Concussion: Update on Pathophysiology and Mechanisms

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CNHS
George Washington University School of Medicine
• Concussion
  – Mechanisms
  – Population Health implications
  – Challenges in recovery
Concussion: Definition

• “Trauma-induced alteration in mental status that may or may not involve loss of consciousness...Confusion and amnesia are the hallmarks of concussion”
• “A bump or a blow that causes the brain to move rapidly within the skull”
• Impulsive force leading to rapid acceleration and deceleration to the brain, including linear, translational, rotational forces
• Trauma resulting in change in brain function
  • Not defined by scan, lab test. (yet) Remains...a clinical diagnosis.
  • Contact/Inertial - “This complex variety of responses makes each injury-causing situation nearly unique”

AAP 1997, CDC 2007, Meany 2011, Noble 2013, Choe 2018
Public Health Concern

- >1.1-1.9 mild/moderate sports related TBI/year in US
- 630,000 pediatric ED visits/year
- 128/100,000 people/year
- Football, Hockey most common sports
  - Most other sports
    - Cheerleading, soccer, wrestling, etc
  - Tennis
  - Falls, Sports, Bicycle
  - Slips, falls, vigorous movement

Continued Challenges: Pathophysiology

- Recollection of event
  - Military blast
  - PTSD
- Mechanisms
- Genetic propensity
- Diagnosis
- Treatment

One Size Fits All?
Mechanisms: Energy Transfers

Mechanical Loading (impact, impulsive)
  
  Direct Impact
  
  Inertial (acceleration) response
    
    Translational
    
    Rotational

Skull and soft tissue stress and strain

  
  Focal lesions
  
  Diffuse lesions

O’connor 2011, Meaney 2011
Mechanisms

Loading to the Head

Inertial Acceleration/Load Transmission

Macroscale Brain Movement

Cellular Level Injury

• Challenges in Translation
  – Mechanistic differences
  – Individual characteristics
  – Pre-morbid functioning
  – Post-injury intervention

Ng 2017, Steenerson 2017
Acute Biochemical Cascade

Neurotransmitter Dysregulation

Cerebral Blood Flow

Microstructural Injury

Modifiers

Genetic Tendency

Psychiatric Propensity

Post-Injury Management

PTSD
Biomarkers?

- Large age range
- Mechanisms vary
- Pre-existing morbidities
- 1-53 month post injury

Niogi 2008
Challenges in Data Interpretation

Pediatric Sports-Related Concussion Produces Cerebral Blood Flow Alterations

Maugans 2012

Hippocampal and Cerebral Blood Flow after Exercise Cessation in Master Athletes

Alfini 2016

Resting cerebral blood flow alteration in severe obstructive sleep apnoea: an arterial spin labelling perfusion fMRI study

Nie 2017
Second Impact Syndrome?
Second Impact

- Controversial
  - If occurs, extremely rare
  - Unclear if related to a second impact, or just an impact
  - Younger individuals
- Unknown mechanism(s)
- Associated with fulminant brain swelling, increased ICP, and death

“If SIS actually exists, then its occurrence is vanishingly rare.”

Squire 2012, Mcrory 2012, Mclendon 2016
Post-Concussion days ➔ weeks

- **Somatic or medical**
  - Headache
  - Fatigue
  - Low energy
  - Sleep disturbance
  - Dizziness
  - Sensitivity to light/noise
  - Nausea

- **Cognitive**
  - Slowed thinking
  - Distractability
  - Learning/memory impairment
  - Problem solving difficulties

- **Emotional/Behavioral**
  - Irritability
  - Emotional lability
  - Depression
  - Anxiety
  - Personality changes

- **Sleep Impairments**
  - EDS
  - Fragmented nighttime sleep
Post Concussive Syndrome

