Concussion: Management, Intervention, & Rehabilitation

Nov 13: Concussion Management Update: Recommendations from the Berlin Meeting
Tamara McLeod, PhD, ATC, FNATA

Nov 14: Chronic Post-Concussion Syndrome: Psychological and Cognitive Implications for Treatment
Brady Whetten, PT, DPT, GCS

Nov 15: Concussion: Conditioning the Brain and Body for Return to Sport
Guest Editor: Mike Studer, PT, MHS, NCS, CEEAA, CWT

Nov 16: Concussion and the Older Adult: Does Age Make a Difference?
Debbie Struikisma, PT, NCS

Nov 17: The Management of Cervicogenic Pain and Headaches After Concussion
Renee James, MSPT, OCS, CMP and Bailey Denno, PT, DPT

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Concussion: Conditioning the Brain and Body for Return to Sport

MIKE STUDER, PT, MHS, NCS, CEEAA, CWT, CSST
Learning Objectives

• Identify the role of physical activity and re-conditioning in concussion rehabilitation.
• Identify at least three tests to stage and advance concussed athletes.
• Describe at least three components of an individualized treatment plan to return to sport.
• Outline an individualized intervention strategy designed to enable the concussed athlete to return to running; dual tasking; and hand/foot-eye coordination for their sport.

Timeline

5 The physiology and epidemiology of concussion
15 Treating early sequelae of concussion: hypersensitivity, headaches, visual
10 The role of early mobilization and exertion
15 Technological advances in balance and treatment
10 Re-integrating visual stimuli
20 The role and timing of multitasking
15 Dosing sport-specific physical exertion
10 Psychology of symptom report + return to play
10 Case Studies
5 Questions and summative comments
OUTLINE

Course outline, content and objectives
Epidemiology and neurophysiology of concussion
Unique attributes and common symptoms of sport-related concussion
Early mobilization and the role of exercise
Treatment of hypersensitivity, imbalance, dizziness
Treatment of migraine, cervical pain, fatigue
Treatment of attention: dual and multi-tasking: visual, auditory, motor, and cognitive
Return to sport
Case studies: Application to your practice
Questions, discussion

What is a concussion?

Physiology: immediate or delayed changes in the brain's chemistry and function (does NOT require observable change on imaging).

Concussion is a traumatic brain injury that can damage brain tissue and change the chemical balance of the brain. Concussion may cause physical, mental, and emotional symptoms and problems, both short-term and long-term. Every concussion is considered a serious injury by health care providers.

A concussion IS a brain injury!
Epidemiology and effects

The Centers for Disease Control (CDC) estimates that 2.5 million concussions occurred in the United States in 2010, the most recent year for which the CDC has statistics.

• 32% of parents have fear that their child will be concussed
  ▪ 1 in 4 parents forbid their children to play some contact sports because of that fear
  ▪ > 300,000 concussions/year in H.S. sports
  ▪ Between 2001 and 2005, more than 225,000 pediatric ER visits due to sport related concussion

High School Concussions

Football (47.1%)
Girls' soccer (8.2%)
Boys' wrestling (5.8%)
Girls' basketball (5.5%)

Football had the highest concussion rate (6.4)
Boys' ice hockey (5.4)
Boys' lacrosse (4.0)

Concussions = 22.2% of total injuries in boys’ ice hockey
All other sports studied (13.0%)
Epidemiology of Concussion

1.6 to 3.8 million concussions occur in sports and recreational activities annually (CDC)

> 300,000 concussions/year in H.S. sports

Falls, MVAs, assaults are next by cause

US Department of Defense reported 253,349 mild TBI cases between 2000 and 2014

2001-05, > 500,000 pediatric ER visits. ½ sport related

After one concussion 1.5x, two concussions 2.8x, and three or more prior concussions 3.4x (likelihood of increased risk)

Mechanisms of concussion

Concussions can occur at any age, from a variety of causes, including:

Car accidents (ie, a head impact, or whiplash)
Work accidents (ie, falls, head trauma)
Playground accidents (ie, falling from a slide or swing)
Sports injury to the head or neck
Any type of fall or direct blow to the head, face, or neck
Consensus Statement on Concussion in Sport: Definition and mechanisms

1. Concussion may be caused by a direct *blow to the head, face, neck, or elsewhere on the body with an “impulsive”* force transmitted to the head. *can occur with whiplash and coup/contrecoup mechanism

2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours.

