Incidence, Anatomy, and Physiological Effects of Concussive Brain Injury

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Mild Traumatic Brain Injury

Concussion: *Concutere* (to strike together)
TBI Defined

• TBI is caused by a bump, blow or jolt to the head or a penetrating head injury that disrupts the normal function of the brain.

• The severity of a TBI may range from “mild,” i.e., a brief change in mental status or consciousness to “severe,” i.e., an extended period of unconsciousness or amnesia after the injury.

• The majority of TBIs that occur each year are concussions or other forms of mild TBI.
At least 1.7 million TBIs occur in the United States each year.

Estimated Average Percentage of Annual TBI by External Cause in the United States, 2002–2006

- 35.2% Falls
- 17.3% Motor Vehicle–Traffic
- 16.5% Struck By/Against
- 21% Unknown/Other
- 10% Assault

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010
TBI By Age/Type

- Motor Vehicle - Traffic
- Falls
- Assault

Rate per 100,000
Two Primary Mechanisms of Blunt Brain trauma

- **Linear Blunt**
  - Example: Falling to the ground and hitting the back of the head. The falling motion propels the brain in a straight line downward.

- **Rotational Blunt**
  - Example: When a player is spun, rolled, turned, his head may strike object; this contact to the head can cause a rotational motion.
The Predicted Intracranial Pressure Wave Following a Concussive Blow is Shown in the upper image. Note the Drastic Change From Positive Pressure (pink, coup) to Negative Pressure (blue, contre-coup) Across the Brain.

Within the Brain Following a Strong Blow to the Head. The Predicted Sheer Stresses (lower image) Differentiate Concussive From Non-concussive Injury. Note the High Sheer Stress (pink) in the Central Core of the Brain.

Cecilia V. Mendez, M.D., Robin A. Hurley, M.D., FANPA, Maryse Lassonde, Ph.D., Liying Zhang, Ph.D. and Katherine H. Taber, Ph. J Neuropsychiatry Clin Neurosci 17:297-303, August 2005
Axonal Injury

- Initially described by Strich (pathologist) in 1956.
  - Axonal degeneration/disintegration
  - Not diffuse per say but predominates in discrete regions of the brain.
  - Axon retraction.
  - Foci of hemorrhage.
  - Long term survivors:
    - Microglial clusters
    - Foci of demyelination
    - Ventricular enlargement

Pathophysiology of DAI

- From rotational forces.

- The injury to tissue is greatest in areas where the density difference is greatest.

- For this reason, approximately two thirds of DAI lesions occur at the gray-white matter junction.

Axonal Injury

- **Location** of injury depends on 2 factors:
  1. Depends on the plane of rotation.
  2. Independent of the distance from the center of rotation.

- **Magnitude** of injury depends on 3 factors:
  1. Distance from the center of rotation.
  2. Arc of rotation.
  3. Duration and intensity of the force.
Typical Locations for DAI

- The lesions typically are ovoid or elliptical, with the long axis parallel to the direction of the involved axonal tracts.
- Not Superficial
- Grey – white junction
- Corpus callosum
- Brain stem (dorsal midbrain)
- Basal ganglia/internal capsule
- Hemispheric white matte
Thalamo-Cortical Connectivity Loss in TBI

Volumetric proton magnetic spectroscopic imaging has found significant changes in with reduced N-Acetylaspartate (NAA)/Creatine (Cr), increased Choline (Cho)/Cr, and reduced NAA/Cho ratios.

The results show evidence of widespread metabolic changes in regions that appear normal on diagnostic MR images.

http://www.kumc.edu/
NOREPINEPHRINE
ALERTNESS
ENERGY

DOPAMINE
ATTENTION
MOTIVATION
PLEASURE
REWARD

SEROTONIN
MOOD
ANXIETY

OBSESSIONS AND
COMPULSIONS
Routine Brain MRI and CAT scans usually show abnormalities in mTBI.

- True
- False
PET SCANNING
Studies have not been able to correlate abnormal findings on regular MRI with either post concussive symptoms or long term outcome. FMRI:

(CDC) Mild Traumatic Injury Workgroup

• Conceptually defined MTBI as
  – "an injury to the head as a result of blunt trauma or acceleration or deceleration forces that result in one or more of the following conditions:
    • (1) Any period of observed or self-reported transient confusion, disorientation, impaired consciousness, dysfunction of memory around the time of injury, or loss of consciousness lasting less than 30 minutes
    • (2) Observed signs of neurological or neuropsychological dysfunction, headache, dizziness, irritability, fatigue or poor concentration.”