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Minor</th>
<th>Moderate</th>
<th>Severe</th>
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<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Nausea</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Balance problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trouble falling asleep</td>
<td>0</td>
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<tr>
<td>Sleeping more than usual</td>
<td>0</td>
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<td></td>
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<tr>
<td>Sleeping less than usual</td>
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<tr>
<td>Drowsiness</td>
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<td>Sensitivity to light</td>
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<tr>
<td>Sensitivity to noise</td>
<td>0</td>
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<tr>
<td>Irritability</td>
<td>0</td>
<td></td>
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<tr>
<td>Sadness</td>
<td>0</td>
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<td>Nervousness</td>
<td>0</td>
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<tr>
<td>Feeling more emotional</td>
<td>0</td>
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<td></td>
<td></td>
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<tr>
<td>Numbness or tingling</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Feeling slowed down</td>
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<td>3</td>
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<td>Feeling mentally “foggy”</td>
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<td>Difficulty concentrating</td>
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<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Visual problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Clinically similar to:
- Depression
- Chronic Fatigue
- POTS
- Fibromyalgia
- Myofascial Pain

Lovell 2008
Military Recommendations 2017

WHAT SHOULD I DO?
After Mandatory 24 Hours of Recovery:

☐ Stage 1: Rest
Rest or do very light activity for another 24 hours. Only do basic things like eating, using the bathroom, resting and sleeping.
- Keep your head above your heart (when you put on your shoes, bring your foot to your knee).
- Sit down when dressing and showering if needed.
- Walk on level surfaces at an easy pace.
- Limit head movements that cause symptoms.
- Stay in a quiet environment with low lighting.
- Watch periods of television with rest breaks each hour.
- Sleep as needed.
- Dress comfortably.

DO NOT!!!
- work or study
- drink alcohol
- exercise
- drive
- hold your breath or grunt*
- exert yourself to the point of making your heart race
- play video games
*Pay attention to whether you are holding your breath when you bend over or are under stress.

After this stage, see your primary care manager to discuss symptoms and determine next steps.

If your heart starts to race, immediately STOP what you are doing and rest.

• drink alcohol
• drive
• play video games
• do resistance training or repetitive lifting
• do sit-ups, push-ups or pull-ups
• go to crowded areas where you may be bumped into
Peds Specific Military Recommendations

- Rest
- Withdrawal
- Breaks
- Wearing glasses

**Concussion-related Symptoms**

<table>
<thead>
<tr>
<th>Physical Abilities</th>
<th>Thinking (Cognitive) Skills</th>
<th>Emotional/Behavioral Issues</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>feeling dizzy/loss of balance</td>
<td>poor concentration, easily distracted</td>
<td>feeling anxious or tense</td>
<td>difficulty falling/staying asleep</td>
</tr>
<tr>
<td>numbness or tingling</td>
<td>forgetfulness, difficulty remembering things</td>
<td>feeling depressed or sad</td>
<td>getting tired easily</td>
</tr>
<tr>
<td>headaches</td>
<td>difficulty making decisions</td>
<td>irritability, easily annoyed</td>
<td>sleeping more than usual</td>
</tr>
<tr>
<td>nausea</td>
<td>slowed thinking</td>
<td>feeling easily overwhelmed by things</td>
<td>sleeping less than usual</td>
</tr>
<tr>
<td>vision problems</td>
<td>difficulty getting and staying organized</td>
<td>something just doesn’t feel right</td>
<td></td>
</tr>
<tr>
<td>sensitivity to light and/or noise</td>
<td>difficulty finding the right words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hearing trouble</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loss of or increased appetite</td>
<td></td>
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</tr>
</tbody>
</table>

**Tip**

The best indicator of how much is too much is whether your child starts to have symptoms. If your child does not experience symptoms during an activity, then it is OK to continue that activity. If your child starts to feel symptoms, then he or she must stop that activity right away and rest. Symptoms are a sign that the brain is being overtaxed.² ⁸ ⁹
The Psychology of Recovery

- Perception of Injustice
- Kinesophobia
- Cephalagiaphobia
- Cogniphobia

“Although avoiding precipitating factors can be adaptive to some degree, excessive avoidance can lead to marked lifestyle changes, psychological comorbidity, as well as sensitizing patients to headache triggers such that headache is elicited more readily when triggers cannot be avoided.”