Consensus Statement on Concussion in Sport: Definition and mechanisms

3. Concussion may result in neuropathologic changes, but the acute clinical symptoms largely reflect a *functional disturbance rather than a structural injury*, and as such, no abnormality is seen on standard structural neuroimaging studies.

4. Concussion results in a graded set of clinical symptoms that *may or may not involve loss of consciousness*. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged.
Concussion: Prognosis modifiers

Number of symptoms
Symptoms remaining at 24 hours
Convulsions
History of concussions AND any concussion in the past 7 days
Age 18 or younger
History of: migraine, depression, ADHD, prior concussion, sleep disorder
Psychoactive medications or anticoagulants
Style of play (aggressive)
Sport and position: high risk/incidence

Imaging

MRI
Diffusion tensor imaging
Transcranial Magnetic Stimulation
Magnetoencephalography
Electroencephalography
fMRI - prognostics
Neurophysiology of Concussion

Impact - mechanically-induced depolarization

Neurotransmitters – decreased glutamate

Circulation ↓ and inflammation ↑ = susceptible to hypoxia

Learned non-use and hypersensitivity

Boyd, 2015 JNPT

Neurophysiology of Concussion

Sudden mechanical loading of the head may generate turbulent rotatory and other movements of the cerebral hemispheres and so increase the chances of a tissue-deforming collision or impact between the cortex and the boney walls of the skull.

Deafferentation of the cortex as a consequence of diffuse mechanically-induced depolarization and synchronized discharge of cortical neurons.

Shaw EA, 2002
Acute signs

• Vacant stare
• Delayed verbal expression (slower to answer or follow instructions)
• Inability to focus attention (distractible)
• Disorientation (walking in wrong direction, unaware of time/day/place)
• Slurred or incoherent speech
• Gross observable incoordination (stumbling, unable to tandem walk)
• Emotional lability
• Memory deficits
• Any period of loss of consciousness
• Nausea or vomiting
• Headache
• Dizziness

Diagnosis-specific considerations: Examination

Concussion
Processing speed, intolerance of stimuli

Recognized or actualized as symptoms of:

   nausea          headaches
   blurred vision  dizziness
   imbalance
Diagnosis-specific considerations: Examination

Objective on-field and clinic exams:

SCAT-5
IMPACT
BESS + CTSIB/Isway
DUAL TASK COST*

*Presently being studied for immediate and latent exams
### ImPACT Clinical Report

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<th>Baseline</th>
<th>Post-concussion</th>
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**Composite Scores**

- **Memory composite (verbal)**: 93 (78), 66 (1%), 57 (1%), 63 (1%), 87 (1%), 88 (1%)
- **Memory composite (visual)**: 70 (73), 41 (1%), 49 (1%), 47 (1%), 55 (1%), 66 (1%)
- **Visual motor speed composite**: 42.58 (42), 45.78 (46), 40.13 (43), 38.03 (41), 45.85 (46), 41.90 (42)
- **Reaction time composite**: 0.54 (44), 0.60 (21), 0.66 (6), 0.54 (44), 0.62 (21), 0.54 (44)
- **Impulse control composite**: 8, 14, 16, 16, 10, 11

**Total Symptoms Score**: 0, 14, 3, 1, 0, 0

* Scores in bold type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline scores. However, scores that do not exceed the RCI scores may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.

1 Clinical composite score is available only for exams taken in ImPACT version 2.0 or later.

### X’s and O’s

In this window, do the following for each shape displayed:

- **Q**: Press this key on your keyboard as quickly as you can when you see:
- **P**: Press this key on your keyboard as quickly as you can when you see:

**PLEASE RESPOND AS FAST AS YOU CAN!**

- **LEFT**: Q
- **RIGHT**: P
Persistent symptoms

- Cognitive impairment (memory, attention, concentration, reaction time)
- Headache (with/without migraine component)
- Difficulty with balance
- Dizziness
- Difficulty focusing or reading
- Fatigue