The base of the skull is rough, with many bony protuberances. These ridges can cause trauma to the temporal lobes during rapid deceleration.
The frontal lobe is the area of the brain responsible for higher cognitive functions. These include:

- Problem solving
- Spontaneity
- Memory
- Language
- Motivation
- Judgment
- Impulse control
- Social and sexual behavior.
The temporal lobe plays a role in emotions, and is also responsible for smelling, tasting, perception, memory, understanding music, aggressiveness, and sexual behavior.

The temporal lobe also contains the language area of the brain.
The limbic system is the area of the brain that regulates emotion and memory. It directly connects the lower and higher brain functions.

A. Cingulate gyrus  
B. Fornix  
C. Anterior thalamic nuclei  
D. Hypothalamus  
E. Amygdaloid nucleus  
F. Hippocampus
How to measure “severity”?

- Concussion grading
  - 16 different grading systems
  - The newest of the 3 most commonly used is over 10 years old
- Duration of loss of consciousness
- Initial score on Glasgow Coma Scale (GSC)
- Length of post-traumatic amnesia
- Rancho Los Amigos Scale (1 to 10)
Post Traumatic Amnesia

**Mild injury**
0-20 minute loss of consciousness GCS = 13-15
PTA < 24 hours

**Moderate injury**
20 minutes to 6 hours LOC GCS = 9-12

**Severe injury**
> 6 hours LOC GCS = 3-8
Categories of Concussion

Grade 1
- Spotty confusion
- **NO** loss of consciousness
- Concussion symptoms go away in *LESS than 15 minutes*

Grade 2
- Spotty confusion
- **NO** loss of consciousness
- Concussion symptoms or abnormalities last *MORE than 15 minutes*

Grade 3
- **ANY** loss of consciousness, either brief (seconds) or prolonged (minutes)
1. Any athlete who is suspected to have suffered a concussion should be removed from participation until he or she is evaluated by a physician with training in the evaluation and management of sports concussions.

2. No athlete should be allowed to participate in sports if he or she is still experiencing symptoms from a concussion.

3. Following a concussion, a neurologist or physician with proper training should be consulted prior to clearing the athlete for return to participation.

American Academy of Neurology Position Statement

Position Statement Approved by the AAN Sports Neurology Section, Practice Committee, and Board of Directors October 2010 (AAN Policy 2010-36).
4. A certified athletic trainer should be present at all sporting events, including practices, where athletes are at risk for concussion.

5. Education efforts should be maximized to improve the understanding of concussion by all athletes, parents, and coaches.
Second Impact Syndrome

- Second concussion occurs before previous concussion injury is healed
- Loss of consciousness not required
- Second impact more likely to cause brain swelling and other widespread damage
- **Can be fatal -- 50% mortality rate in most severe cases**
- Higher risk of long-term problems
Concussion Risk Factors

Predisposed to Concussion
- Female gender
- Fatigue
- Prior concussion
- $T^{\text{Ser53Pro}}$ polymorphism*
- APOE promoter G-219T-TT*

*Possible risk factor but requires more research to confirm

Prognosticate Poor Outcome
- Female gender
- Prior concussion
- Preconcussion anxiety or depression
- Preconcussion learning disorder
- Preconcussion migraine headaches
- Post-traumatic amnesia
- Younger age (high school>college>professional athletes)
- Excessive post injury exercise

Increase Risk of Catastrophic Injury
- Young age (<18y)
- Recent history of concussion
- Still symptomatic from concussion

Position Statement: American Academy of Physical Medicine and Rehabilitation
Vol. 3 S452 S459 October 2011
Intracellular Damage

Delayed cytoskeletal damage may result from activation of intracellular proteases called calpains and proteins such as amyloid precursor protein accumulate at the injury site.

In addition, at the time of the initial injury, voltage-dependent potassium channels open, which causes an efflux of potassium into the extracellular space.

Metabolic demand is increased when the adenosine triphosphate-dependent sodium-potassium pump is activated to reestablish the normal resting membrane potential. The excitatory neurotransmitter glutamate also is released at the time of injury.