Self perpetuating

- Anxiety/fear regarding exacerbating symptoms
- Heightened sense of vulnerability
- Avoidance of exacerbating situations
- Increased sedentary behaviors
- Worsened symptoms, diminished conditioning

- Exercise – “neurologic” symptoms – dizziness, headache, etc
- **Experimental Bed Rest**
  - 3-6 days: Headache, dizziness, mood changes, restlessness, poor sleep

Alla 2010, Fortney 2011, Silverberg 2016
Goals of Management

• Prevention of concussion
• Prevent serious injury/exacerbation after concussion
• Maintain function
• Prevent long-term dysfunction
• Be mindful of neurodegenerative conditions
Treatment/Intervention

- Reassurance
- Refrain from excessive restriction
  - Social, academic
- Engage in exercise

The Effect of Physical Exercise After a Concussion

Lal 2017
What’s wrong with rest?

Bed rest: a potentially harmful treatment needing more careful evaluation

— “Published results give little support for bed rest as a form of management in a wide range of settings, and suggest that it may actually delay recovery and even harm the patient.”
Final common Pathway?

Fibromyalgia  POTS  Myofascial Pain  Lyme  Concussion

Pain
Impaired sleep
Cognitive impairments
Fatigue
Mood Disturbances
Dizziness
Exercise and Neuroprotection: The Role of the Neurologist in Public Health?

Physical activity prescription: a critical opportunity to address a modifiable risk factor for the prevention and management of chronic disease:

Physical fitness and academic performance in middle school students

Ronald W. Bass (bassr@district87.org), Dale D. Brown, Kelly R. Laurson, Margaret M. Coleman
Illinois State University, School of Kinesiology and Recreation, Bloomington, IL, USA

Interactive report
Neuroprotective signaling and the aging brain: take away my food and let me run
Mark P. Mattson

“Thank you very much, Dr. DiFazio. Wow, you have no idea how happy I was to hear what you had to say. Jude seemed a bit disappointed as he has been convinced something is terribly wrong. Teachers and coaches all feed into the whole picture. With your permission, I would like to forward to the coaches at GP. Thank you again.”
Final word

1. Is there data to support strict rest/withdrawal – i.e., does it hasten recovery?

2. Is there data that indicates a return of clinical symptoms is an exacerbation of underlying brain injury and a contraindication to exercise/return to play/school/life?

3. Is there evidence that cumulative injury in childhood leads to CTE in adulthood?

4. Can we cause injury by restricting activity?

5. Is there evidence that exercise enhances brain function?
Neurology and SCORE: Why not urgent care?

- Sarah E – 1 ½ years out of school
- Michael P – stroke risk?
- Early referral to Neurology for acute concerns, reassurance/reinforcement of your teaching

SCORE
- Detailed neuropsychiatric assessments, education, GREAT educational assistance
- Ongoing research on best practice
- Benefit: Complex/complicated patients
Thanks for your Attention!
Addendum
• Worsened outcomes (more symptoms of PCS) with longer periods of enforced rest VS usual care.

Thomas 2015
Acute Cognitive and Physical Rest May Not Improve Concussion Recovery Time

Thomas A. Buckley, EdD, ATC; Barry A. Munkasy, PhD; Brandy P. Clouse, MS, ATC
Prolonged Activity Restriction After Concussion: Are We Worsening Outcomes?

