Concussion is Treatable
Beginning Treatment the Day After
the Mechanism

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I have no financial conflicts with this presentation

Outline of Presentation
• Definition of Treatment vs Return to play
• Justification for early treatment
• Risk factors and predictors prolonged recovery
• Rethinking the term concussion
• Profiles/Disorders/Dysfunction/Deficits/ Subtypes to be determined by the evaluation
• Categories for post-concussion follow up evaluation
• Treatment Philosophy and Outline
  o Definition of rest
  o Sleep
  o Exercise
  o Nutrition
  o Profiles/Deficits treatment
    • Cervicogenic
    • Psychological
    • Vestibular
    • Ocular
    • Cognitive Fatigue
    • Migraine
• Sport Reaction Time Training
• Criteria for return to play
• Informed consent
Practical Implementation of Concussion Treatment

**Definitions**

**Treatment**: Any intervention that occurs between injury mechanism and clearance to return to sport. May also include intervention done after athlete returns to sport.

**Return to Play**: Progression from medical clearance to return to sport and full unrestricted play.

Initial Evaluation

- On field- “Go or No Go”
- Serial follow up evaluations
- Initial take home education and instructions for family and patient
- Referral for further assessment if more than a “concussion”

Early Treatment

Begin active treatment while still symptomatic

**Misconceptions**

1. Once an athlete is cleared to return they are 100% recovered
2. There is nothing that can be done to help with recovery or improve function
Justification for early treatment

In pediatric population, vestibulo-ocular dysfunction (VOD) is a significant risk factor for developing Post Concussion Syndrome.

VOD was found in 28% of acute sports-related concussions in pediatric population.

VOD was found in 62% of post-concussion syndrome patients in pediatric population.

Can early assessment, recognition and treatment prevent some of these PCS cases? **YES**


Justification for early treatment

- Cerebellum will accommodate for abnormalities.
- Vestibular System accommodations can become ingrained if not corrected early.

**DON’T IGNORE FATIGUE**

Ellis M. et al., Vestibulo-ocular dysfunction in pediatric sports-related concussion. *J Neurosurg Pediatr* 2015

Justification for early treatment Performance

- MLB Players had lower batting average, slugging percentage, and on base percentage in the 2 weeks after return from concussion vs players on bereavement/paternity leave players. (2)
- Study of NFL players show no difference in player performance after concussion whether return to play within one week or longer. (3)
- Schmidt et al. 2017 UGA: Less vehicle control even after symptoms resolve. (4)


Justification for early treatment
Risk of Injury

- Increase risk of injury after cleared to return to play after concussion.

  According to Lynall et al., "Up to 180 days after concussion, the group with concussion was 2.02 (95% CI, 1.08-3.78; P = 0.02) times more likely to have experienced an acute lower extremity musculoskeletal injury after concussion than before concussion." (1)

- Study former NFL players; greater number of concussion = greater number of relative risk for lower extremity musculoskeletal injuries (4)

- College athletes with concussion had a higher risk of non-contact LE Strain/sprain. (5)

- Positive association between concussion history and lower extremity injuries (odds ratios, 1.6-2.9 elevated risk) among student-athletes at the conclusion of their intercollegiate athletic careers. (6)


Hypothesis for increase in risk

Increase risk of lower extremity injury after return to sports post concussion has been hypothesized as change in proprioception and lower extremity muscle tone from altered oculomotor system.

Justification for early treatment
Risk of Injury

Lower Extremity Stiffness Changes after Concussion in Collegiate Football Players

- Lower extremity stiffness is altered after concussion, which could contribute to an increased risk of lower extremity injury. These data provide further evidence of altered neuromuscular function after concussion.

- Concussion group showed an increase in hip stiffness, a decrease in knee and leg stiffness but no change in ankle stiffness from pre- to postseason.

- A motion capture system recorded subjects jumping on one limb from a 25.4-cm step onto a force plate.

DuBois et al., Medicine & Science in Sports & Exercise, Jan 2017
Prolonged Effects of Concussion?

More research and testing is showing that there may be persistent alteration in brain function after concussion.

Lancaster, Olson, McCrea et al 2016. White matter changes at 6 months
Purdue Neurotrauma Group. Changes from contact without symptoms

Current tools are not be sensitive enough to detect

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Re-thinking the term concussion

- Concussion induced traumatic headache
- Concussion induced cognitive deficit
- Concussion induced oculomotor disorder
- Concussion exacerbated psychological condition
- Concussion induced cognitive fatigue
- Concussion induced vestibular disorder
- Concussion induced cervical sprain

More accurate: Concussion induced traumatic headache, vestibular dysfunction and anxiety exacerbation

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Slide from Gary Wilkerson
Follow up Evaluation

Goal of Evaluation: Determine Deficits/"Profiles"/Subtypes to guide treatment

- Symptom Score
- Clinical Interview
  - Helps determine risk factors for prolonged issues or complication of management
  - Assess for secondary gain
  - Assessment Drug or Substance use/abuse (Drug Toxicology Screening?)
- Neurological exam
- Reaction Time Assessment
- Gait Assessment: Change of base of support with spatial processing compromise over-focalization
- Neurocognitive/Neuropsychological Assessment
  - Vestibular Ocular Movement Screen (VOMS) (1)
  - Vestibular Assessment
  - Ocular/Vestibular Field Assessment
  - Psychological Assessment
  - Exertional/Exercise Test: Balke Exercise Protocol (2), Buffalo concussion treadmill test
- Sleep Assessment
- Nutrition Assessment
- Heart Rate Variability (3)
- Imaging or advanced testing: Brain Mapping (BMA), fMRI etc...


Risk Factors

- Should these be determined before participating in contact risk sports?
- Moving away from “Baseline Testing”
- Move toward “Neuro PPE” - (Jeff Kutcher MD)
  - Add more neuro screening to PPE so you know risk factor before you have to treat “concussion induced...”