Glutamate can bind to a number of receptors including N-methly-d-aspartate receptors. When glutamate binds the N-methyl-d-asparate receptor, intracellular calcium levels increase. The neuron attempts to contain the calcium by sequestering it within the mitochondria. However, increased calcium concentrations within the mitochondria inhibit mitochondrial function and may lead to mitochondrial swelling and rupture and, potentially, cell death either via necrosis or apoptosis.

Position Statement: American Academy of Physical Medicine and Rehabilitation
Vol. 3 S452 S459 October 2011
Mild injury is important to discuss

- Long-term impact for 15%
- Don’t see that TBI is cause of deficits
- Repeated injury leads to problem emergence—”second impact syndrome”
- 300,000 sports and recreational injuries
- CT, MRI and EEG are usually normal
Early Signs and Symptoms

- Headache
- Amnesia for the event
- Anterograde amnesia
- Retrograde amnesia
- Vacant stare
- Confusion/Disorientation
- Communication impairment
- Emotional lability
- Memory deficit
- Attention/concentration
- Dizziness
- Visual abnormalities
- Decreased processing
- Irritability
- Poor coordination
## Emotional and Motivational Disturbance

- Irritability
- Agitation
- Restlessness
- Inappropriate social response
- Anxiety
- Paranoia
- Tires easily
- Sleep disturbance

- Belligerence
- Anger
- A-spontaneity
- Depressed
- Impulsiveness
- Rapid mood changes
- Loss of drive or initiative
Effects of mild TBI

- Problems disappear on their own in about 85% of cases
- Compensatory skills acquired
- Education prevents emotional upset ("shattered sense of self")
Effects of mild TBI: outcomes

• Problems are not attributed to TBI
• Compensatory skills are not learned
• Best approach is early education and information
• Best rehab assessment is neuropsychology
Cumulative Rate of Major Depression After Traumatic Brain Injury as a Function of Depression

Bombardier, C. H. et al. JAMA 2010;303:1938-1945
Impact on Individual depends on:

- Severity of initial injury
- Rate/completeness of physiological recovery
- Functions affected
- Meaning of dysfunction to the individual
- Resources available to aid recovery
- Areas of function not affected by TBI
Treatment and Referral Options

• Early:
  – Reassurance and observation

• Later 12-24 weeks:
  – Cognitive evaluation
    • Neuropsych testing
    • ImPACT testing
  – Cognitive remediation
    • Speech and language therapist
    • Day treatment for more severe cases
  – Vestibular PT for vertigo/dizziness
Treatment and Referral Options

• Referrals to consider:
  – CT/MRI/PET/MEG
  – Psychiatry referral
  – Neuro-Psychology
  – Neurology
  – Sleep specialist
  – P.T., Vestibular therapy
  – O.T.
  – Speech/cognitive therapy
  – Day treatment program
  – Community ABI programs
  – Vocational Rehab

• Medication options:
  • It depends!
    • OTC analgesics
    • Valproic acid ER
    • Antidepressants
      • Tricyclics
      • SSRI’s
      • SSNRI’s
    • Attention deficit meds
    • Others
You have been diagnosed with a concussion (also known as a mild traumatic brain injury). This personal plan is based on your symptoms and is designed to help you recover. Your careful attention to it can also prevent further injury.

**First aid**

You should not participate in any high-risk activities (e.g., sports, physical education, PE, riding a bike, etc.) if you still have any of the symptoms below. It is important to limit activities that require a lot of thinking or concentration (homework, job-related activities), as this can also make your symptoms worse. If you no longer have any symptoms and believe that your concentration and thinking are back to normal, you can slowly and carefully return to your daily activities.

Children and teenagers will need help from their parents, teachers, coaches, or athletic trainers to help monitor their recovery and return to activities.

**Today’s symptoms**

<table>
<thead>
<tr>
<th>Physical</th>
<th>Thinking</th>
<th>Emotional</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>Sensitive to light</td>
<td>Feeling mentally foggy</td>
<td>Intensity</td>
</tr>
<tr>
<td>Nausea</td>
<td>Vomiting</td>
<td>Feeling more emotional</td>
<td>Sweating more than usual</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Numbering/Ticking</td>
<td>Problems concentrating</td>
<td>Sadness</td>
</tr>
<tr>
<td>Visual problems</td>
<td>Warning</td>
<td>Feeling more slowed down</td>
<td>Unconcerned</td>
</tr>
</tbody>
</table>

**Dizziness**

| Balance problems |
|------------------|------------------|
| Dizziness         |