Persistent symptoms

- Photosensitivity
- Fogginess
- Feeling slowed down (bradyphrenia)
- Mood disruption (irritable, nervous, depressed)
- Amnesia (retrograde or anterograde)
- Sleep disturbance (inadequate or excessive)
Early stage management: rehabilitative handling after concussion

- Light activity earlier = better
- Sufficient and INTERESTING stimuli - recognize goal/error
- More active patient involvement – providing feedback
- Introduce dual tasking at the right time (Stage #3)
- Measure your results!
- Allow for success, enjoyment, return to norm, + satisfaction

Stages of recovery: (5)

Rest and precaution* (now no greater than 48 hours)

Aerobic activity, light. Reduce headaches and sensitivities to stimuli + movement

Restoring physical and cognitive endurance + sport-specific exercise

Returning to non-contact training/drills in sport + increase cognitive load

Full contact practice/return to sport
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**Stages of recovery: (1)**

**Rest and precaution** - no greater than 48 hours

**REDUCE:**

Screen time of all kinds: TV, phone, computer, gaming
Artificial light exposure
Noise
Pressure/distractions

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**continued**
Debunking the bunk-ing ...(bedrest)

"Recommending strict rest from the ED did not improve symptom, neurocognitive, and balance outcomes in youth diagnosed with concussion," authors write. "Surprisingly, adolescents who were recommended strict rest after injury reported more symptoms over the course of this study."


Concussion: symptom management

Prolonged bedrest is not a treatment for concussion
Rest – amount and advice

- Avoid daytime naps
- Regular circadian cycle of wake and bed times (individual, pre-injury)
- Relaxation strategies (again, individualized WITHOUT overstimulation)
- Restrict caffeine and other stimulants for wakefulness
- Limit stimulating physical activity just prior to sleep
- Berlin 2017* – 24 to 48 hours

Concussion: symptom management

- Stimuli intolerance: sound, light, overload
- Headaches, migraines and blurred vision
- Dizziness and imbalance
- Attentional interference, distractibility
- Deconditioning
Stages of recovery (2)

Reducing headaches and sensitivities to stimuli or movement

Cervical intervention

Gradual re-exposure: light, sound, movement (habituation)

General exercise without risk (no free weights or balance needed). *Consider aerobics and sport specifics.*

Oculomotor and vestibular programming: dizziness, imbalance

Intolerance of stimuli

• Visual
• Auditory
• Psychological
• Physical – resistance, endurance, impact
• Life stressors (environmental or self imposed)
• Task-specific (cognitive demand, dual/multi task)
Rebuilding tolerance

• Light/sound
• Cognitive
• Psychological
• Activity

Headaches

Determine the origin and treat the cause:

• Exertion: Begin light and test Modified Balke
• Stimuli: Visual, auditory, cognitive, psychological
• Musculoskeletal/mechanical: cervicogenic, other
Headaches

Determine the origin and treat the cause:

• Compensation for dizziness/imbalance

• Nutritional/hydration

• Sleep
Blurred vision

- Investigate vestibular integration (VOR, DVA)

- Investigate cervical stability, endurance

- Rehabilitate with vision therapy using principles of neuroplasticity, adaptation*
Dizziness

Vestibular habituation techniques work. Why?

- Processing speed
- Integration of signals
- Proximity/interconnected “Vestibular cortex”
- Neuroplasticity
Imbalance

• Static and quickly to dynamic
• Limit visual distractions during rehab of balance, re-integrate later
• Sport specific and person specific = interest
• Reduce visual dependency in neuroplasticity (early tendencies to rely solely on vision)
Stages of recovery (3)

Restoring Strength, Physical and Cognitive Endurance
Reversing deconditioning (physical and cognitive)
Restoring kinesthesia, gradually sport-specific
Monitoring return of ANY symptoms with exertion
Limited intensities
Best delivered in intervals with rest periods
Begin dual task introduction
Consider nutrition and hydration (patient less-likely to do so)

Physical Re-conditioning

Patients with refractory postconcussion symptoms and measured the effects of controlled exercise, specifically SUBSYMPTOM THRESHOLD EXERCISE TRAINING (SSTET).

