Concussive Injury: Diagnosis, Evaluation and Management.

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Standards of Care

Consensus Statement on Concussion in Sport—the 4th International Conference on Concussion in Sport Held in Zurich, November 2012

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This consensus paper is broken into a number of sections:

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Standards of Care

American Medical Society for Sports Medicine position statement: concussion in sport

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Harmon KG, Drezner JA, Gammons M, et al. Br J Sports Med 2013, 47, 15–26

Concussion Definition

- A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.
- Features helpful in defining a concussive injury:
  - Caused by direct or indirect blow anywhere on the body.
  - Rapid onset, short-lived impairment of neurological function.
  - Usually resolves spontaneously.
  - Neuropathologic changes are ***functional.***
  - Normal structural neuroimaging.
  - May or may not involve loss of consciousness.

Epidemiology

- > 1 million ER visits annually for TBI.
  - Most are concussions.
  - Likely underreported.
- Sports-related concussions:
  - 1.6-3.8 million annually.
  - Likely under-reported.

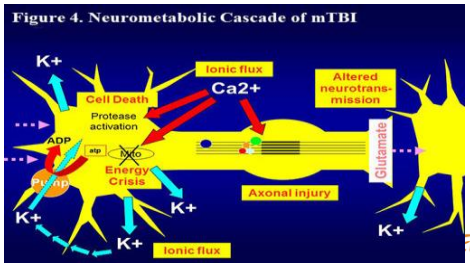
Pathophysiology

- Rotational and angular forces
  - Disrupts neural membranes.
    - Depolarization of neurons.
- K+ efflux into extracellular space.
- Influx of Ca++
  - suppressed neuron activity.
  - Impaired mitochondrial oxidative metabolism.
- Release of excitatory amino acids.

Pathophysiology

- Fuel need-delivery mismatch.
  - Na-K pumps try to restore balance:
    - Increases energy demand.
  - Simultaneous decrease in cerebral blood flow
    - Less energy available.
  - Lasts 7-10 days.
- Exaggerated sympathetic nervous activity vs controls.
  - May remain for several wks.

Pathophysiology



Symptoms

- Vague, non-specific.
  - Establish relationship between mechanism and onset of symptoms.
- Onset: rapid or delayed.
- Loss of consciousness not required.

Symptoms

- Common:
  - Headache.
  - Dizziness.
  - Fogginess.
  - Balance disturbance.
  - Sleep disturbance.

Table 2. Selected Symptoms of Concussion

Affective/emotional	**Sleep†**
Anxiety/nervousness*†	Decreased sleep
Clinginess	Difficulty initiating sleep
Depression†	Drowsiness*§
Emotional lability	Increased sleep*
Irritability*†	**Somatic/physical**
Personality changes	Blurred vision*§
Sadness	Convulsions
Cognitive	Dizziness/poor balance*‡§
Amnesia	Fatigue*†§
Confusion‡	Headache*†‡§
Delayed verbal and other responses	Light-headedness†
Difficulty concentrating*†§	Light sensitivity*†§
Difficulty remembering*†§	Nausea*‡§
Disorientation*†	Noise sensitivity*§
Feeling foggy*§	Numbness/tingling
Feeling slowed down*§	Tinnitus†
Feeling stunned	Vomiting‡
Inability to focus	
Loss of consciousness	
Slurred speech	
Vacant stare	

Classification

- **Old:**
  - Grades:
    - Cantu.
    - AAN.
    - CO.
  - "Simple"/"Complex" definition from Prague Guidelines.
- **Current**:
  - Individualized approach.
    - Developed over time as the patient recovers.

Assessment Tools

- **Symptom checklist**:
  - –May improve symptoms reported.
  - –Quick, easy, cost-effective.
  - –Most are developed via clinical judgement.
    - Postconcussion Symptoms Scale.
    - Graded Symptom Checklist.
    - Concussion Symptom Inventory – only empirically based checklist.