**RED FLAGS** Call your doctor or go to your emergency department if you suddenly experience any of the following:

- Difficulty with memory
- Lack of awareness
- Cannot remember people or places
- Unusual behavior change
- Memory loss
- Unsteady walking
- Decreased coordination
- Increasing irritability
- Lack of concentration
- Fambly speech
- Weakness or numbness in arms or legs
- Loss of consciousness

**Returning to Daily Activities**

1. Get lots of rest. Be sure to get enough sleep at night—no late nights. Keep the same sleep/wake cycle on weekdays.

2. Take daytime naps or rest breaks when you feel tired or fatigued.

3. Limit physical activity as well as activities that require a lot of thinking or concentration. These activities can make symptoms worse.

4. Drink lots of fluids and eat carbohydrates or protein to help maintain blood sugar levels.

5. As symptoms decrease, you may begin to gradually return to your daily activities. If symptoms worsen or return, lessen your activities, then try again to increase your activities gradually.

6. During recovery, it is normal to feel frustrated and sad when you do not feel as well as you were. 7. 

**Returning to Work**

1. Planning to return to work should be based upon careful attention to symptoms and under the supervision of an appropriate health care professional.

2. Limiting the amount of work you do soon after your injury may help speed your recovery. It is very important to get a lot of rest. You should also reduce your physical activity as well as activities that require a lot of thinking or concentration.

**Schedule Considerations**

| Shortened work day | No driving | Allows for breaks when symptoms worsen | No heavy lifting or working with machinery | Reduced task assignments and responsibilities | No heights due to possible dizziness, balance problems |

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**Gradual Return to Play Plan**

1. Gradual return to sports practice under the supervision of an appropriate health care provider.

2. Return to play should have occurred in gradual steps beginning with aerobic exercise, and increasing your heart rate (e.g., stationary bicycle); then increasing your heart rate to a moderate level (e.g., running), then adding controlled contact (if appropriate); and finally return to sports competition.

3. Pay careful attention to your symptoms and your thinking and concentration skills at each stage of activity. Move to the next level of activity only if you do not experience any symptoms at the current level. If your symptoms return, step back to the activity where symptoms were controlled and maintain your level of physical activity. Once you have not experienced symptoms for a minimum of 24 hours and you receive permission from your health care provider, you should start again at the previous level of activity.

**Gradual Return to School Plan**

1. Gradual return to school under the supervision of an appropriate health care professional.

2. Return to school should have occurred in gradual steps beginning with aerobic exercise, then increasing your heart rate (e.g., stationary bicycle); then increasing your heart rate to a moderate level (e.g., running), then adding controlled contact (if appropriate); and finally return to sports competition.

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**Table of Contents**

- **Returning to Sports**
- **Returning to Work**
- **Gradual Return to School Plan**

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**Note**

This referral plan is based on today's evaluation.

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**ACE Care Plan Completed by:**

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ACUTE CONCUSSION EVALUATION (ACE)

You have been diagnosed with a concussion (also known as a mild traumatic brain injury). This personal plan is based on your symptoms and is designed to help speed your recovery. Your careful attention to it can also prevent further injury. You should not participate in any high risk activities (e.g., sports, physical education PE, riding a bike, etc.) if you still have any of the symptoms below. It is important to limit activities that require a lot of thinking or concentration (homework, job-related activities), as this can also make your symptoms worse. If you no longer have any symptoms and that your concentration and thinking are back to normal, you can slowly and carefully return to your daily activities. Children and teenagers will need help from their parents, teachers, coaches, or athletic trainers to help monitor their recovery and return to activities.

Today the following symptoms are present (circle or check). No reported symptoms

<table>
<thead>
<tr>
<th>Physical</th>
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<th>Emotional</th>
<th>Sleep</th>
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<td>Sensitivity to light</td>
<td>Fatigue</td>
<td>Feeling mentally foggy</td>
</tr>
<tr>
<td>Nausea</td>
<td>Sensitivity to noise</td>
<td>Problems concentrating</td>
<td>Feeling emotionally drained</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Numbness/Tingling</td>
<td>Problems remembering</td>
<td>Feeling more emotional</td>
</tr>
<tr>
<td>Visual problems</td>
<td>Dizziness</td>
<td>Feeling more slowed down</td>
<td>Feeling less than usual</td>
</tr>
<tr>
<td>Distance Problems</td>
<td>Headaches</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RED FLAGS: Call your doctor or go to your emergency department if you suddenly experience any of the following