Predictors of Prolonged Recovery

- McCrea et al reviewed records of 18,000+ HS & College athletes determined that unconsciousness, post-traumatic amnesia and more severe acute symptoms are predictors of outcome longer than 7 days (1)
  - Loss of consciousness not a predictor in other studies
- Pre-injury psychiatric history - Anxiety (6)
- Female (6)
- Younger athletes especially with history of multiple concussions (5)
- Learning disorders, attention-deficit disorders (ADD/ADHD) and migraine headaches complicate diagnostic and management of a concussion (2)
- On-field Dizziness, 4.3 x greater risk for protracted (21+ days) recovery (3)
- Greater symptom load, Headache lasting more than 60 hrs & self reported fatigue and fogginess (4)
- Motion sickness, ocular dysfunction (7)
- Migraine history (8)
- Continuing to participate after initial mechanism [references will be later in presentation]

Evaluation to determine clinical subtypes

Review of mechanisms of injury; specifically location, force and direction of trauma (Bloom & Blount, 2015; Collins et al., 2014; Ellis et al., 2014; Giza et al., 2013; Harmon et al., 2013; McCrory et al., 2013)

Relevant past medical history including age, gender, prior concussion history, and comorbid concussion risk factors (Collins et al., 2014; Kontos et al., 2012; Lau et al., 2013; Meehan et al., 2014)

Symptoms checklist (Bloom & Blount, 2015; Collins et al., 2014; Ellis et al., 2014; Giza et al., 2013; Harmon et al., 2013; McCrory et al., 2013)

Symptoms screening or evaluation (Bloom et al., 2014; Guskiewicz et al., 2005; Iverson et al., 2002; Iverson et al., 2004; Iverson et al., 2005; Lau et al., 2011; Lau et al., 2013; Lau et al., 2015; Vanderploeg et al., 2005)

Balance assessment (Collins et al., 2014; Guskiewicz et al., 2005; Register-Mihalik et al., 2008; Sosnoff et al., 2011)

Neurocognitive screening or evaluation (Bloom et al., 2014; Ellis et al., 2014; Guskiewicz et al., 2005; Iverson et al., 2002; Iverson et al., 2004; Iverson et al., 2005; Lau et al., 2011; Lau et al., 2013; Lau et al., 2015; Vanderploeg et al., 2005)

Assessment or screening of ocular motor function (Elbin et al., 2014; Meehan et al., 2014; Pearce et al., 2015; Pitakas & Elbert, 2014)

Balance assessment (Bloom & Blount, 2015; Collins et al., 2014; Ellis et al., 2014; Giza et al., 2013; Harmon et al., 2013; McCrory et al., 2013)

Examination of the cervical spine (Kontos et al., 2012; Collins et al., 2014; Schneider et al., 2014)

Consideration of neuroimaging if indicated (DiFiori & Giza, 2010; Emtman et al., 2012; Yuh et al., 2014)

PMH of risk factors

Profiles/Disorders/Dysfunction/Deficit/Subtypes to be determined by the evaluation

1) Vestibular
2) Ocular-motor
3) Cognitive/cognitive fatigue
4) Post-traumatic migraine/headaches
5) Psychological Anxiety/Mood
6) Cervicogenic?

These subtypes are a work in progress and will change by what we continue to learn.

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Collins MW et al., A comprehensive, targeted approach to the clinical care of athletes following sport-related concussion. Knee Surg Sports Traumatol Arthrosc 2014
Follow up Evaluation

**Goal of Evaluation**: Determine Deficits/Profiles/Subtypes to guide treatment

- **Symptom Score**: A screen to do more in-depth assessment.
- **Clinical Interview**
  - Helps determine risk factors for prolonged issues or complication of management
  - Assess for secondary gains
  - Assessment Drug or Substance use/abuse (Drug Toxicology Screening?)
- **Neurological exam**
- **Reaction Time Assessment**
- **Gait Assessment**: Change in base of support with spatial processing compromise over-localization
- **Neurocognitive/Neuropsychological Assessment**
- **Vestibular Assessment**
- **Ocular/Visual Field Assessment**
- **Musculo-Skeletal Cervical Assessment**
- **Psychological Assessment**: Assess for PTSD
- **Exertional/Exercise Test**: Balke Exercise Protocol, Buffalo Concussion Treadmill Test (2)
- **Sleep Assessment**
- **Heart Rate Variability** (3)
- **Imaging or Advanced testing**: Brain Mapping (BNA), fMRI etc...

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**Clinical Interview**

With patient and possible family. Does not need to be done in one sitting

**Goal of Clinical Interview**

- Determine Risk Factors for prolonged issues
- Guides for further assessment
- Determine patients goals- Secondary Gains

**Exact Mechanism**

- Single or multiple hits
- Location of hit

**Progression of Condition**

- Removed immediately or return to contact or exercise
- Sleep will be discussed specially later

**Previous History**

- Concussions: Diagnosed & Undiagnosed
- Motion sickness
- Migraines/Headaches
- Substance use
- Psychological conditions/Behavior issues
- Other medical issues/injuries
- Family history
- Migraine
- Substance use
- Psychological conditions/Behavior issues
- Concussions
Neurologic Exam & Simple Reaction Time

Neurologic Exam:
- Cranial Nerves
- Myotomes & Dermatomes
- Reflexes
- Coordination

Reaction Time:
- Hockey Stick Drop Test
- ImPACT Test
- C3 Logix

Effect of Sport Related Concussion on Clinically Measured Simple Reaction Time
Eckner, Kutcher, Broglio, and Richardson, Br J Sports Med 2013
C3 Logix- https://youtu.be/wPc29yjIWD4
https://youtu.be/2tXNKLaFCPoU

Vestibular Ocular Motor Screening (VOMS)
Systematic method to evaluate oculomotor function
- Ages 9-40
- Abnormal findings or provocation of symptoms may indicate dysfunction and result in referral
- Equipment
  - Tape measures
  - Metronome
  - Target with 14 point font

https://www.youtube.com/watch?v=S66o9ODhmIk

Mucha, AJSM, 2014
Smooth Pursuit
• Ability to track a slowly moving target
• May become “jerky” in concussion

Saccades
• Ability to quickly move the eyes from one target to another
• After 3-4 attempts, should be able to precisely reach two stationary targets
• May see “undershoot” or “overshoot” in concussion

Vestibulo-Ocular Reflex (VOR)
• Counter-movement of the eyes to maintain focus on a visual target during a fast head turn
• May be jerky or unable to maintain fixation in concussion
VOR Suppression (Visual Motion Sensitivity)

- Ability to suppress counter-movement of the eyes during fast head turning, maintaining focus on a moving target
- May be jerky or unable to maintain fixation in concussion

VOMS Considerations

Advantages
- Easy to administer
- High correlation with symptoms
- High sensitivity: (+) identify concussion
- Assists in targeted treatment plan

Possible Limitations
- Unknown inter-tester reliability
- Relying on symptoms can result in recall bias
- Convergence only measured test
- No correlation to BESS
  - May not be sensitive to dynamic vestibular function