Marc DiFazio, MD¹, Noah D. Silverberg, PhD²,³, Michael W. Kirkwood, PhD⁴,⁵, Raquel Bernier, MD¹, and Grant L. Iverson, PhD⁶,⁷,⁸,⁹

Figure 1. Theoretical model for prolonged rest and activity restriction contributing to persistent symptoms.
“Lastly, consider the mental changes, the demoralizing effects of staying in bed. At the start it may produce fussiness, pettiness, and irritability. The patient may acquire an exaggerated idea of the seriousness of his illness and think, "Surely I must be very ill if I am kept in bed?" At a later stage a dismal lethargy overcomes the victim.”
Physical Activity Level and Symptom Duration Are Not Associated After Concussion

Cognitive Rest and Graduated Return to Usual Activities Versus Usual Care for Mild Traumatic Brain Injury: A Randomized Controlled Trial of Emergency Department Discharge Instructions

Resilience Is Associated with Outcome from Mild Traumatic Brain Injury

Rest and treatment/rehabilitation following sport-related concussion: a systematic review

Division III Collision Sports Are Not Associated with Neurobehavioral Quality of Life

Suicide and Chronic Traumatic Encephalopathy

Factors Associated With Concussion-like Symptom Reporting in High School Athletes
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Gerard A. Gioia, PhD
Concussion in Kids: Update on Management

Gerard A. Gioia, Ph.D.
Pediatric Neuropsychologist
Chief, Division of Pediatric Neuropsychology
Director, Safe Concussion Outcome, Recovery & Education (SCORE) Program
Children’s National Health System
Professor, Pediatrics and Psychiatry & Behavioral Medicine
George Washington University School of Medicine
Washington, DC
Objectives

1. Update concussion management – Berlin conference, CDC guidelines
   – Active rehabilitation

2. Berlin School update
   o Recommendations

3. CAST program highlights
   o Next year?
Mild TBI 15-20 Years Ago

- Little understanding of mTBI
- Few treating healthcare providers
- Few medical tests or tools
- Minimal research/funding
- Little public awareness of risks
- No rules to protect athletes
- Passive model of management (rest only)
Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016

What is the difference in concussion management in children as compared with adults? A systematic review

Gavin A Davis,¹ Vicki Anderson,¹ Franz E Babl,¹ Gerard A Gioia,² Christopher C Giza,³ William Meehan,⁴ Rosemarie Scolaro Moser,⁵ Laura Purcell,⁶ Philip Schatz,⁷ Kathryn J Schneider,⁸ Michael Takagi,¹ Keith Owen Yeates,⁹ Roger Zemek¹⁰

ABSTRACT

Aim To evaluate the evidence regarding the management of sport-related concussion (SRC) in children and adolescents. The eight subquestions included the effects of age on symptoms and outcome, normal and abnormal concussion threshold, and the neurophysiological assessment of concussion. The consortium also looked at the evidence on the presence of one or more risk factors (e.g., female gender, history of concussions) and their role in the return to play (RTP) decision. A systematic review of the literature was performed to search for relevant studies. The review identified 294 studies, of which 79 were selected for further analysis. These studies provided evidence on the management of SRC in children and adolescents, but the evidence was limited by the low quality of the studies. The consortium concluded that more research is needed to improve the management of SRC in children and adolescents.
CDC

Report from the Pediatric Mild Traumatic Brain Injury Guideline Workgroup:
Systematic Review and Clinical Recommendations for Healthcare Providers on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children
How Long Does it Take to Recover from a Concussion?
Factors in Recovery

• History (developmental, medical, social/psychiatric)
• Nature of the Injury
• Symptom burden/ type
• Individualized management
Research literature is still limited with respect to understanding concussion recovery outcomes across full age range, and for boys and girls (IOM, 2013).

Largest pediatric study (Zemek et al., 2016; n>3,000; age 5-18) indicates 70 +/-% symptom recovery within 4 weeks.
General Principles of Recovery

• No additional forces to head/brain
• Get good sleep

• Progressive Activity Management
  – Not over-exerting body or brain
  – Not under-exerting body or brain
  – Avoid activities that produce symptoms

Ways to over-exert

• Physical
• Cognitive! (concentration, learning, memory)
• Emotional
Historic Approach(es) to Concussion Treatment

- REST
- REST
- REST
- TIME

(CISG, AAP, etc.)
Active Treatment
CDC CLINICAL RECOMMENDATION FOR HEALTHCARE PROVIDERS
Treatment