- Headaches that worsen
- Look very drowsy, don't want to wake up
- Sensitivity to light or noise
- Changes in behavior
- Seizures
- Nausea
- Vomiting
- Dizziness
- Weakness in arms or legs
- Loss of consciousness
- Numbness

Returning to Daily Activities

1. Get lots of rest. Be sure to get enough sleep at night- no late nights. Keep the same bedtime weekdays and weekends.
2. Take daytime naps or rest breaks when you feel tired or fatigued.
3. Limit physical activity as well as activities that require a lot of thinking or concentration. These activities can make symptoms worse.
   - Physical activity includes PE, sports practices, weightlifting, running, soccer, football, or using the balance board.
   - Thinking and concentration activities (e.g., homework, classroom work, job-related activity).
4. Drink lots of fluids and eat carbohydrates or protein to maintain appropriate blood sugar levels.
5. As symptoms decrease, you may begin to gradually return to your daily activities. If symptoms worsen or return, lessen your activities, then try again to increase your activities gradually.
6. During recovery, it is normal to feel frustrated and sad when you do not feel better and you can't be as active as usual.
7. Repeated evaluation of your symptoms is recommended to help guide recovery.

Returning to School

1. If you (or your child) are still having symptoms of concussion you may need extra help to perform school-related activities.
2. Inform the teacher(s), school nurse, school psychologist or counselor, and administrators about your (or your child's) injury and symptoms. School personnel should be instructed to watch for:
   - Increased problems paying attention or concentrating
   - Increased problems remembering or learning new information
   - Longer time needed to complete tasks or assignments
   - Greater irritability, less able to cope with stress
   - Symptoms worsen (e.g., headaches, tiredness) when doing schoolwork

Returning to Sports

1. You should NEVER return to play if you still have ANY symptoms. (Be sure that you do not have any symptoms at rest and while doing any physical activity and/or activities that require a lot of thinking or concentration.)
2. Be sure that the PE teacher, coach, and/or athletic trainer are aware of your injury and symptoms.
3. It is normal to feel frustrated and sad, and even angry because you cannot return to sports right away. With any injury, a full recovery will reduce the chances of getting hurt again. It is better to miss one or two games than this whole season.

The following are recommended at the present time:

- Do not return to PE class at this time.
- Return to PE class.
- Do not return to sports practices/games at this time.
- Graduate return to sports practices under the supervisor of an appropriate health care provider.

Gradual Return to Play Plan

1. No physical activity.
2. Low levels of physical activity (e.g., walking).
3. Moderate levels of physical activity with body/mind movement. This includes moderate jogging, brisk walking, moderate-intensity stationary biking, moderate-intensity weightlifting (reduced load and/or reduced weight from your typical routine).
4. Heavy non-contact physical activity. This includes sprinting/running, high-intensity stationary biking, regular weightlifting (normal body/mind movement).
5. Full contact in control practice.
6. Full contact in game play.

This referral plan is based on today's evaluation:
- Refer to Neurosurgery
- Ref to Neurology
- Ref to Sports Medicine
- Ref to Physiatrist
- Ref to Psychologist
- Ref to Neuropsychological Testing

ACE Care Plan Completed by: MD RN NP PhD ATC

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No Return to Play
Any athlete who exhibits signs and symptoms of concussion should be removed from play and should not participate in games or practices until they have been evaluated and given permission by an appropriate health care provider. Research indicates that high school athletes with less than 15 minutes of on-field symptoms exhibited deficits on formal neuropsychological testing and re-emergence of active symptoms, lasting up to one week post-injury.  

Exertion
Symptoms will typically worsen or re-emerge with exertion, indicating incomplete recovery. If the athlete is symptom-free, provoking with exertion is recommended (e.g., 5 push-ups, 5 sit-ups, 5 knee bends, 40 yard sprint).  

Return to play should occur gradually. Individuals should be monitored by an appropriate health care provider for symptoms and cognitive function carefully during each stage of increased exertion.  

Repeated Evaluation
On-field, follow-up evaluation (e.g., every 5 minutes) is important, as signs and symptoms of concussion may evolve over time.  