After SSTET, subjects could exercise longer (pretraining exercise duration 9.8 minutes, posttraining 18.7), with higher peak heart rate (147 pretraining versus 179 posttraining) and systolic blood pressure (142 pretraining versus 156 posttraining) AND without symptom exacerbation.

Fatigue: Cognitive and physical

1) CONSIDER WHAT (sport, activity) we are returning them to....

2) Remember that we need to rebuild physical and cognitive loading

3) Too much protection/rest/precaution = learned non-use; hypersensitivity rebound AND psychological impact (depression)
Attentional interference

Dual task rehabilitation considers:

• Mode of distraction this person needs
• Exertion of the primary task
• Symptoms of overload (headache, dizziness, nausea) for this person
• Progression toward multi-tasking

How does a task become (and stay) automatic?

• Thousands of repetitions

• Forced dual tasking with practice (later)

• Focusing on the retraining/repetitions AND the ability to inhibit distractions
What tasks and functions are automatic?

• Walking
• Dressing
• Brushing your teeth
• Typing
• Driving
• Communication (non verbal cues)

Why and HOW are these tasks automatized?

• Thousands of repetitions

• Forced out of conscious processing

• Dual tasking as a function of life/choices
What does everyday movement AND SPORTS require?

• Automatic motor operations
• Overlay of internal thoughts
• Interaction with environmental motion
• Planning the next movements

Clinical screening for dual task tolerance

• CTUG
• Walking while talking task
• Naming tests with dual task mobility
• Phone dial task
• Multiple tasks test
• Trails A/B
Modes of dual tasking

- Cognitive – internal thought
- Auditory – sound (verbal or otherwise)
- Visual - peripheral or central distractor
- Manual – handling (hands or feet)

Visual

- Glare
- Sudden movement in visual field
- Phone, texting
- Media
- Conversational eye contact
- Environmental (not relevant to the task)
- Lamellar flow (traffic, walking, running) in your peripheral visual field
Manual

- Task-related with manipulation
  - Phone
  - Wallet/purse
  - Toothbrush, medications
- Functional/gross motor: carrying clothes, plate, cup
- Sport-specific manipulation of ball, bat, stick, glove

Testing

Objective examination of each mode of attention, progressively in the context of:

I. Balance (static)
II. Mobility (dynamic balance)
III. Sport (task-specific mobility and distractions)
Parameters of Attention

• Focused – amount/vigilance
• Sustained – duration
• Divided – simultaneous two or more
• Alternating – switching
• Selected – filtering

Tests that measure attention (and executive functioning)

• SLUMS (St Louis Univ Memory Scale)
• Trail Making A and B
• MoCA
• Stroop
• Hayling Sentence Inhibition
• MMSE
• Mini-cog
SLUMS Examination

1. What day of the week is it?
2. What is the year?
3. What state are we in?
4. Please remember these five objects. I will ask you what they are later.
   - Apple
   - Pen
   - Car
   - Home
   - Hair
5. You have $100 and you go to the store and buy a dozen apples for $3 and a tricycle for $26. How much do you have left?
6. How many of us do you see?
7. Please name as many animals as you can in one minute.
   - How many minutes?
8. What were the five objects I asked you to remember? I point for each one correct.
9. I am going to give you a series of numbers and I would like you to give them to me backwards. For example, if I say 42, you would say 24.
   - 7 5 6 3 2 1
10. This is a clock face. Please put in the hour numbers and the time at ten minutes to eleven o'clock.
    - Time correct
11. Please place an X in the triangle.
12. Which of the above figures is largest?
13. I am going to tell you a story. Please listen carefully because afterwards, I'm going to ask you some questions about it.
    - She was a very successful cookbook writer. She made a lot of money on the stock market. She then met another man who was a doctor. He was her best friend. They lived in Chicago. She then taught at a large university.
    - What was the woman's name?
    - What work did she do?
14. What did she go back to work?
15. What state did she live in?
16. What was the female's name?
17. What work did she do?
18. What state did she live in?

TOTAL SCORE

Trail Making (Part A)

Instructions:
- Start at the number 1.
- Alternate between even and odd numbers.
- Circle numbers clockwise.

Numbers:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

Date: [ ]

[Image of Trail Making (Part A)]
Demonstration

In a moment, you will see a list of words.