General areas of treatment for patients and families
A. Patient/ Family Education and Reassurance
B. Cognitive/ Physical Rest and Aerobic Therapy
C. Psychosocial/ Emotional Support
D. Return to School
CDC Clinical Recommendations
A. Patient/Family Education and Reassurance

24. In providing education and reassurance to the family, the healthcare provider should include the following information:

• Warning signs of more serious injury
• Description of injury and expected course of symptoms and recovery
• Instructions on how to monitor postconcussive symptoms
• Prevention of further injury
• Management of cognitive and physical activity/rest
• Instructions regarding return to play/recreation and school
• Clear clinician follow-up instructions (Level B)
Impact of Early Intervention on Outcome After Mild Traumatic Brain Injury in Children
Jennie Ponsford, Catherine Willmott, Andrew Rothwell, Peter Cameron, Gary Ayton, Robyn Nelms, Carolyn Curran and Kim Ng
*Pediatrics* 2001;108:1297-1303
DOI: 10.1542/peds.108.6.1297

Use of Modified Acute Concussion Evaluation Tools in the Emergency Department
Noel S. Zuckerbraun, MD, MPH, Shireen Atabaki, MD, MPH, Michael W. Collins, PhD, Danny Thomas, MD, MPH, and Gerard A. Gioia, PhD
(doi: 10.1542/peds.2013-2600)
25. Healthcare providers should counsel patients to observe more restrictive physical and cognitive activity during the first several days following mTBI in children. (Level B)

26. Following these first several days, healthcare providers should counsel patients and families to resume a gradual schedule of activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity). (Level B)
27. Following the successful resumption of a gradual schedule of activity (see 26), healthcare providers should offer an active rehabilitation program of progressive reintroduction of noncontact aerobic activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity). (Level B)

28. Healthcare providers should counsel patients to return to full activity when they return to premorbid performance if they have remained symptom free at rest and with increasing levels of physical exertion (see 25-27). (Level B)
“Active” Aerobic Rehabilitation

- **Aerobic Activation** (Gagnon et al., 2009; Leddy et al, 2010)
- Structured and monitored subsymptom threshold exercise to facilitate healing.
- Progressive “controlled” exercise below level that produces symptom occurrence or worsening.
“Active” Aerobic Rehabilitation

A Preliminary Study of Subsymptom Threshold Exercise Training for Refractory Post-Concussion Syndrome

John J. Leddy, MD,*† Karl Kozlowski, PhD,‡ James P. Donnelly, PhD,§
David R. Pendergast, EdD,‖ Leonard H. Epstein, PhD,‖ and Barry Willer, PhD**

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David R. Pendergast, EdD,‖ Leonard H. Epstein, PhD,‖ and Barry Willer, PhD**

Objective: To evaluate the safety and effectiveness of subsymptom threshold exercise training for the treatment of post-concussion syndrome (PCS).

Design: Prospective case series.

Setting: University Sports Medicine Concussion Clinic.

Participants: Twelve refractory patients with PCS (6 athletes and 6 non-athletes). Treatment consisted of 3 to 5 days of controlled exercise at 70% maximal heart rate to perceived effort.

Conclusions: Treatment with controlled exercise is a safe program that appears to improve PCS symptoms when compared with a no-treatment baseline. A randomized controlled study is warranted.

Key Words: traumatic brain injury, exertion, symptoms, physiology, blood pressure

(Clin J Sport Med 2010;20:21–27)
Benefits of Aerobic Activity

I. Aerobic Activity
   Increase brain-derived neurotrophic factor (BDNF)
   Synaptogenesis
   Increased cardiovascular activity
   Altered cerebral vascular function and brain perfusion
   Increased endorphin release
   Improved brain autoregulation
   Improve overall fitness level
   Reduce fatigue/improve energy levels
   Reduce stress, worry and anxiety
   Improve mood
   Improve cognition
   Improve self-efficacy and performance
When Recovery Doesn’t Go Smoothly: Targeting Clinical Profiles