Vestibular Evaluation

Screening Questions to Ask
• Do busy environments increase your dizziness/fogginess/symptoms?
• Do you become dizzy looking up/down or turning your head?
• Do quick movements bring on your symptoms?
• Do you have increase symptoms while riding in a car?
• Do you get blurred or fuzzy vision while reading?
• Hearing loss and Benign Paroxysmal Positional Vertigo (BPPV) should be ruled out BEFORE starting vestibular rehabilitation
  – Need to see a specialist

Slide from Michael Collins

Vestibular Involvement
• ImPACT- 3 letter sequence & XO’s
• Symptoms with VOMS
  – VOR
  – VOR Motion Sensitivity
• Increase symptoms at end of the day
• Increase symptoms in busy environment
• Less symptoms in morning
  – If anxiety associated will have morning symptoms

Slide from Michael Collins

Advanced Assessment of Dizziness


Oculomotor Assessment

Evaluation
- VOMS: Convergence, Pursuit, Saccades
- King-Devick
- ImPACT: Visual Memory, reaction time (Collins et al 2014)

Questions (Collins)
- Do you feel a frontal pressure in your head/behind your eyes when reading doing computer work?
- Do you have blurred or double vision while reading or difficulty reading
- Are you having more significant difficulty in math/science?
- Are you fatigued after a lot of schoolwork?

Oculomotor Disorder

- Symptoms (Ciuffreda, 2011)
  - Difficulty reading, dizziness, headaches, ocular pain, poor visual based concentration
  - End of day fatigue
- Family History of lazy eye, nystagmus
- May manifest into poor academic/work performance, motion sensitivity/car sickness (Collins, 2014)
- Convergence insufficiency was common (~42%) in athletes evaluated within 1 month after an SRC. (Pearce et al 2015)
Oculomotor Screening

- Smooth pursuit and ocular ROM
- Saccades
- Gaze stability
- Vergence
- Eye alignment

Oculomotor Test

Near Point of Convergence
- Ask the patient to look at a small letter on a stick that looks like a tongue depressor and instructs the patient to keep the letter single as it moves closer and closer to the bridge of the nose.
- Should be able to maintain single vision until the object reaches about 6 cm (2 inches) from the bridge of the nose.

Convergence

- Ability to follow a visual target in towards the nose
- The “near point” is the closest distance to the nose without double vision or one eye deviating outwards
- Normal is less than 6cm
Convergence Insufficiency

- Inability to maintain binocular function (keeping the two eyes working together) while working at a near distance
  - Typically, one eye will turn outward (intermittent exotropia) when focusing on a word or object at near
- Symptoms
  - Diplopia & Headaches when reading
  - Difficulty concentrating on near work (computer, reading, etc.)
  - Written word blurs after prolonged periods of reading or if reading when tired
- Remote near point of convergence
  - Maintain binocular fixation on a fusional target up to at least 5 inches from the tip of the nose

https://www.slideshare.net/mobile/maclester/near-point-of-convergence

Eye Alignment and Symmetry

- Ask patient to look at target 6-8 feet away
- Observe eye alignment
- Should be symmetrical at center
- Left-right
- Up-down

Red Flags for More Advanced Evaluation

Oculomotor
- Visual acuity change
- Flashes of light
- Diplopia
- Mal-alignment of eyes
- NPC not resolving quickly

Vestibular
- Hearing changes
- Ringing in ears
- Vertigo-spinning
- Dizziness with strain
Musculo-Skeletal and Gait Assessment

- Gait Assessment
  - Abnormalities could be Oculomotor or Vestibular spinal
- Cervical Assessment

Cervicogenic Headache

Cervicogenic headache is a syndrome characterized by chronic hemicranial pain that is referred to the head from either bony structures or soft tissues of the neck. (1)


Neurocognitive/Neuropsychological Assessment

- ImPACT
- C3 Logix
- ANAM
- CogState
- XLNTbrain Sport
- Concussion Vital Signs
- Paper and pencil exams

These are not pass/fail tests. They give you information to guide care and treatment. Neuropsychologists expertise
How Are Concussions Currently Managed?

**REST**

**Physical Rest**

**Cognitive Rest**

“Rest”

- Initial education post concussion. **Avoiding any exacerbating activities.**
- Teach and allow patient autonomy to control their own activity (physical and cognitive) to manage symptoms
- **NO SECONDARY TRAUMA** *Most important (1,2,3)*
  - Second Impact Syndrome- Immature brain
- **Period of vulnerability**
  - Decrease glucose metabolism shown in human and animal research. Prins et.al 2013 In animal models second trauma during period of vulnerability (when cerebral metabolic rate of glucose (CMRglc) is decreased) shows significant increase in decreased CMRglc. When new mTBI is introduced after metabolic recovery the CMRglc depression is similar to single injury.


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**13.5 days to return if continued to play**
**5.6 days to return if immediately removed**
**Study out of University of Florida**

Athletes who do not immediately report symptoms of a concussion and continue to participate in athletic activity are at risk for longer recoveries than athletes who immediately report symptoms and are immediately removed from activity. Continuing to participate in athletic activity during the immediate aftermath of a concussion potentially exposes the already injured brain to compounded neuropathophysiologic processes.

- **Immediately removed** - Days Missed 6.8 ± 2.6
- **Delayed removal** - Days Missed 12.3 ± 12.2

"Playing Through It": Delayed Reporting and Removal From Athletic Activity After Concussion Predicts Prolonged Recovery.
Breton M. Asken, Michael A. McCrea, James R. Clugston, MD, et. al. JAT April 2016

**Removal from play in recovery in young athletes**

- Compared young athletes recovery after sports related concussion between those who were REMOVED immediately and those who continued and PLAYED
- Those who continued to play were 8.80 times more likely to demonstrate protracted recovery (greater than 21 days)
- Recovery time average. PLAYED 44.4 +/- 36.0 vs REMOVED 22.0 +/- 19.7

Removal From Play After Concussion and Recovery Time. PEDiatrics 2016
R.J. Elbin, PhD, a Alicia Sufrinko, PhD, b Philip Schatz, PhD, c Jon French, PsyD, b Luke Henry, PhD,b Scott Budnick, PsyD, b Michael M. Collins, PhD, b Anthony P. Kontos, PhD

