<tr>
<td>10.</td>
<td>Do you feel overwhelmed or anxious when in a crowd?</td>
</tr>
<tr>
<td>11.</td>
<td>Does riding in a car make you feel dizzy or uncomfortable?</td>
</tr>
<tr>
<td>12.</td>
<td>Do you experience anxiety or nervousness because of your dizziness?</td>
</tr>
<tr>
<td>13.</td>
<td>Do you ever find yourself with your head tilted to one side?</td>
</tr>
</tbody>
</table>
TREATMENT

- Prism glasses
- Vision therapy
- Decrease work on eyes
PSYCHOLOGICAL ASSESSMENT

• Assess emotional symptoms and track

• Risk factors
  • Isolation from team activities
  • History of mental health disorders (anxiety)
  • Poor social support
  • Poor/no communication with team/training staff
SYMPTOMS

- Personality changes
- Sad, withdrawn
- Irritable/emotional
- Mood swings
- Nervous
- Paranoia
TREATMENT

• Keep tracking athlete
• Keep athlete engaged —> goal-oriented
• Education
VESTIBULAR DYSFUNCTION
VESTIBULAR DYSFUNCTION

• Connected with visual

• Positional, heart rate, head movement, body movement
SYMPTOMS

• Dizziness/Vertigo
• Motion Sensitivity/Height Phobia
• Tinnitus
• Lightheadedness
• Blurred vision/Double vision/Trouble Focusing
• Photophobia
• Imbalance (especially in dark)
VESTIBULAR ASSESSMENT

- Dynamic Visual Acuity Testing (DVA)
- Dynamic Gait Index (DGI)
- Functional Gait Assessment (FGA)
- BESS Test
- VOMs
VESTIBULAR REHAB FOCUS

- Fine motor
- Reaction time
- Eye head coordination
- Fatigue
- Vision
- Balance
- Dual task performance
- Body mechanics/posture
PHYSICAL THERAPY

- Cervical injury often missed
- Weaker cervical stabilizers increase risk of concussion
- Whiplash mechanism —> no MRI findings
- Goal-oriented activity for patient
PHYSICAL THERAPY GOALS

• Treat MSK pain
• Improve functional movement
• Improve cervical stability and control —> prevent concussion
• Integrate with vestibular and visual treatment
• Exercise protocol
EXERCISE
**PHYSICAL ACTIVITY**

- Old thinking: no exercising until symptoms resolve
- New thinking: exercise once athlete can tolerate
- Keep intensity very low then progress as tolerated
- Default to no exercise in 1st 72 hours if unsure


EXERCISE WITH SYMPTOMS

Research supports avoiding complete rest after acute phase of injury

Exercise enhances recovery*

PHYSICAL ACTIVITY

- Buffalo Concussion Treadmill Test
- Only functional test shown to safely and reliably reveal physiological dysfunction in concussion
- Can differentiate concussion from other diagnoses (eg, cervical injury, depression, and migraines)
- Quantify clinical severity and exercise capacity of concussed patients


BUFFALO CONCUSSION TREADMILL TEST

- Based on the Balke cardiac protocol
- Starting speed is 3.2-3.6 mph at 0% incline
- Incline ↑1% at minute 2, then 1% per minute after
- Maintain same speed until athlete cannot continue
- Stop when ↑3 pts on 1-10 VAS compared to pre-test

BUFFALO CONCUSSION TREADMILL TEST

- Record heart rate at threshold of symptom exacerbation
- Safe for PCS athletes to exercise to 74% max HR
- Can be used in light aerobic exercise stage
- Compare HR when symptoms exacerbated to athlete’s theoretical maximum HR
- Closer the two numbers are shows how close athlete is to recovery
EXERCISE PROTOCOL

• Should be started when athlete appears to be recovered from concussion

  • Athlete “feels” normal, ready to play again

  • No symptoms or back to baseline level

  • SCAT 5 back to baseline

• EP NOT something athlete tries to see if s/he can do in order to RTP faster
EXERCISE PROTOCOL

- Conflicts with when doctor needs to clear athlete
- Protocol NOT intended to see if athlete can take a hit
- Testing whether brain can handle increased blood pressure and heart rate
- FLAW: Not sport/activity specific

LAST STAGE: Full contact practice
SLEEP

- Seen in up to 84% of TBI
- 20% have sleep cycle disruptions > 3 yrs
- Unable to initiate or maintain sleep
- Cannot cycle through REM sleep stages
- Can last months or years after concussion

SLEEP TREATMENT

- Melatonin: 5mg at dinner
- Sleep hygiene
  - No devices or reading in bed
  - White noise
- Avoid blue light sources
SLEEP TREATMENT

• Take naps no longer than 30 minutes
  • Caffeine naps also helpful
• Evaluate for sleep apnea, neck pain