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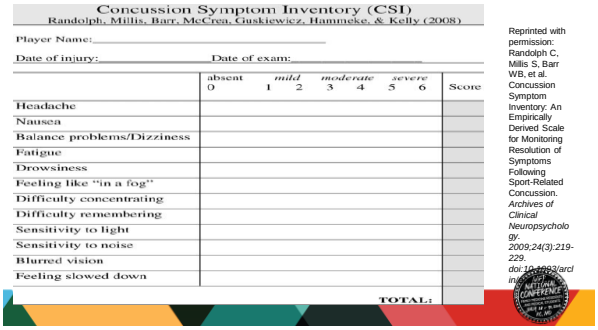


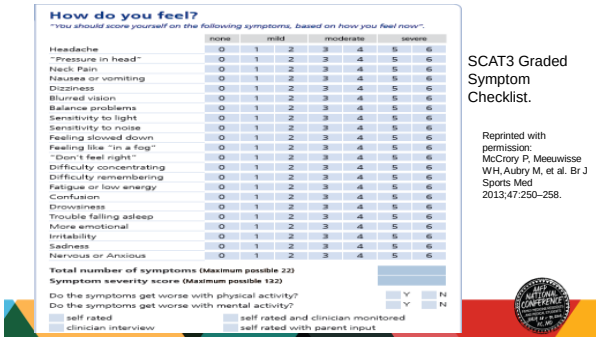
Concussion Symptom Inventory (CSI)
Randolph, Millis, Barr, McCrea, Guskiewicz, Hammeke, & Kelly (2008)

Player Name:

Date of injury: Date of exam:

	absent 0	mild 1 2	moderate 3 4	severe 5 6	Score
Headache					
Nausea					
Balance problems/Dizziness					
Fatigue					
Drowsiness					
Feeling like "in a fog"					
Difficulty concentrating					
Difficulty remembering					
Sensitivity to light					
Sensitivity to noise					
Blurred vision					
Feeling slowed down					
				TOTAL:	

Reprinted with permission: Randolph C, Millis S, Barr WB, et al. Concussion Symptom Inventory: An Empirically Derived Scale for Monitoring Resolution of Symptoms Following Sport-Related Concussion. *Archives of Clinical Neuropsychology. 2009;24(3):219-229. doi:10.1093/arcl in*



How do you feel?
"You should score yourself on the following symptoms, based on how you feel now".

	none	mild	moderate	severe
Headache	0	1 2	3 4	5 6
"Pressure in head"	0	1 2	3 4	5 6
Neck Pain	0	1 2	3 4	5 6
Nausea or vomiting	0	1 2	3 4	5 6
Dizziness	0	1 2	3 4	5 6
Blurred vision	0	1 2	3 4	5 6
Balance problems	0	1 2	3 4	5 6
Sensitivity to light	0	1 2	3 4	5 6
Sensitivity to noise	0	1 2	3 4	5 6
Feeling slowed down	0	1 2	3 4	5 6
Feeling like "in a fog"	0	1 2	3 4	5 6
"Don't feel right"	0	1 2	3 4	5 6
Difficulty concentrating	0	1 2	3 4	5 6
Difficulty remembering	0	1 2	3 4	5 6
Fatigue or low energy	0	1 2	3 4	5 6
Confusion	0	1 2	3 4	5 6
Drowsiness	0	1 2	3 4	5 6
Trouble falling asleep	0	1 2	3 4	5 6
More emotional	0	1 2	3 4	5 6
Irritability	0	1 2	3 4	5 6
Sadness	0	1 2	3 4	5 6
Nervous or Anxious	0	1 2	3 4	5 6
Total number of symptoms (Maximum possible 22)				
Symptom severity score (Maximum possible 132)				

Do the symptoms get worse with physical activity? Y N
Do the symptoms get worse with mental activity? Y N

self rated | self rated and clinician monitored
clinician interview | self rated with parent input

SCAT3 Graded Symptom Checklist.