**“Rest”**

- After mTBI the metabolic-glucose needs of the cell increase dramatically body unable to upregulate cerebral blood flow. Creates “metabolic mismatch”(1,3)
- Gioia et al reported increase in symptoms severity during school within first 2 weeks. (2)
- Study shows “Extensive cognitive activity level after concussion is associated with longer symptom duration” in 355 patients mean age of 15. Same study showed complete abstinence from cognitive activity may be unnecessary. (4) “Cognitive Fatigue”

References:
Study of post-concussion activities found that both the highest and the lowest activity levels were associated with the worst scores on neurocognitive testing; those with "moderate" activity fared the best. (1)

Pilot Study on Strict Rest

- 99 patients age 11-22
- Trial of cognitive and physical rest versus usual care following concussion
  Patients prescribed 5 days of rest had worse symptoms at 10 days post-injury

Institute of Medicine and National Research Council of the National Academies
Sports-Related Concussion in Youth
October 2013

“there is little empirical evidence for the optimal degree and duration of physical rest needed to promote recovery or the best timing and approach for returning to full physical activity.”

https://iom.nationalacademies.org/~/media/Files/Report%20Files/2013/Concussions/concussions-RB.pdf

“Rest”

According to Griesbach et al., animal studies suggest that properly timed exercise-induced activation can beneficially affect recovery after concussive brain injuries. However, premature activation, either through forced or voluntary exercise, is deleterious to the injured brain, leading to molecular, anatomical, and behavioral deficits.


Effectiveness of Rest

- 3 studies showing too much activity delayed recovery = worse outcomes
- 2 studies show rest improves outcomes
- 4 studies found no association between rest and outcomes
- 1 study found strict rest resulted in a longer recovery

“Rest”

- Hypothesis: Increase in symptoms occur during metabolic mismatch
- Determine activities that exacerbate symptoms
- Work these activities only at level that does not increase symptoms—Work below the metabolic mismatch
- Prevent secondary trauma
  - Second impact and secondary insult caused by energy deficit

Cognitive Rest

- Avoid excessive neurometabolic processes associated with cognitive activities
- Avoidance of mental challenges during the initial post-injury stage
  - Limit ADL activities
  - Limit scholastic stressors
  - Limit computer, e-mail, text, IM
  - Modify school attendance/activities

Valovich McLeod & Gioia, ATC, 2010

Cognitive Rest

- No activity
- Full activity
- Asleep or comatose
- Normal school
- Goal: limit cognitive activity to a level that is tolerable and does not exacerbate symptoms
Treatment

- Evaluation and Re-assessment guides treatment

  "Rest" - Avoid any exacerbating activities
  - Control known risk factors
  - Sleep Correction
  - Nutrition
  - Don’t “shut down” areas that do not exacerbate symptoms
  - Allow them to read and work on computer
  - Cardiovascular Exercise
    - if can do easy cardio exercise without increase in symptoms allow
  - Treat area of deficits found in evaluation
  - Treat areas at risk to develop deficits
  - Treat areas without deficit
Example of Exacerbating Activities to Avoid

These will be based on evaluation and previous medical history

- **Photophobia** - avoid sun, wear sunglasses different colors help different people, Lower brightness of computer.
- **Fogginess** - watch videos, tv etc., for shorter periods of time
- **Cognitive deficit/fatigue** - avoid reading for prolonged periods
- **Dizziness** - avoid over stimulating peripheries - large areas with people, driving in car
  - **Vestibular issues** - decrease early VOR overstimulation by wearing hooded sweatshirt?
- **Anxiety** - don’t isolate, normalize feelings, exercise
- **Convergence issue** - enlarge font and move away from screen, Get off phone
- **Cervicogenic** - posture

These need to be limited for only short period of time. Need to implement normal activity to promote healing.

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Educate to prevent this

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Treatment Philosophy

<table>
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<th>Create environment to heal</th>
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<tbody>
<tr>
<td>Determine individual deficits – Strengthen the deficits to work as part of full system</td>
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<tr>
<td>Work full system together as soon as possible</td>
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<tr>
<td>Always work systems together with functional activity - work at lower level to not overwork the effected system (overworking will cause symptoms)</td>
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<tr>
<td>Work functional activity to build/maintain/correct motor program in brain</td>
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Sleep

• FIRST deficit that needs to be addressed

Brain regions and systems regulating arousal, alertness, attention and sleep are vulnerable to TBI (1)

• Associated with anxiety, depression and pain but does not account for all sleeping disorder after TBI (1)

• Adolescent patients with perceived sleep disturbance reported greater number of concussion symptoms & lower neurocognitive function (ImPACT) (2)

• Has negative impact on every other area

• Sleep deficits will mimic injury to other areas that may not be present

Assess, Educate, Treat


Glymphatic System

• Functional waste clearance pathway for vertebrates

• Cleanses brain of toxic molecules

• Helps control the flow of cerebrospinal fluid

• Functions mainly during sleep.

• Disengaged during wakefulness.

• Facilitates brainwide distribution of glucose, lipids, AA, growth factors, neuromodulators.

• Efficient elimination of soluble proteins and metabolites

Xie et al. “Sleep initiated fluid flux drives metabolic clearance from the adult brain.” Science, October 18, 2013. DOI: 10.1126/science.1241224
Advanced Sleep Assessment

- When you lay down to go to bed do you fall asleep shortly after?
  Is this normal for you?
- Do you wake up in the middle of the night?
  Is this normal for you?
- If you wake up in the middle of the night are you able to fall back asleep?
  Is this normal for you?
- Are you waking up in the morning at your usual time?
  Is this normal for you?
- Are you still drowsy in the morning?
  Is this normal for you?
- Are you having nightmares?
  Is this normal for you?
- Are you having unusual body movements during sleep?
  Is this normal for you?