Please read the color the word is written in, not what the word says. Read the first column, then the second, then the third, and finally the fourth.

Example: RED say “Red”
Example: GREEN say “Red”

Please loudly state the color the word which is printed.

When you are done with all four columns, please raise your hand.
Sentence Inhibition Activity

Instructions: Have participants verbally state a word that is different than the typical response, after you verbally state the first part of the sentence.

The captain will go down with the _____
Don’t judge a _____ by it’s cover
The early _____ gets the worm
Beauty is in the eye of the _______
Measuring Attention

Use standardized, objective measures of function in concert with formal distractions

Test patient without distractions, record score
Test patient with distractions, compare score

\[
\text{Measuring Attention}
\]

Single task – Dual task \( \times 100 = \) DTCost

\[
\text{Single task}
\]

Example: 40yd single = 5sec; distracted = 6.5 sec

\[
\frac{5.0 - 6.5 \text{ sec}}{5.0 \text{ sec}} \times 100 = 30\%
\]
Dual task overlay: mobility

Tests lending themselves to dual task overlay:

• BERG
• TUGO
• 4 square step test
• 2 or 6 minute walk test
• Dynamic Gait Index
• Functional Gait Assessment

Testing mobility with a cognitive distractor: in concussion

“...greater dual-task average gait speed costs were independently associated with prolonged symptom duration. Examinations of dual-task gait may provide useful information during multifaceted concussion examinations. Quantitative assessments that simultaneously test multiple domains, such as dual tasks, may be clinically valuable after a concussion to identify those more likely to experience symptoms for >28 days after injury.”


*Most dual task research based in the elderly with vs. without cognitive loss
Functional dual task training

Walking while:

- Pulling a Kleenex from your pocket
- Retrieving an item from your purse
- Holding eye contact in conversation
- Buttoning a shirt
- Brushing teeth
- Donning clothes

Functional dual task training

Walking while:

- Eating
- Adjusting glasses/cleaning
- Looking up a name in a phone book
- Reading the paper
Balance and physical function

• Computerized dynamic posturography
• Clinical Test of Sensory Interaction in Balance (CTSIB)
• Modified CTSIB
• Balance Error Scoring System (BESS Test)

Clinical Test for Sensory Integration in Balance
Determining the relative contribution of sensory systems for balance organization. Eyes open/closed, surface stable/motion, surround is “sway-referenced” or not.
Computerized Dynamic Posturography
Forceplate and visual surround with recorded sway for testing and training
May include CTSIB, reach, motor control, etc.

Firm and Foam
Eyes open and Eyes Closed
*Often tested with feet approximated (nudge)
May have computerized monitor or scored by time
Balance Error Scoring System (BESS)
Standardized balance performance test without posturographic assistance.
20 seconds/trial
Recording number of errors (out of static hold position)
Pre and post concussion

Testing BALANCE with a cognitive distractor: in concussion

“...two 2-min trials standing on a Nintendo Wii Balance Board™ during which the COP under their feet was recorded: i) double-leg stance, eyes open; ii) double-leg stance, eyes closed. Participants also completed a dual-task condition combining a double-leg stance and a Stroop Colour-word test.”

Testing BALANCE with a cognitive distractor: in concussion

“Adding a cognitive task during the tandem gait test resulted in longer detectable deficits post-concussion compared to the traditional single-task tandem gait test. As a clinical tool to assess dynamic motor function, tandem gait may assist with return to sport decisions after concussion.”


Return to school considerations

• Sleep
• Transport/driving
• Size of class and distractions
• Examinations
• Expectations/AP
Returning to safety: automaticity and tolerance

Street crossing

Dual tasking in gait (texting, conversing, carrying objects)

Stairs/changes in surface

Passenger in a car

Driving...