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Assessment Tools

- Neuropsychological Testing:
  - Written or Computer-based.
  - Baseline (pre-concussion) test is helpful.
  - Utility unclear:
    - No evidence it affects outcomes.
    - No statistically significant difference in written vs computer-based.
    - Limited use in pediatrics.
    - Confounders: psych conditions, motivation, cultural factors.
  - Beneficial:
    - Complex pts: etiology of symptoms is unclear.
    - Return to play decisions.

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Assessment Tools

- Postural Stability Testing:
  - – Impaired balance common after concussion.
  - – High sensitivity in diagnosing concussion.
  - – Limited data for monitoring recovery.
  - – Balance Error Scoring System (BESS).
    - – Quick.
    - – Minimal equipment needed.
    - – Reliability and validity documented.

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BESS

- 3 timed stances, 20 secs each:
  - Double-leg stance (hands on hips, feet together).
  - Single-leg stance (on nondominant leg, hands on hips).
  - Tandem stance (nondominant foot behind dominant) heel-to-toe.
- Eyes closed, on firm and unstable surface.
- Errors counted with each trial.
  - opening eyes, lifting hands off hips, stepping/ stumbling/falling from position, lifting forefoot/heel, abducting the hip > 30° , or failing to return to test position in > 5 secs.

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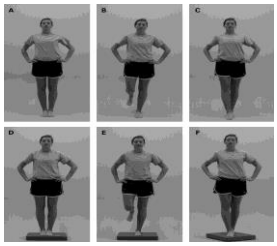
Balance Error Scoring System (BESS) performed on firm surface (A-C) and foam surface (D-F).



Reprinted with permission: Davis, G et al. Contributions of neuroimaging, balance testing, electrophysiology and blood markers to the assessment of sport-related concussion. Br J Sports Med 2009;43:i36-i45

G A Davis et al. Br J Sports Med 2009;43:i36-i45

BJSM

BESS Scoring

- Max errors for each position = 10.
- Multiple errors simultaneously = 1.
  - steps/stumbles, opens eyes, and removes hands from hips simultaneously = 1 error.
- Average scores:
  - Controls: 10.
  - Concussed: 17.
- Average return to baseline: 3-5 days.
- Scores negatively affected by:
  - Fatigue
  - Bracing/taping
  - Age

Imaging

- Imaging contributes little to management.
  - Concussion is a FUNCTIONAL injury.
- Initial study: CT
  - Improved sensitivity for intracranial bleed.
- Prolonged deficits:
  - MRI
- fMRI?
  - Data and clinical utility unclear.

Imaging Guidelines

- AAFP/AAP Guidelines:
  - LOC > 60 secs.
  - Evidence of skull fx.
  - Focal neuro findings on exam.

Imaging Guidelines

- ACEP Guidelines:
  - LOC w/: diffuse HA, vomiting, age >60, intoxicated, STM deficits, seizure, GCS score < 15, focal neuro findings, coagulopathy.
  - No LOC: focal neuro deficit, vomiting, severe HA, age >65, signs of basilar skull fx, GCS < 15, coagulopathy, significant mechanism (ejected from car, fall > 3 ft).

Sideline Evaluation

- Rule out C-spine injury.
- SCAT 3: Not validated.
  - Symptom checklist.
  - Maddock's questions: concentration/memory.
  - SAC:
    - Drop >/= 1 pnt from baseline:
      - 95% sensitive.
      - 76% specific.
    - Junior High School age and older.
  - Modified BESS.
  - GCS.

Cognitive assessment
Standardized Assessment of Concussion (SAC)*

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

List	Trial 1	Trial 2	Trial 3	Alternative word list		
elbow	0 1	0 1	0 1	candle	baby	finger
apple	0 1	0 1	0 1	paper	monkey	penny
carpet	0 1	0 1	0 1	sugar	perfume	blanket
saddle	0 1	0 1	0 1	sandwich	sunset	lemon
bubble	0 1	0 1	0 1	wagon	iron	insect
Total						
Immediate memory score total						of 15

Concentration: Digits Backward

List	Trial 1	Alternative digit list		
4-9-3	0 1	6-2-9	5-2-6	4-1-5
3-8-1-4	0 1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0 1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0 1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4				

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration score		of 5

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Clinic Evaluation

- Thorough **HPI**.
  - Mechanism.
  - When did symptoms present?
  - How have they changed?
- Physical exam:
  - Neuro.
  - Balance testing.
- PMHx:
  - Hx of concussions?
  - Number and when?
  - Length of time for recovery?

