Neurological Effects of Sports-Related Injury

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Disclosures

Neither I nor my spouse/partner has a relevant financial relationship with a commercial interest to disclose.
Epidemiology

1.6–3.8 million sport-related TBIs occur annually in the USA alone
Does not include those which are not reported (i.e. most of them)
10% of all contact sport athletes get a concussion each season
After 1 concussion, risk of a second one is markedly increased
Definition

Concussion is a complex pathophysiological process that affects the brain and is induced by traumatic biomechanical forces.

Concussion typically occurs following transmission of direct or indirect impulsive forces to the head.

Results in rapid onset of short-lived neurological impairments and presents clinically with cognitive, physical and behavioral signs and symptoms.

Jordan 2013
Definition

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Symptoms

Most frequent symptoms:
- Headache
- Dizziness
- Memory impairment

Box 2: Symptoms of acute concussion

Cognitive features
- Decreased speed of information processing
- Disorientation
- Lack of awareness
- Confusion
- Amnesia or other memory impairments
- Impaired concentration
- Loss of consciousness
- Feeling in a “fog”

Behavioural features
- Sleep disturbance
- Irritability
- Emotional liability
- Nervousness and/or anxiety
- Psychomotor retardation
- Apathy
- Fatigue
- Easily distracted

Physical features
- Headache
- Dizziness and/or vertigo
- Nausea
- Vacant stare
- Impaired playing ability
- Gait unsteadiness and/or loss of balance
- Impaired coordination
- Diplopia and/or blurred vision
- Photophobia
- Hyperacusis
- Concussive convulsion and/or impact seizure

Jordan 2013
Pathophysiology

Sudden stretching of the neuronal and axonal membranes -> flux of ions through previously regulated ion channels

Widespread release excitatory amino acids (EAAs)

Glutamate binds kainite, NMDA and D-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid ionic channels -> further depolarization, causing influx of calcium ions into the cells.

This leads to mitochondrial calcium overloading -> change in membrane permeability with consequent malfunctioning, uncoupling of oxidative phosphorylation and an energy crisis due to this oxidative stress.

Signoretti et al 2011
Pathophysiology

**Figure 2.** Diagram of the acute cellular biological processes occurring after concussion/mild TBI. mTBI, mild traumatic brain injury.

Giza & Hovda 2014
Management

Recognize
Remove
Re-evaluate
Rest
Refer
Return
Recognition: Sideline Management

a) Players manifesting clear on-field signs of sports-related concussion (SRC; eg. loss of consciousness, tonic posturing, balance disturbance) should immediately be removed from sporting participation.

b) Players with a suspected SRC following a significant head impact or with symptoms can proceed to sideline screening using appropriate assessment tools—for example, SCAT5. Takes about 10 minutes.

c) Both groups can then proceed to a more thorough diagnostic evaluation, which should be performed in a distraction-free environment (eg, locker room, medical room) rather than on the sideline.

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When a player shows any symptoms or signs of an SRC:

a) The player should be evaluated by a physician or other licensed healthcare provider on site using standard emergency management principles, and particular attention should be given to excluding a cervical spine injury.

b) The appropriate disposition of the player must be determined by the treating healthcare provider in a timely manner. If no healthcare provider is available, the player should be safely removed from practice or play and urgent referral to a physician arranged.

c) Once the first aid issues are addressed, an assessment of the concussive injury should be made using the SCAT5 or other sideline assessment tools.

d) The player should not be left alone after the injury, and serial monitoring for deterioration is essential over the initial few hours after injury.

e) A player with diagnosed SRC should not be allowed to return to play on the day of injury.

McCrory et al 2017 Consensus Statement
The key features of follow-up examination should encompass:

a) A medical assessment including a comprehensive history and detailed neurological examination including a thorough assessment of mental status, cognitive functioning, sleep/wake disturbance, ocular function, vestibular function, gait and balance.

b) Determination of the clinical status of the patient, including whether there has been improvement or deterioration since the time of injury. This may involve seeking additional information from parents, coaches, teammates and eyewitnesses to the injury.

c) Determination of the need for emergent neuroimaging to exclude a more severe brain injury (eg, structural abnormality).

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Biomarkers

Advanced neuroimaging such as tractography, fluid biomarkers and genetic testing are important research tools and may at some point have a role in the acute assessment and management of sports-related concussion, but require further validation to determine their ultimate clinical utility.
Rest

a) While physical and cognitive rest are commonly prescribed, there is currently insufficient evidence that prescribing complete rest is required and clearly no evidence as to how much request is required.

b) For highly trained athletes, complete rest can make psychological symptoms worse.

c) After a brief period of rest during the acute phase (24–48 hours) after injury, patients can be encouraged to become gradually and progressively more active while staying below their cognitive and physical symptom-exacerbation thresholds.

d) It is reasonable for athletes to avoid vigorous exertion while they are recovering.

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Rehabilitation

a) Most athletes recover in 10-14 days.

b) Closely monitored active rehabilitation programs involving controlled sub-symptom-threshold, submaximal exercise have been shown to be safe and may be of benefit in facilitating recovery.

This is an area of active research where much more information is needed
Rehabilitation

a) Most athletes recover in 10-14 days.

b) Closely monitored active rehabilitation programs involving controlled sub-symptom-threshold, submaximal exercise have been shown to be safe and may be of benefit in facilitating recovery.

c) Controlled cognitive stress, pharmacological treatment, and school accommodations, may be beneficial.

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a) Refer if persistent symptoms (>14 days in adults, >4 weeks in children).

b) Assessment should include a comprehensive history, focused physical examination, and special tests where indicated (e.g., graded aerobic exercise test).

c) Treatment should be individualized and target-specific medical, physical and psychosocial factors identified on assessment. There is preliminary evidence supporting the use of:
   a) an individualized symptom-limited aerobic exercise program in patients with persistent post-concussive symptoms.
   b) a targeted physical therapy program in patients with cervical spine or vestibular dysfunction.
   c) cognitive behavioral therapy to deal with any persistent mood or behavioral issues.

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### Table 1: Graduated return-to-sport (RTS) strategy

<table>
<thead>
<tr>
<th>Stage</th>
<th>Aim</th>
<th>Activity</th>
<th>Goal of each step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Symptom-limited activity</td>
<td>Daily activities that do not provoke symptoms</td>
<td>Gradual reintroduction of work/school activities</td>
</tr>
<tr>
<td>2</td>
<td>Light aerobic exercise</td>
<td>Walking or stationary cycling at slow to medium pace. No resistance training</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td>3</td>
<td>Sport-specific exercise</td>
<td>Running or skating drills. No head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4</td>
<td>Non-contact training drills</td>
<td>Harder training drills, eg, passing drills. May start progressive resistance training</td>
<td>Exercise, coordination and increased thinking</td>
</tr>
<tr>
<td>5</td>
<td>Full contact practice</td>
<td>Following medical clearance, participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
</tr>
<tr>
<td>6</td>
<td>Return to sport</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
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Thank you