Sleep Recommendations

“Good Sleep Hygiene”

Good Sleep Habit
- Bedroom should be comfortable, quiet, dark and have a comfortable temperature
- Light music or fan in room can help with consistent noise
- Avoid bright light exposure near bedtime
- Avoid caffeine in afternoon or evening (Energy drinks, Soda, coffee, tea etc)
- Avoid tobacco
- Avoid eating or drinking for 2 hours before bed.
- Use the bathroom before you go to bed
- Follow a relaxing, calming bedtime routine.
- Go to bed and wake up at the same time every day, even on weekends.
- With concussion attempt to extend sleeping some on both ends Go to bed a little earlier sleep a little later?
- Do not sleep or nap for an extended time during the day.
- Avoid visual stimuli from electronics (Phone, computer, tablet) for an hour before your going to bed

https://dvbic.dcoe.mil/resources/management-sleep-disturbances
Ponsford, J et.al
Sleep Correction

• If you cant sleep get out of bed
  o Keep lights low
  o Avoid any overstimulating activity-each person is different to what this is
  o Stay off electronics. If one use night modes

Create Routine

• Go to bed same time
• Get up same time
• Eat regularly at same time
• Work out consistently at same time

Sleeping Medication

Melatonin (1)
Eszopiclone (Lunesta)
Zolpidem (Ambien)
Trazodone
Rozerem

AVOID
Neuroleptics (e.g. Seroquel)
Excess alcohol
Anticholinergics (e.g. Benadryl) Benzodiazepines

Source:
Exercise as Treatment Modality
Active Rehabilitation

- Exercise has a positive effect on mental health
- There is increasing evidence that exercise has noteworthy effects on sleep/wake cycles and circadian clock modulation (Morgan et al. Journal of Molecular Psychiatry-2015)
- Closely monitored rehabilitation in post-acute phase improved recovery time in adolescents who were slow to recover (Gagnon, Brain Inj, 2009)
- Controlled sub-symptom threshold aerobic exercise improved recovery in athletes with PCS (Leidy, CJSM, 2010, 2011)

Adolescent- Early exercise vs rest on risk for PCS

- Prospective, multicenter cohort study of 3063 children and adolescents aged 5.00 to 17.99 years after propensity matching, the proportion with postconcussive symptoms at 28 days was 28.7% with participation in early physical activity vs 40.1% with conservative rest, a significant difference.
- Participation in physical activity within 1 week after injury may benefit symptom recovery following acute concussion in children and adolescents

- Groel et al 2016 JAMA Association Between Early Participation in Physical Activity Following Acute Concussion and Persistent Postconcussive Symptoms in Children and Adolescents
Buffalo Concussion Treadmill Test

- Test to determine exercise tolerance
  - Helps to establish physiological recovery
  - Readiness to return to activity
- Modified Balke Protocol
  - 3.6mph @ 0% incline for 1 minute
  - Increase incline by 1% each minute after
  - Until maximal incline or patient cannot complete
  - Rate of perceived exertion (RPE), HR, BP, symptoms assessed each 2 minutes
- Test is stopped with increased symptoms
  - >3 points from pre-test resting symptom score


Buffalo Concussion Treadmill Test

- Good intra-rater reliability and sufficient test-retest reliability (Leddy, 2011)
- Recovery in high school athletes (Darling, 2014)
  - All athletes returned to sport without symptom exacerbation or recurrent symptoms
  - 48% had one or more CNT sub-scores below average
  - BCTT better predicted readiness to begin RTP protocol

Buffalo Concussion Treadmill Test

Assists with differential diagnosis (Leddy, 2013)

- Patients with concussion stop at submaximal level
- If able to exercise to exhaustion without replicating symptoms then symptoms not due to...
Buffalo Concussion Treadmill Test

- Assist with exercise treatment (Leddy, 2016)
  - Aerobic exercise 20 min/day @ 80% threshold HR
  - 5-6 days per week
  - Terminate if symptoms appear or after 20 min

Exercise Interventions

- Avoid stimulating brain activities that are correlated to symptoms
- Type of exercise
  - Duration
  - RPE
  - HR
  - BP
  - Symptoms
- Initially do not stimulate visual field, vestibular
- Progress to add stimuli

Figure 2: Return to activity algorithms for concussion and post-concussion syndrome. Time the symptom resolution will vary depending on clinical circumstances. Most patients recover within 1-3 weeks. *Treadmill testing at patients with persistent symptoms should not be performed before 3 weeks after injury. Neurophysiological testing is not indicated because the patient is still symptomatic. If neurophysiological testing has been used, ensure that there is a baseline protocol test or valid normative data for the particular patient. Exercise to evaluation without exacerbation of symptoms. Exercise should be at a sustained effort level because of symptom resolution. Repeat testing interval will vary depending on clinical circumstances; it may be several days to several weeks. If athlete is recovering, consider aerobic exercise only. If computerized neurocognitive testing has been used, we recommend exercise treatment and consider consultation with a neuropsychologist to evaluate for a specific cognitive deficit. KPA, return to activity; KPC, post-concussion syndrome; KO, neurocognitive.
Treatments Examples

- Anxiety with Vestibular involvement exercising in stimulating environment will cause migraine
  - Introduce exercise in low vestibular stimulating environment
- Anxiety or oculomotor issue without vestibular-(ImPACT will not have visual motor deficits) Exercise Hard.

Nutrition

- Anti-inflammatory diet
- Fish Oil-DHA or EPA&DHA (3)
- Proper Hydration (2)
- Avoidance of alcohol
- Adequate Complex Carbohydrates during recovery to offset the Metabolic Demand for glucose?
- Ketogenic Diet? (1)

Strong data is not currently available to the benefit

- These recommendations are universal and will have overall health benefits
- Newer Evidence-exercise in combination with dietary factors, have an affect on molecular event related to the management of energy metabolism and synaptic plasticity. (4)

• These recommendations are universal and will have overall health benefits
• Newer Evidence-exercise in combination with dietary factors, have an affect on molecular event related to the management of energy metabolism and synaptic plasticity. (4)

2) Spigt M, Weerkamp N., Troost J, van Schayck CP, Knottnerus JA. A randomized trial on the effects of regular water intake in patients with recurrent headaches. Family Practice 2012
Nutrition

- Glucose not stored in brain
- Need to have consistent glucose levels
- Need to keep this level up
- Higher demand energy system damaged so not as efficient
- Eat every 2 hours to prevent a deficit
- Eat complex carbohydrates for energy
- Anti-inflammatory diet

Anti-inflammatory Food Pyramid


Psychological Disorders

Anxiety/Mood

- In a study looking at patients who were still symptomatic at 3 month Ponsford et al. states managing the anxiety response in vulnerable individuals (patients with a pre-injury psychiatric history) with mTBI may be important to minimize ongoing sequelae. (2)
- Mild Traumatic Brain Injury leaves patient at risk for developing anxiety disorders. A potential molecular mechanism has been shown in rodent models (1)
- Emotional disturbance after concussion is different than emotional disturbance after musculoskeletal injury at 2 weeks in college aged athletes. (3)

References:
Psychological Disorders
Anxiety/Mood

Evaluation (1)
- Risk Factors-Personal/Family history of anxiety
- Symptoms-ruminative thoughts (compulsively focused attention on symptoms), hypervigilant, feelings of being overwhelmed, sadness, and/or hopelessness.
- Sleep disorders
- Strong co-occurrence with vestibular dysfunction
- Wake up in morning with headache
- If lacking vestibular component neurocognitive tests results may be normal

Referral-Psychiatrist, Psychologist

Collins MW et al., A comprehensive, targeted approach to the clinical care of athletes following sport-related concussion. Knee Surg Sports Traumatol Arthrosc 2014

Psychological Disorders
Anxiety/Mood

Evaluation Questions
- How often do you symptoms inventory?
- Do you have difficult time turning off your thoughts?
- Do you become symptomatic when thinking about your symptoms?
- Have social activities been restricted?
- Do you feel you have been missing out of activities because of symptoms?
- Do you have headache in morning?