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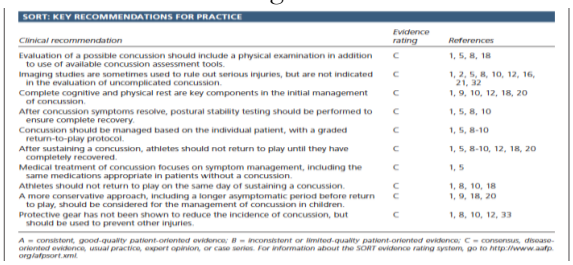
Management



SORT: KEY RECOMMENDATIONS FOR PRACTICE

Clinical recommendation	Evidence rating	References
Evaluation of a possible concussion should include a physical examination in addition to use of available concussion assessment tools.	C	1, 5, 8, 18
Imaging studies are sometimes used to rule out serious injuries, but are not indicated in the evaluation of uncomplicated concussion.	C	1, 2, 5, 8, 10, 12, 16, 21, 32
Complete cognitive and physical rest are key components in the initial management of concussion.	C	1, 9, 10, 12, 18, 20
After concussion symptoms resolve, postural stability testing should be performed to ensure complete recovery.	C	1, 5, 8, 10
Concussion should be managed based on the individual patient, with a graded return-to-play protocol.	C	1, 5, 8-10
After sustaining a concussion, athletes should not return to play until they have completely recovered.	C	1, 5, 8-10, 12, 18, 20
Medical treatment of concussion focuses on symptom management, including the same medications appropriate in patients without a concussion.	C	1, 5
Athletes should not return to play on the same day of sustaining a concussion.	C	1, 8, 10, 18
A more conservative approach, including a longer asymptomatic period before return to play, should be considered for the management of concussion in children.	C	1, 9, 18, 20
Protective gear has not been shown to reduce the incidence of concussion, but should be used to prevent other injuries.	C	1, 8, 10, 12, 33

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to http://www.aafp.org/afpsort.xml.

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Management

- Physical ***and*** cognitive rest in first 2 wks.
- Cognitive stressors: blue screens, printed text.
  - Stimulating environments: bowling allies, sports venues, music venues, etc.
- Patient education:
  - Failure to rest may worsen symptoms or prolong recovery.
  - No physical exertion is acceptable.

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Management

- Advocate for your patients
  - Write letters, call professors/deans/supervisors, etc.
- Pain medications
  - Tylenol PRN headaches.
  - NSAIDs once bleed has been ruled out.
  - Educated pt on how to take these.
- Close follow up:
  - Symptom checklist at f/u visits.

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Management

- Reassure pt/family:
  - Most cases recover within 10 days.
- Rest until asymptomatic X 24 hrs off meds.
- Graded “return to play”/”return to life” program.
  - Reintroduce progressively harder physical stressors.
  - Reintroduce progressively harder cognitive stressors.

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Return to Play

- No same day return.
- Adults: 5 day progression.
  - Progressively harder stresses each day.
- 24 hrs between phases.
- Exertion stops if symptoms return during activity.
  - Then rest until asymptomatic X 24 hrs.
  - Restart at level achieved before symptoms developed.

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Table 1 Graduated return to play protocol

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Symptom limited physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70% maximum permitted heart rate No resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, eg, passing drills in football and ice hockey May start progressive resistance training	Exercise, coordination and cognitive load
5. Full-contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

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Modifying Factors

- Can influence management.
- May predict risk for prolonged symptoms.
- Presence may justify additional evaluation tools:
  - Professional nueropsych (NP) testing.
  - Neuroimaging.