Off-Field Management
The physician should provide information to parents/caregivers regarding the athlete’s condition. For example, the athlete:
- Should not operate a motor vehicle or participate in activities such as sports, PE class, riding a bicycle, riding carnival rides, etc.
- May experience cognitive/behavioral difficulties at home, making it necessary to reduce physical and cognitive exertion (e.g., running, lifting weights, intensive studying) until fully recovered.
- Should receive follow-up medical and neuropsychological evaluation, both for managing injury and determining return to sports.

CDC Concussion in Sports
This palm card provides information and tools to help medical staff with the on-field recognition and management of concussion.  

<table>
<thead>
<tr>
<th>Concussion Signs and Symptoms \1</th>
<th>Symptoms Reported by Athlete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signs Observed by Medical Staff</strong></td>
<td><strong>Symptoms Reported by Athlete</strong></td>
</tr>
<tr>
<td>Appears dazed or stunned</td>
<td>Headache or “pressure” in head</td>
</tr>
<tr>
<td>Is confused about assignment</td>
<td>Nausea</td>
</tr>
<tr>
<td>Forgets sports plays</td>
<td>Balance problems or dizziness</td>
</tr>
<tr>
<td>Is unsure of game, score, opponent</td>
<td>Double or fuzzy vision</td>
</tr>
<tr>
<td>Moves clumsily</td>
<td>Sensitivity to light</td>
</tr>
<tr>
<td>Answers questions slowly</td>
<td>Sensitivity to noise</td>
</tr>
<tr>
<td>Loses consciousness (even briefly)</td>
<td>Feeling sluggish or slowed down</td>
</tr>
<tr>
<td>Shows behavior or personality changes</td>
<td>Feeling foggy or groggy</td>
</tr>
<tr>
<td>Can’t recall events prior to hit or fall</td>
<td>Does not “feel right”</td>
</tr>
</tbody>
</table>

\1 Adapted from Lovell MR, Collins MW, Iverson SL, Johnston KM, Bradley AJ. Grade 1 or “ding” concussions in high school athletes. The American Journal of Sports Medicine 2004;32(1):40-44.  

<table>
<thead>
<tr>
<th>Signs of Deteriorating Neurological Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>An athlete should be taken to the emergency department if any of the following signs or symptoms are present:</td>
</tr>
<tr>
<td>• Headaches that worsen</td>
</tr>
<tr>
<td>• Seizures</td>
</tr>
<tr>
<td>• Focal neurologic signs</td>
</tr>
<tr>
<td>• Looks very drowsy or can’t be awakened</td>
</tr>
<tr>
<td>• Repeated vomiting</td>
</tr>
<tr>
<td>• Slurred speech</td>
</tr>
<tr>
<td>• Can’t recognize people or places</td>
</tr>
<tr>
<td>• Increasing confusion or irritability</td>
</tr>
<tr>
<td>• Weakness or numbness in arms or legs</td>
</tr>
<tr>
<td>• Neck pain</td>
</tr>
<tr>
<td>• Unusual behavior change</td>
</tr>
<tr>
<td>• Significant irritability</td>
</tr>
<tr>
<td>• Any loss of consciousness greater than 30 seconds or longer. (Brief loss of consciousness (under 30 seconds) should be taken seriously and the patient should be carefully monitored.)</td>
</tr>
</tbody>
</table>

### On-Field Mental Status Evaluation

(This mental status assessment is recommended for high school-age athletes and older. Any inability of the athlete to respond correctly to the questions below should be considered abnormal.)

<table>
<thead>
<tr>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>What period/quarter/half are we in?</td>
</tr>
<tr>
<td>What stadium/field is this?</td>
</tr>
<tr>
<td>What city is this?</td>
</tr>
<tr>
<td>Who is the opposing team?</td>
</tr>
<tr>
<td>Who scored last?</td>
</tr>
<tr>
<td>What team did we play last?</td>
</tr>
</tbody>
</table>

**Anterograde Amnesia**

Ask the athlete to repeat the following words: Girl, Dog, Green

<table>
<thead>
<tr>
<th>Retrograde Amnesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask the athlete the following:</td>
</tr>
<tr>
<td>Do you remember the hit?</td>
</tr>
<tr>
<td>What happened in the play prior to the hit?</td>
</tr>
<tr>
<td>What happened in the quarter/period prior to the hit?</td>
</tr>
<tr>
<td>What was the score of the game prior to the hit?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask the athlete to do the following:</td>
</tr>
<tr>
<td>Repeat the days of the week backwards (starting with today)</td>
</tr>
<tr>
<td>Repeat the months of the year backwards (starting with December)</td>
</tr>
<tr>
<td>Repeat these numbers backward 63 (96), 419 (914), 6294 (4926)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Word List Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask the athlete to repeat the three words from earlier: Girl, Dog, Green</td>
</tr>
</tbody>
</table>
Acute Concussion Evaluation
Care Plan Publication