• Concussions fall within spectrum of many clinical profiles suggesting need for varied, targeted treatments based on patient-specific presentation
• More than one concussion subtype may contribute to a patient’s clinical presentation. For ex., patient may have a predominantly vestibular subtype but also have elements of the headache subtype
• Refer for more indepth evaluation of the clinical profile to guide treatment recommendations.
Targeting Clinical Profiles

• Concussion Subtypes:
  – Cognitive
  – Ocular-Motor
  – Headache/Migraine
  – Vestibular
  – Anxiety/Mood

• Subtype-Associated conditions:
  – Sleep Disorder
  – Cervical-spinal strain
Medical System Responsibility
“Discharge” Education (Preparation):
Key Components (all providers)

1. Educate about concussions (definition, risks)
2. Reasons to go/return to Emerg. Dept. (red flags)
3. Safety restrictions: sports, other risk activities
4. Activity restriction & management
5. **School/ work return guidance**
6. Medical follow up
POST-CONCUSSION RETURN TO SCHOOL LETTER

Dear School Staff:

[Student] sustained a concussion on [Date].

Recovery typically takes between several days to several weeks. The student should return to school as soon as they can tolerate it but many students will benefit from some accommodations to their school programme as they recover. As symptoms resolve and the student’s learning/cognitive functioning returns to normal, s/he can gradually progress to their normal school day with reduced supports.

Current Symptoms: The student is currently reporting the following symptoms as indicated by the (√) below. These can be viewed as targets for supportive classroom accommodations to assist a successful return. See suggested supports for these symptoms on page 2.

<table>
<thead>
<tr>
<th>PHYSICAL</th>
<th>COGNITIVE</th>
<th>EMOTIONAL</th>
</tr>
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<tbody>
<tr>
<td>□ Headaches</td>
<td>□ Fatigue</td>
<td>□ Feeling mentally foggy</td>
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<tr>
<td>□ Sensitivity to light</td>
<td>□ Sensitivity to noise</td>
<td>□ Irritability</td>
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<tr>
<td>□ Blurry/double vision</td>
<td>□ Nausea/vomiting</td>
<td>□ Memory problems</td>
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<tr>
<td>□ Balance Problems</td>
<td>□ Dizziness</td>
<td>□ Anxiety/nervousness</td>
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<td>□ Slowed thinking/</td>
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<td>performance</td>
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<td></td>
<td></td>
<td>□ Sadness</td>
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<td></td>
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<td>□ Difficulty concentrating</td>
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<td></td>
<td></td>
<td>□ Feeling more emotional</td>
</tr>
</tbody>
</table>

Return to School: The student can return to school when:

(1) S/he can concentrate on school work for 30 minutes before symptoms worsen significantly.
(2) Symptom exacerbation reduces/resolves with cognitive rest breaks, allowing return to activity.

Based on the current symptoms, he/she is ___ permitted to return to school.
___ is excused for _____ days

Safety Restrictions: To reduce risk for re-injury, there should be

- No physical (risk) activity during recess
- No Physical Education (Gym) class
- No sports participation
- Other: _______________________________

Physical Activity: Mild-moderate symptom-limited exercise (walking) daily is permitted.

Health Care Provider Signature ___________________________ Date ____________________

Contact Information ____________________________________

Children’s National
CDC Clinical Recommendations

D. Return to School

30. To assist children returning to school following mTBI, medical and school-based teams should counsel the student and family regarding the process of gradually increasing the duration and intensity of academic activities as tolerated, with the goal of increasing participation without significantly exacerbating symptoms. (Level B)

31. Return to school protocols should be customized based on the severity of postconcussion symptoms in children with mTBI as determined jointly by medical and school-based teams. (Level B)