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Table 2 Concussion modifiers

Factors	Modifier
Symptoms	Number Duration (>10 days) Severity
Signs	Prolonged loss of consciousness (LOC) (>1 min), Amnesia
Sequelae	Concussive convulsions
Temporal	Frequency—repeated concussions over time Timing—injuries close together in time 'Recency'—recent concussion or traumatic brain injury (TBI)
Threshold	Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion
Age	Child and adolescent (<18 years old)
Comorbidities and premorbidities	Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder (ADHD), learning disabilities (LD), sleep disorders
Medication	Psychoactive drugs, anticoagulants
Behaviour	Dangerous style of play
Sport	High-risk activity, contact and collision sport, high sporting level

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Loss of Consciousness

- **Not** a predictor of injury severity.
- Zurich: "Whilst published findings in concussion describe LOC associated with specific early cognitive deficits, it has not been noted as a measure of injury severity. Consensus discussion determined that prolonged (>1 minute duration) LOC would be considered as a factor that may modify management."

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Amnesia, Convulsions

- Amnesia: significance uncertain.
  - Severity tends to vary with time of measurement post-injury.
- Convulsions:
  - Generally benign.
  - No specific management beyond standard treatment of the concussive injury.

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Depression

- May mask clinical improvement:
  - "negative" depressive symptoms parallel post-concussive symptoms.
- May follow a concussion.
- Pre-existing: risk factor for prolonged recovery.

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Pediatrics (<18 yo)

- Most data is on high-school and college-aged athletes.
- Underreporting:
  - 2004 study (McCrea et al):
    - Only 47.3% of HS FB players reported their injuries.
    - Similar findings in other sports, including females.
  - Pediatric organizations: less likely to have organized concussion management.

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Pediatrics

- Report concussive symptoms differently.
  - Age appropriate symptoms checklist.
  - Evaluation should include pts daily contacts.
- NP testing:
  - Use earlier to help in management decisions.
  - Needs to be age sensitive.
  - Interpretation by neuropsychologist.
    - Baseline comparisons difficult due to rapid CNS maturation.
    - Caution if no baseline:
      - Normative samples are typically from older athletes.

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Pediatrics

- Recovery takes longer.
  - HS vs college aged athletes: younger recover slower.
  - Double return to play/life protocol.
- Data from pediatric brain injury studies:
  - Increased likelihood of long-term sequelae.
  - Underdeveloped/Developing skills most vulnerable.
  - Minimal effect on cognitive skills already established.

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Medications

- Not evidence-based.
  - Extrapolated from studies on TBI.
- Consider if prolonged symptoms.
- Focused on symptom management.
  - Depression: SSRIs
  - Persistent headache:
    - CCB: verapamil 80 mg TID
    - TCA: amitryptiline, nortriptyline, Topamax
    - Beta blockers.
    - Vitamin B2 (riboflavin): 100 mg, 2 tabs BID.
    - Magnesium oxide: 250 mg, TID.

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Post Concussive Syndrome

- No accepted definition.
  - Varies from > 2 wks to > 3 months.
  - Recovery varies based on cohort studied:
    - Longer in youth.
    - ? longer in specific sports.
- Most common symptoms:
  - HA, depression, fatigue, irritability, impaired memory and concentration, insomnia.

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Post Concussive Syndrome

- What to do?
  - Current guidelines: rest until asymptomatic.
  - Ensure compliance.
  - Review medications and lifestyle factors.
- Consider 2ndary symptoms of prolonged rest:
  - Fatigue.
  - Reactive depression.
  - Physiological deconditioning.

Post Concussive Syndrome

- Consider graded exertion?
  - Animal data:
    - Premature ex in the 1st wk after concussion impairs recovery.
    - Aerobic ex 14-21 days after injury improves cognitive performance. [10]
- Leddy JJ, Kozlowski K. A Preliminary Study of Subsymptom Threshold Exercise Training for Refractory Post-Concussive Syndrome. *Clin J Sport Med.* 2010; 20(1):21-27.