- **Physical Symptoms**
  - Headaches
  - Nausea
  - Fatigue
  - Visual Problems
  - Balance Problems
  - Sensitivity to light
  - Sensitivity to noise
  - Numbness/Tingling
  - Dizziness

- **Emotional**
  - Irritability
  - Sadness
  - Feeling more emotional
  - Nervousness

- **Thinking**
  - Feeling mentally foggy
  - Problems concentrating
  - Problems remembering
  - Feeling more slowed down

- **Sleep**
  - Drowsiness
  - Sleeping more than usual
  - Sleeping less than usual
  - Trouble falling asleep
Red Flags

• Headaches that **worsen**
• Seizures
• Neck Pain
• Look **very** drowsy, can’t be awakened
• **Repeated** vomiting
• Slurred speech
• Can’t **recognize** people or places
• Increasing confusion
• Weakness or numbness in arms or legs
• Unusual behavior change
• Increasing irritability
• Loss of consciousness
Returning to Daily Activities

1. Get lots of rest. Be sure to get enough sleep at night – no late nights. Keep the same bedtime weekdays and weekends.

2. Take daytime naps or rest breaks when you feel tired or fatigued.

3. Limit physical activity as well as activities that require a lot of thinking or concentration. These activities can make symptoms worse.

   Physical activity includes PE, sports practices, weight-training, running, exercising, heavy lifting, etc. Thinking and concentration activities (e.g., homework, classwork load, job-related activity).

4. Drink lots of fluids and eat carbohydrates or protein to maintain appropriate blood sugar levels.

5. As symptoms decrease, you may begin to gradually return to your daily activities. If symptoms worsen or return, lessen your activities, then try again to increase your activities gradually.

6. During recovery, it is normal to feel frustrated and sad when you do not feel right and can’t be as active as usual.

7. Repeated evaluation of your symptoms is recommended to help guide recovery.
Returning to School

1. If you (or your child) are still having symptoms of concussion you may need extra help to perform school-related activities. As your (or your child’s) symptoms decrease during recovery, the extra help or supports can be removed gradually.

2. Inform the teacher(s), school nurse, school psychologist or counselor, and administrator(s) about your (or your child’s) injury and symptoms. School personnel should be instructed to watch for:
   - Increased problems paying attention or concentrating.
   - Increased problems remembering or learning new information.
   - Longer time needed to complete tasks or assignments.
   - Greater irritability, less able to cope with stress.
   - Symptoms worsen (e.g., headache, tiredness) when doing schoolwork.
Return to Play Plan

1. It is very important to **NEVER** return to play (physical education class, sports, practice, or game) while still experiencing symptoms of a concussion.

1. Management of concussive injuries should not only focus on the physical demands but also the cognitive/mental exertion placed on the recovering brain.

2. The presence and/or reoccurrence of post-concussion symptoms are a sign that the athlete has **NOT** fully recovered from this injury.


## Gradual Return to Physical Activity

<table>
<thead>
<tr>
<th>Stage</th>
<th>Functional Exercise</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No Activity</td>
<td>Complete physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming or stationary cycling keeping intensity &lt;70% maximum predicted heart rate. No resistance training</td>
<td>Increase HR</td>
</tr>
<tr>
<td>4. Non-contact training</td>
<td>Progression to more complex training e.g. passing drills in football and hockey. May start progressive resistance training</td>
<td>Exercise, Coord. Cog load</td>
</tr>
<tr>
<td>5. Full contact practice</td>
<td>Participate in normal training activities</td>
<td>Restore confidence assess skill by coach</td>
</tr>
<tr>
<td>6. Return to play</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gradual Return to Cognitive Activity

1. Athletes who are reporting numerous symptoms such as headache, dizziness, fatigue, and inability to concentrate should be encouraged to limit scholastic activities and other cognitive stressors.

2. ACE Care Plan: [HTTP://WWW.CDC.GOV/CONCUSSION/HEADSUP/PDF/ACE-A.PDF]
“He can go back in the game. It’s just a bruise.”