Return to school considerations

• Partial attendance
• Late starts/early dismissals
• Rest periods during day
• Extra time for assignment completion
• Excuse from nonessential assignments
• Postpone or stagger testing
• Excuse from standardized testing
• Extra time and/or open book testing
• Examinations in small/quiet rooms
• Tutorial assistance
• Homebound instruction

• Excuse from gym and attendance in sport practices
• Excuse from assemblies, band/orchestra, woodshop
• Lunch in quiet area
• Accommodations for light and noise sensitivity (earplugs, ball cap, sunglasses, dimmer lights)
• Preferential classroom seating
• Books on tape
• Audiotaped lectures
• Provide notetaker or scribe
• Provide classroom notes or Powerpoint slides prior to class
Stages of recovery (4)

Returning to Normal Activity or Sport

Programmed and task-specific grading:

Player movement
Ball manipulation/tracking
Speed of direction change/agility
Dual and multi-task considerations sport specific
Power/burst considerations
Education for preventing a second concussion
Rest and in-game rotation

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**Return to sport considerations**

- Speed of game and likelihood of impact
- Timeline of recovery/loss of conditioning
- Position changes/ability to rotate-out or limit impact
- Patient insight, safety, honesty, self-advocacy*

Return to sport considerations

• ATC, parental and coaching support

• Patient history (# concussions)

• Tolerance + exposure to conditions in practice

• Duration and ambient conditions

Return to sport considerations

• Rebuilding skill in a non-contact manner (ball handling, direction changes, impact of running, agility)

• Rebuilding confidence (post-traumatic stress) with psychological and physiological considerations

• Rebuilding automaticity – through well-timed and dosed dual tasking
Stages of recovery (5)

Stage 5: Full-contact practice

Normal and full-speed training activities
Restore confidence and assess game readiness
Psychology of return (coach, player, team, parent)
Set expectations for player rotation, rest breaks
Consider pressure situations, player strengths
Ensure that game-level exertion does not provoke symptoms

Prevention

Equipment

Neck strengthening

Education

Rules changes
**Prevention**

**Equipment:** There is **no evidence** to support the use of helmets or mouth guards for prevention of concussion; **(131)** however, to reduce the risk of more severe brain injury, dental injury, and facial injury, the use of helmets, mouth guards and facial protection is recommended.

**Neck strengthening:** Strength of the muscles of the neck and posterior shoulders has the potential to moderate acceleration/deceleration forces during direct or indirect head trauma. **Neck strength was a significant predictor** of concussion, where every 1-lb increase in neck strength decreased the odds of having a concussion by 5%.

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**Prevention**

**Education:** Increased importance on getting the player assessed immediately; reduced stigma; improved officiating education.

**Rules changes:**
Attempts are being made to reduce inherent penalties for removing a player, allowing for time to assess and rule-in/out a concussion
Some of the most dangerous plays/moves are being more penalized
Automatic removal for: helmet coming off and other precautions
Case studies

Summary statistics and facts...

- **Prior history of concussion** appears to be associated with increased concussion risk, more severe presentation, and a protracted recovery course following subsequent concussion.
- In sports with similar rules (e.g., soccer, basketball, softball, baseball), **women sustain concussion at rates significantly higher** than men do.
- High school athletes take longer to recover from a concussion than do collegiate athletes.
- Athletes with posttraumatic **migraines** show greater cognitive impairment and are more likely to have a more protracted recovery following concussion.
- The presence of psychiatric disorders has been associated with worse outcomes following concussion in several studies.
- Patients with history of learning disability had protracted recovery following mTBI, and presence of attention deficit hyperactivity disorder (ADHD) may be associated with **greater risk of concussion.**
Summary statistics and facts (continued)...

• Brief LOC does not appear to be related to recovery following concussion.

• Presence of amnesia may be associated with symptoms at 3 days postinjury, with retrograde more predictive than anterograde (posttraumatic) amnesia. However, amnesia might not be related to prolonged (<3 wk) recovery.

• As an acute (on-field) symptom, dizziness has been shown to be strongly associated with prolonged recovery after concussion. When present at 1 or 2 weeks after injury, dizziness appears to be predictive for development of persistent PCS.

• Patients reporting the symptom of fogginess postinjury appear to have a more severe and protracted recovery course.

• Cognitive deficits in the first few days (<3 d) following concussion are predictive of more complicated and prolonged recovery. This effect appears magnified when more areas of cognitive function are involved.
Questions?
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References + evidence


References + evidence


References + evidence


*Spontaneous recovery occurs within 10 to 21 days for 80% to 90% of athletes following sport-related concussion.
# DUAL TASK References