From Michael Collins

Psychological Disorders
Anxiety/Mood

Cognitive Restructuring (1)-Cognitive Behavior Intervention have shown improvements in general anxiety, depression and a transient mood measure, tension-anxiety following acquired brain injury (2)
- Patients with anxiety often do better when provided with structure and this type of regimented schedule will help to regulate autonomic functioning and again, speed recovery. (3)
- Normalizing feelings
- Aggressive exercise therapy if lacking vestibular component
- Mood stabilizing medication

Learn about the difference between TBI and PTSD along with some overlapping symptoms

Overlapping Symptoms

- Fatigue
- Sleep problems
- Trouble with memory and attention
- Feeling depressed
- Irritability

Possible Symptoms of TBI
- Headaches
- Disorientation/balance problems
- Nausea
- Sensitivity to light and sound
- Vision changes
- Impulsivity

Possible Symptoms of PTSD
- On high alert
- Started easily
- Fearfulness
- Flashbacks
- Nightmares
- Guilty feelings
- Assistance
- Anxiousness
- Self-destructive behavior

Anxiety Issues

- Psychosocial risk of treatment
- Need to know if being at practice, meetings etc… causes stress or relieves stress
- Need to understand stress of removing from social environment
- Individualized patient centered care

Cervicogenic Treatment

- Postural Assessment and Correction
- Manual Therapy
- Soft Tissue Assessment and Treatment-IASTM
- Modalities
- Range of Motion/Muscle Stretching
- Muscle Strength, Endurance and Activation
- Physical Conditioning
- Biofeedback
- Breathing Pattern
- Trigger Point Treatment
Traumatic Headache/Migraine

- **Risk Factors**: History or family history of migraines. History of anxiety?
- **Symptoms**: Variable headaches and intermittently severe, nausea with photo & phonosensitivity
- **Migraines may be caused by vestibular dysfunction. Treat vestibular dysfunction**
- **Headache classification after TBI**: Migraine/probable migraine, tension type, cervicogenic (1)
- **Migraine was most frequent type (1)**
- **Post Traumatic Migraine-Headache, nausea, photosensitivity, phonosensitivity (2)**
- **Acute Migraine vs Chronic Migraines**
- **Chronic migraine-referral for assessment for prophylaxis medication**


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Cognitive Fatigue

**Risk Factor**: Hx of learning disability/ADHD
**Symptoms**: Fatigue, General HA, End of Day Symptoms
**VOMS**: Normal
**Neurocognitive Test (ImPACT)**: Global deficits

**Questions**:
- Do you have general HA that increases as day progresses?
- Do you have more fatigue at end of day?
- Do you feel more distractible in school?
- Have you pushed through symptoms?

**End of Day Fatigue without Oculomotor Deficits**

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Cognitive Fatigue

- **DO NOT LET THEM PUSH THRU THIS**
- Physical/Cognitive Breaks throughout day
- Monitoring activity/exertion
- Stimulant medications?
- Monitor the Type A personality!!!
Cognitive Fatigue
• Cognitive Rehabilitation/Therapy if needed
• Stimulate then recover
• Fuel the system

Vestibular Rehabilitation

Vestibular System
Slide courtesy of Bridgett Wallace

Peripheral
• Bony and membranous labyrinth
• Signal begins, transformed into an electric signal and sent to the central system

Central
• Vestibular nuclei, cerebellum, cortex
• Signals are processed, interpreted, and integrated with other sensory cues

Motor Output
• Oculomotor: Gaze stabilization
• Vestibulospinal: Postural control
Peripheral Sensory Apparatus

- Bony Labyrinth
  - Semi-circular canals
  - Cochlea
  - Vestibule
- Membranous labyrinth
  - Membranous portion of semi-circular canals
  - Otolith organs
    - Utricle
    - Saccule

Vestibular Function

- Detection of angular and linear acceleration
- Relation of head with respect to gravity
- Functional outcomes
  - Ocular: gaze stabilization
  - Vestibulospinal: contribution to postural control

Vestibular Reflexes

- Vestibulo-ocular reflex (VOR)
  Generates eye movements that enable clear vision when the head is moving
- Vestibulocollic reflex (VCR)
  Acts on neck musculature to stabilize the head
- Vestibulospinal reflex (VSR)
  Generates compensatory body movements to maintain head and postural stability (i.e. prevent falls)
Benign Paroxysmal Positional Vertigo (BPPV)

- Displaced otoconia (calcium carbonate crystals) in posterior semicircular canal
- Produces a transient positional nystagmus
- **Benign** – it is not life-threatening
- **Paroxysmal** – it comes in sudden, brief spells
- **Positional** – it gets triggered by certain head positions or movements
- **Vertigo** – a false sense of rotational movement

www.vestibular.org; Shumway-Cook, Ch 27, Vestibular Rehabilitation

BPPV

- Transient vertigo
  - Spinning sensation mainly when changing positions
    - Laying down or rolling in bed
  - Brief in duration
  - Uncommon in children and adolescents
- Easily diagnosed: Dix Hallpike

http://vestibular.org/understanding-vestibular-disorders/types-vestibular-disorders/benign-paroxysmal-positional-vertigo#sthash.s0QYTTJl.dpuf; Shumway-Cook, Ch 27, Vestibular Rehabilitation
BPPV

Quickly correctable
- Canalith Repositioning Maneuvers
- Immediately resolved

Vestibular Rehabilitation After Concussion

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaze stabilization (X1)</td>
<td>↓ Dizziness rating</td>
</tr>
<tr>
<td>Standing balance</td>
<td>↑ Activities-specific balance confidence scale</td>
</tr>
<tr>
<td>Walking with balance challenges</td>
<td>↓ Dizziness Handicap Inventory (DHI)</td>
</tr>
<tr>
<td>Canalith repositioning</td>
<td>↑ Dynamic gait index</td>
</tr>
<tr>
<td></td>
<td>↑ Functional gait assessment</td>
</tr>
<tr>
<td></td>
<td>↓ Timed up and Go (TUG)</td>
</tr>
<tr>
<td></td>
<td>↑ Sensory Organization Test-SOT (all conditions)</td>
</tr>
</tbody>
</table>

Alsalaheen, JNPT, 2010

STEP WISE APPROACH: Visual-Vestibular

Continue increasing demand as symptoms decrease with each new demand.