32. For any student with prolonged symptoms that interfere with academic performance, school-based teams should assess the educational needs of that student and determine the student’s need for additional educational supports, including those described under pertinent federal statutes (eg, Section 504, IDEA). C137 (Level B)
33. Postconcussion symptoms and academic progress in school should be monitored collaboratively by the student, family, healthcare provider, and school teams, who jointly determine what modifications or accommodations are needed to maintain an academic workload without significantly exacerbating symptoms. (Level B)

34. The provision of educational supports should be monitored and adjusted on an ongoing basis by the school-based team until the student’s academic performance has returned to preinjury levels. (Level B)

35. For students who demonstrate prolonged symptoms and academic difficulties despite an active treatment approach, healthcare providers should refer the child for a formal evaluation by a specialist in pediatric mTBI. (Level B)
What factors must be considered in ‘return to school’ following concussion and what strategies or accommodations should be followed? A systematic review

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**ABSTRACT**

**Objective** To evaluate the evidence regarding (1) factors affecting return to school (RTS) and (2) strategies/accommodations for RTS following a sport-related concussion (SRC) in children and adolescents.

**Design** A systematic review of original studies specifically addressing RTS following concussion in the paediatric and sporting context.

**Data sources** MEDLINE (Ovid), Embase (Ovid), PsycINFO (Ovid) electronic databases and the grey literature OpenGrey, ClinicalTrials.gov and Google Advanced.

**Eligibility criteria** Studies were included if they were original research on RTS following SRC in children aged 5–18 years published in English between 1985 and 2017.

**Results** A total of 180 articles were identified; 17 articles met inclusion criteria. Several factors should be considered for RTS after concussion, including: symptomatology; rest following injury; age/grade; and course load. On RTS after concussion, 17%–73% of students were provided academic accommodations or experienced difficulty with RTS. Students were more likely to obtain academic accommodations in schools with a support. However, postconcussion cognitive symptoms such as impaired memory, attention and concentration, and somatic symptoms such as headaches, dizziness and fatigue may negatively impact students’ ability to RTS.\(^8\)–\(^10\) Students with more numerous/severe symptoms may have symptom exacerbation with RTS.\(^11\)

Several consensus/position statements and guidelines have addressed RTS after concussion.\(^12\)–\(^16\) Following the Fourth International Consensus Conference on Concussion in Sport, the Child-SCAT3 assessment tool was developed for children aged 5–12 years, with a child-specific symptom scale and recommendations for RTS. The Concussion in Sport Consensus Statement also addressed children’s cognitive requirements and need for school accommodations.\(^17\) However, these resources have been based on limited empirical research. Many areas of RTS lack evidence-based guidelines.

Therefore, this systematic review addressed two questions:

1. What factors must be considered in ‘return to
What Berlin has to say about School Return

Five factors influence return to school post-concussion:

1. **Age**: Adolescents tend to take longer to recover and return to school; adolescents more concerned about the negative academic effects of concussion than younger children.

2. **Symptom load/severity**: Students with greater number/ severity of symptoms tend to take longer to return to school, require more academic accommodations, longer to recover.

3. **Course load**: Certain subjects pose greater problems for students returning to school: math (#1) reading/language arts (#2), then science, social studies.
4. **Medical follow-up**: Students who receive RTS letter in ED, medical follow-up after ED more likely to receive academic accommodations.

5. **School resources**: Schools with concussion policies that include student/parent concussion education tend to...
   - provide more accommodations and greater variety of accommodations to students
   - be more likely to form concussion management teams at school to facilitate return to school
   - have students and parents who are more knowledgeable about concussion (Glang et al. 2014)
Berlin Recommendations

1. All schools encouraged to have concussion policy that includes education on concussion prevention and management for teachers, staff, students, parents; should offer appropriate academic accommodations and support to students

2. Upon diagnosis of concussion, students should be provided with medical RTS letter to facilitate provision/receipt of necessary academic accommodations

3. Students should have early/ongoing medical follow-up to identify symptom targets, monitor recovery and help with return to school.