Subsymptom Threshold Ex Training (SSTET).

- Population: 12 subjects with post concussive symptoms; duration >6 wks, <52.
  - Symptom exacerbation with graded treadmill test.
  - 7 men, 5 women; avg age of 27.9.
  - 50% of subjects were athletes.
  - 50% had hx of 1 or more concussions in past.

SSTET

- Baseline test:
  - Incremental treadmill ex test.
    - Balke protocol.
    - Stopped when pt reported symptoms exacerbation.
  - Time and max HR recorded.
- Intervention:
  - Daily aerobic ex at 80% of HR noted on treadmill test, until symptom exacerbation or time met.
  - Treadmill ex tests Q 3 wks.
  - Success:
    - Ability to ex to exhaustion without symptoms exacerbation.

SSTET

- All 12 achieved tx success.
- No occasions where subjects could not ex b/c of symptom exacerbation.
- Range of tx days: 11-112.
  - Athletes completed tx in ~1/3 the time of non-athletes.
- Significant improvement in symptoms reduction:
  - 9.67 +/- 5.87 vs 5.42 +/- 4.54
- Significant improvement in ex time.
  - 9.75 +/- 6.38 vs 18.67 +/- 2.53.
- Greater exertional peak HR and SBP after SSTET.
  - HR: 147 +/- 27 bpm vs 179 +/-17 bpm.
  - SBP: 142 +/- 6 mm Hg vs 156 +/- 13 mm Hg.

SSTET

- Results: 3 month follow up.
  - 10/12 were symptom free at rest.
  - All returned to work , school, and athletics.
    - At entry:
      - All athletes were in school but were not participating in sports.
      - 5/6 non-athletes were not working or going to school.
- Significance?
  - PCS can be safely tx'd with individualized, progressive, SSTET.
  - SSTET can accelerate recovery from PCS.

Difficult Decisions

- Athletes with multiple concussive injuries:
  - Identify "red flags":
    - Worsened symptoms with similar impact forces.
    - Similar symptoms with lower impact forces.
    - Prolongation of symptoms vs prior injuries.
  - ID possible cause of frequent concussions.
    - Risky behavior vs possible predisposition.
  - Discussion(s):
    - Athlete + significant others reg risks of future injuries.

Case 1

- 35 yo, male cyclist involved in high speed crash.
- Immediately after accident:
  - No LOC, headache, dizziness, nausea, or photophobia.
- 2 days later:
  - Mild HA, eye fatigue, fatigue, irritable.

Case 1

- Social Hx:
  - Heavy caffeine on wkends – caffeine w/drawal on Mon is common.
  - High stress job - frequent use of blue screens, with eye strain after prolonged use.
  - Baseline sleep deprivation - 6.5 hrs Q night.
  - Exs daily: 75-120 + mins, 2-3 hard workouts per wk, racing most wkends.
- Is he concussed?
- Can he continue to train and race?

Case 2

- 20 yo male soccer player: strikes head on ground during game while diving for ball.
- Eval'd at side: denies all symptoms.
- Held out, re-eval'd 15 mins later: denies symptoms.
- Allowed to return to play.
- PMHx:
  - 4 concussions, most recent 1 yr ago, requiring 4 wks to recover.
  - All other injuries required ~2 wks recovery.
- Should he have been returned to the game?

Case 2

- 2 days later: HA, "foggy thinking", fatigue, photophobia, which started the day after the game.
  - Athlete withheld this from the ATC; practiced with symptoms.
- After 1 wk of rest: persistent symptoms, mild improvement.
  - Parents push for neuro referral, CT, question if pt should retire.
- How do you advise the pt and parents?
- Do you refer and/or image?
- 3 wks later: moderate improvement, minor fogginess and slight photophobia remain.
  - Do you recommend retirement form the sport?

Q&A

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