Courtesy of Bridgett Wallace PT Presentation 2016
STEP WISE APPROACH: Visual-Vestibular

- Sitting
- Standing
- Unstable Surfaces
- Moving

Continue increasing demand as symptoms decrease with each new demand. Bridgett Wallace PT Presentation 2016

STEP WISE APPROACH: Visual-Vestibular

- Isolated Skills
- Integration w/other Skills
- Stable Backgrounds
- Busier Backgrounds
- Unpredictable

Continue increasing demand as symptoms decrease with each new demand. Bridgett Wallace PT Presentation 2016

Treatment for ingrained vestibular issues

- Vestibular suppressants (short term basis)
  - Anticholinergics
  - Antihistamines
  - Benzodiazepines
- Balance Rehabilitation Therapy (BRT)
  - Vestibular rehabilitation

Traditional Indications for Vestibular Therapy

- **Atypical Recovery**
  - Not back to baseline on balance assessment by 10 days post-concussion
  - Impaired dynamic visual acuity tests
  - Dizziness
  - Motion provoked dizziness
  - Nausea
  - Blurred vision with head movement
  - Motion sensitivity

Indications for Vestibular Rehabilitation Concussion Clinic

- **Symptoms**
  - Vertigo (especially when lying in bed)
  - Dizziness/imbalance
    - No improvement over one week or is persistent beyond two weeks
- **Balance impairments**
  - Strong Romberg (after one week)
  - BESS
    - ↑ BL after 1 wk or > 10 errors per set, > 30 total after 1 wk
- **Dix Hallpike**
  - +/- improvement or resolution with Epley maneuver
  - Patients generally like the active nature of participating in their recovery

Examples of Vestibular Exercises

- **Gaze Stabilization**- eyes fixed stationary object move head side to side & up/down
- **Smooth Pursuit**- eyes fixed on target. Move target side to side & up/down or 2 targets apart move eyes between 2 targets (side to side & up/down)
- **Head and eyes same direction** - fix eyes on target (ie thumb) move target (side to side & up/down) head & eyes in same position
- **Head and eye opposite direction** - fix eyes move target and head in opposite direction
**X1/VOR1 Vestibular Exercises**

- Stationary target
- Subject moves head
  - Horizontal and vertical
- Maintains visual fixation on target
- Target should remain clear (focused) while head is moving

[Video link](http://careguides-videos.med.umich.edu/media/gaze+stabalization-VOR-x1/1_nayn8lb1/20345631)

**X1/VOR1 Errors**

- Not keeping the eyes on the target
  - Instead glancing from side to side
- Making the head movement too large
  - Patient is looking out of the corner of the eyes
- Not moving the head in a consistent in this movement
  - Not staying horizontal
Remembered Target Exercise

- Patient fixates on a small target
- Closes eyes, pretending to look at that target
- Patient makes a horizontal head movement, trying to remember where the target is
- Opens eyes to check whether or not they are still looking at the target
- Aims to foster central pre-programming of eye movements

Rehabilitation Strategies for Ingrained Problem

- Adaptation
  - Ability of the vestibular system to make long-term changes in the neuronal response to input
- Substitution
  - Using other strategies to replace lost function
- Habituation
  - Reduction in symptoms produced through repeated exposure to the movement

X2/VORx2Vestibular Exercises

- Target and the head move in opposite directions
- Patient focuses on target
- Errors
  - Similar to X1 errors
  - Confusion when trying to move head and target in opposite directions
  - Results in VOR cancellation

https://www.youtube.com/watch?v=0Ca1CkwIcM
Dual Task Strategies

- Combined postural control and cognitive tasks
- Retrain executive attentional networks
- Secondary cognitive activities improve postural control (Wulf, 2001; Huxhold, 2006; Resch, 2011)

Vestibular Exercise Progressions
Oculomotor Disorder

- **Treatment**
  - Oculomotor retraining / rehabilitation

- **Prevention**
  - Pre-season vision training
  - Exploratory study out of University of Cincinnati shows decrease in concussion rate (9.2 vs. 1.4 concussion/100 player seasons) after pre-season vision training (Clark, 2015)

Convergence Insufficiency

- Inability to maintain binocular function (keeping the two eyes working together) while working at a near distance
  - Typically, one eye will turn outward (intermittent exotropia) when focusing on a word or object at near distance

- **Symptoms**
  - Diplopia & Headaches when reading
  - Difficulty concentrating on near work (computer, reading, etc.)
  - Written word blurs after prolonged periods of reading or if reading when tired

- **Remote near point of convergence**
  - Maintain binocular fixation on a fusional target up to at least 6 cm from the tip of the nose
Effectiveness of Oculomotor Rehab

- Patients with long term issues
- Vergence-based oculomotor rehabilitation was effective in individuals with mTBI who reported near work-related symptoms
- Overall improvement in nearly all of the critical, abnormal measures of vergence was observed both objectively and clinically (Thiagarajan, 2013)

Pencil Push Ups

Step 1 - Hold a pencil in front of you at arm’s length. The pencil should be vertical, with the tip of the sharpened pencil at the top. The pencil should be directly in front of your face.

Step 2 - Move the pencil slowly toward your face as you concentrate and focus on the tip. Soon you’ll notice that you see two pencils rather than one. Stop.

Step 3 - Look away from the pencil briefly to rest your eyes. Focus on something across the room for two or three seconds, and then look back at the pencil point where you stopped it. Focus on the point carefully, and try to focus so that the double vision disappears. And you only see one pencil.

Step 4 - Move the pencil back out to arm’s length when you are able to rid yourself of double vision. If it takes more than a few seconds, look away and try again. Once you are able to accomplish this, move the pencil back in to arm’s length and complete the exercise again.