4. Students may require temporary absence from school after injury

5. Clinicians should assess risk factors/modifiers that may prolong recovery and require more/prolonged/formal academic accommodations. Adolescents may require more academic support during recovery

6. Further research is required to determine the appropriate return to school accommodations for children and adolescents with prolonged symptoms.
### Symptom Targeted Academic Management Plan (STAMP)

Below, please see the symptoms they are currently experiencing. To promote recovery, the student will be provided with the following classroom accommodations that support their academic learning and performance:

<table>
<thead>
<tr>
<th>Symptom (check)</th>
<th>Functional school problem</th>
<th>Accommodation/management strategy (select)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention &amp; concentration difficulties</td>
<td>Short focus on lecture, classwork, homework</td>
<td>Shorter assignments (odd/even problems, requiring outline or bullet points instead of full written responses)</td>
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<tr>
<td></td>
<td></td>
<td>Break down tasks and tests into chunks/segments</td>
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<tr>
<td></td>
<td></td>
<td>Lighter work load: Max. nightly homework (including studying): ___ min</td>
</tr>
<tr>
<td>Working memory</td>
<td>Trouble holding instructions, lecture, reading material, thoughts in mind</td>
<td>Repetition</td>
</tr>
<tr>
<td>(short-term memory)</td>
<td></td>
<td>Written instructions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide student with teacher generated class notes</td>
</tr>
<tr>
<td>Memory consolidation/retrieval</td>
<td>Accessing learned information</td>
<td>Smaller chunks/segments to learn, repetition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recognition cues</td>
</tr>
<tr>
<td>Processing speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Fatigue/ Fogginess</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical Symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headaches</td>
<td>Interferes with concentration Increased irritability</td>
<td>Intersperse rest breaks, shortened day if symptom does not subside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allow for short naps in quiet location (e.g., nurse’s office)</td>
</tr>
<tr>
<td>Light/ noise sensitivity</td>
<td>Symptoms worsen in bright or loud environments</td>
<td>Wear sunglasses/hat, seating away from bright sunlight</td>
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<tr>
<td></td>
<td></td>
<td>Limit exposure to SMART board, computers, provide class notes</td>
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<tr>
<td></td>
<td></td>
<td>Avoid noisy/crowded environments such as lunchroom, assemblies, chorus/music class, and hallways. Leave class early.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allow student to wear earplugs as needed</td>
</tr>
<tr>
<td>Dizziness/ balance/ nausea</td>
<td>Unsteadiness when walking Nausea or vomiting</td>
<td>Elevator pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class transition before bell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shortened day or rest breaks</td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td>Decreased arousal, shifted sleep schedule, trouble falling asleep</td>
<td>Later start time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Periodic rest breaks, short naps in quiet location</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Lack of energy</td>
<td>Passive participation</td>
</tr>
</tbody>
</table>
Summary

• Most children & adolescents recover from concussion within 1-4 weeks

ACTIVE TREATMENT APPROACH:

• **Initial** restriction of activity with good nighttime sleep
• Individualized progressive cognitive and physical activity with monitored symptom management
• Return to School requires medical-school teamwork
• Schools need Concussion Management Teams to provide systematic, coordinated support services
Concussion Academy Skills Training (CAST) Program

Dr. Gerard Gioia
Dr. Jeffrey Strelzik
Kerin Webber
Goals/ Intended Outcomes for Providers

• Increase frequency of providing (at least) initial concussion care for your child and adolescent patients

• Increase skill & confidence in clinical evaluation management, using clinical pathway

• Improve communication with school, assist with return

• Solidify understanding of recovery criteria, return to risk

• Differentiate complex cases and make appropriate referral for specialty care
Concussion Learning Sessions

• September, 2017
  – Kickoff General Overview: Primary Concussion Care
  – Diagnosis & initial education/ management (incl. triage/red flags)
• November, 2017
  – Management principles & practice
• January, 2018
  – Return to School: communication & management issues
• March, 2018
  – Criteria for Recovery & Return to Risk (Sport, etc.)
• June, 2018
  – Rehabilitation & specialty medical management