Step 5 - Do the pencil pushups for 10 minutes, continuing to move the pencil back and forth in front of your face. Talk to your optometrist if the treatment doesn’t help your convergence insufficiency.
Brock String

Talk to them during this

Teach this to be “reflexive” without need to concentrate

Horizontal and Vertical Saccades

- Many exercises
  - Maze
  - Number saccades
  - 4 square saccades

- Standing Tennis ball Toss and Catch
  - Waist level
  - Shoulder level
Mardsen Ball

Eye Charts

- Move back and forth between charts at different depths
- Use patterns
- Say color or say direction

Oculomotor

- May have NPC normal but can they keep it?
- Difficulty reading to writing
- Reading notes- Increase symptoms

Treatment Techniques

- Read note out loud. Get auditory learning
- Listen to recordings of lecture to allow studying longer without increase in symptoms
- Train shorter periods more often 5-10 min
- Morning is better. End of day fatigue will effect rehab
- Exercise may help decrease symptoms
Oculomotor exercise progression

- Saccades
  - Shorter distance apart predictable to faster different distance
  - Slower speed to faster speed
  - Simple background to complex
  - Steady surface to unsteady
  - Head steady to head movement
  - Work to functional sports specific

Combination Oculomotor & Cervicogenic

- Increase symptoms with Oculomotor activity
  - Posture, Heads stability?
- Attempt Oculomotor exercises supine
  - Pencil push ups
  - Ball Toss and Catch. Up and down, off wall
- Combined Cervical Stability and Oculomotor activity
  - Push ups with charting or reading material on ground. Straight below or off to side

Migraine/Post Traumatic Migraine

- Is it primary?
- Is it secondary from sleep issues, vestibular, ocular, anxiety, cervicogenic?
- Fix all secondary issues
- Primary: don’t exert thru.
- Referral to specialist: Medication need assessment.
Reaction Time Training

Incorporate hand, eye, feet, core stability, head motion etc...

Sport Reaction Time

Stimuli Seeing or Sensing

↓ Recognize Stimuli

↓ Reflexively &/or Cognitively React

↓ Move Feet, Trunk, Head to correct position

↓ Hands are in right position to do something

Reaction time training in rehab

• Progress to sport specific training
• Even if still having symptoms
  – No risk of contact
  – Symptoms do not increase with activity
Add video of tennis ex that parker was doing

Returning to Participation
Early addition of sports specific activity

- Importance of adding sport back early
- Key: Add sport without risk of contact. Progressively adding sport back even with symptoms as long as symptoms do not increase.
- Psychological benefit of not isolating
- Sport trains ocular motor, vestibular, reaction time, cognitive systems

Reaction time in sport

What is reaction time in sport?
- Can it be measured with computer test?
- Can it be measured with finger or hand tests?
- Can it be measured with hand touching lights?

Sport Reaction Time

Stimuli Seeing or Sensing

- Recognize Stimuli
- Reflexively &/or Cognitively React
- Move Feet, Trunk, Head to correct position
- Hands are in right position to do something
Return to Play

- New data looking at return to play is not 1-2 weeks but is looking like 3-4 weeks. (1)
- UA Data 2014-2016 seasons 11 days average for concussions that returned during the season
- INFORMED CONSENT- Physicians (ATs) have a duty to provide athletes and their parents with information about concussion risk factors, symptoms, and the risks for post-concussion neurologic impairments. (2)
- Knowing your patients

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Evaluation for Clearance

- Symptom Score
- Vestibular Ocular Assessment
- Vestibular Spinal Assessment
- Ocular Assessment
- Vital Signs
  - HR & Blood Pressure for orthostasis
  - Heart rate variability
- Exercise Stress Test
- Cardio Endurance Stress Test (HRV?)

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Evaluation for Clearance (Cont)

- Cervical Extensor Endurance Test (1)
- Reaction Time Assessment*
- Neuropsychological Assessment
- Sport Progression Non-contact to Contact
- Performance Assessment
- Informed Consent- Patient wants to return
- Acknowledge sport difference. Risk of contact

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References:


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Continuing Rehab after return?

- Is sport specific activity enough?
- Monitor productivity on the field/court/sport
- Continuing with vestibular, ocular therapy & reaction time training?

Advanced Rehab

- Brain injury is very complex
- Advanced rehab needs to be very advanced

Early Treatment Approach

- Determine what will cause symptoms
- Introduce Cardiovascular Conditioning early
- Train areas without deficits - Can we prevent further issues?
- Initially rest - how long is the million dollar question
- Then work into activities that exacerbate symptoms
- You may (and probably should) cause increase in symptoms with treatment. Expose then recover. Control level of activities

You won't know how far you can progress until you go a little too far. This is OK as long as you do risk with contact
Re-assess after they have returned?

- Monitoring and documenting symptoms score after the patient has returned
- Other assessment needed?
- Sport performance assessment documentation

Recommendations for AT

- Set up treatment team- May need to look at telemedicine
- Communicate with treatment team
  - What are specific sign/symptoms/evaluation findings the would require referral to specialist. Discuss time frame of referral recommendation.
  - What can you implement on your owns as AT, Primary care physician and when can you implement?
- Education of athletes to be “HONEST”. This is key to treatment
  - “I will make you worse with treatment and progression if you are not honest with me about symptoms”
  - Document this education

Recommendations for AT

- Know your patients goals. Support their goals. Patient Centered Care
- Educate other healthcare providers. They do not know this information. Strict rest is doing harm. Educate on avoiding self medicating
- Assess for drug use (opiates & marijuana) for athletes with diagnosed and undiagnosed concussion
- Early addressing of vestibular ocular, cognitive fatigue and psychological issues-Data starting to point that PCS have high prevalence of these issues
• Protecting yourself from liability-appropriate documentation
• Quality Assurance Program to assess the documentation

Medical Records
• How long do you keep records?
  – 7 year requirement in many states
  – May want to keep these longer
• Keep copies of education-content and attendance
• Keep copies of current standards. If they change over years keep with year of standard or protocols.

Discussion/Questions
Specialist with publications to watch

• Overall Treatment- Michaels Collins, Anthony Kontos…UPMC Group
• Physiology-Chris Giza-UCLA Brain Inj Research Center
• Vestibular Therapy Bridgett Wallace, Shelly Massingale,
• Leddy- Exercise therapy
• William Padilla, Charlie Shearer OD. Oculomotor Rehab

Thank You

The “End”