Future of Pediatrics: Concussion Management

Elizabeth Wells, MD
Marc DiFazio, MD
Gerard Gioia, PhD
Management of Concussion in Youth: Time to Get Active!

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Chief, Division of Pediatric Neuropsychology
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Concussion as ADHD in 1980

**ADHD**
- 1980: Most kids were evaluated and treated by specialists
- 2013: Most kids are evaluated and treated by primary care physicians
  - Refer Complex Cases

**Concussion**
- 2013: Most kids are evaluated and treated by specialties
- 20??: Most kids are evaluated and treated by primary care physicians
  - Refer Complex Cases
Neurometabolic Cascade Following Traumatic Brain Injury

(Giza & Hovda, 2001)
Recovery From Concussion: How Long Can it Take?

All Athletes — No Previous Concussions — 1 or More Previous Concussions

Collins et al., 2006, Neurosurgery
The Symptom Culprits

- Headaches
- Fatigue
- Vestibular (dizziness, balance)
- Cognitive problems (attention, memory, executive function, speed)
- Anxiety/ mood problems
Historic Approach(es) to Concussion Treatment

- REST
- REST
- REST

(CISG, AAP, etc.)
Is Rest After Concussion “The Best Medicine?”

• “Practice guidelines recommend an initial period of rest for concussion/ mild traumatic brain injury (MTBI)...

• BUT, compelling evidence that other health conditions can be worsened by inactivity, improved by early mobilization/ exercise...

• Best available evidence suggests that rest exceeding three days is probably more harmful than helpful...

• Gradual resumption of pre-injury activities should begin as soon as tolerated...

• Supervised exercise may benefit patients who are slow to recover…”

Silverberg & Iverson (JHTR, 2013)
“New” Management Strategies
“Active” Rehabilitation

• No additional forces to head/brain
• **INITIALLY**, resting the brain & getting good sleep (1st few days)
• Individualized moderated, monitored symptom management
  – Managing/ facilitating physiological recovery; teaching symptom monitoring, exertion concepts
  – Find the activity “sweet spot”
  – Optimized activity w/o over-exertion; Not too much BUT not too little
  – Plan of graduated physical and cognitive activation

Ways to over-exert
• Physical
• Cognitive (concentration)
• Emotional (stress)
<table>
<thead>
<tr>
<th>Treatment Domain</th>
<th>Message</th>
</tr>
</thead>
</table>
| Patient/ Family Educational Interventions | “Kids get better”  
“Every concussion is different (snowflakes)” |
| General Symptom Management: Exertional Activity | Balance activity with rest  
“Not too Little, Not too Much” |
<p>| Active Aerobic Rehabilitation           | Dosing of physical activity                                            |
| Management of Graduated Return to School | “Get back to your routine, academically &amp; socially”                     |
| Targeted Symptom Intervention (persistent) | “Treating symptoms that interfere with your recovery”                  |</p>
<table>
<thead>
<tr>
<th>Treatment Domain</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient/ Family Educational Interventions</td>
<td>ACE Post-Concussion Home/ School Instructions</td>
</tr>
<tr>
<td></td>
<td>CDC Heads Up materials</td>
</tr>
<tr>
<td>General Symptom Management: Exertional Activity</td>
<td>Progressive Activities of Controlled Exertion</td>
</tr>
<tr>
<td></td>
<td>(PACE) Protocol</td>
</tr>
<tr>
<td>Active Aerobic Rehabilitation</td>
<td>PCERT</td>
</tr>
<tr>
<td></td>
<td>STR Progress Log</td>
</tr>
<tr>
<td>Management of Graduated Return to School</td>
<td>Gradual Return to School Chart</td>
</tr>
<tr>
<td>Targeted Symptom Intervention (persistent)</td>
<td>Standard Therapeutic Approaches</td>
</tr>
</tbody>
</table>
Treatment Modalities

- Headache: behavioral medicine, lifestyle education, medication
- Cognitive problems: strategy use, environmental accommodations, medication
- Anxiety/ Mood: psychotherapy, medication
- Fatigue/ Sleep issues: behavioral sleep treatment, (medication)
- Vestibular dysfx: vestibular therapy
Standardized Acute mTBI Instructions for Home and School

ACE POST-CONCUSSION
HOME/ SCHOOL INSTRUCTIONS

You have been evaluated for a suspected concussion. Following these instructions can prevent further injury and help recovery.

WHEN TO SEEK CARE URGENTLY
Seek care quickly if symptoms worsen or if there are any behavioral changes. Also, watch for any of the following Danger Signs:

- Headache
- Seizures
- Nausea
- Unusual behavior change
- Very drowsy, can’t be awakened
- Repeated vomiting
- Significant speech
- Suspected mental fatigue

- Can’t recognize people or places
- Increasing confusion
- Weakness/numbness in arms/legs
- Less responsive than usual

If you observe any of the above Danger Signs, call your doctor or return to the Emergency Department immediately.

COMMON SIGNS & SYMPTOMS
It is common to have one or many concussion symptoms. There are four types of symptoms: physical, cognitive, emotional, and sleep. Keep track of them and record them.

<table>
<thead>
<tr>
<th>Physical</th>
<th>Cognitive</th>
<th>Emotional</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>Feeling mentally foggy</td>
<td>Irritability</td>
<td>Drowsiness</td>
</tr>
<tr>
<td>Fatigue/Feeling</td>
<td>Feeling slowed down</td>
<td>Sadness</td>
<td>Sleeping less than usual</td>
</tr>
<tr>
<td>Sensitivity to</td>
<td>Difficulty remembering</td>
<td>More emotional</td>
<td>Sleeping more than usual</td>
</tr>
<tr>
<td>light or noise</td>
<td>Difficulty concentrating</td>
<td>Nervousness</td>
<td>Trouble falling asleep</td>
</tr>
<tr>
<td>Balance Problems</td>
<td>Numbness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RETURNING TO DAILY ACTIVITIES
The key to recovery is sleeping, resting physically and mentally, and avoiding activities that might cause head injury.

- Avoid:
  - Physical activities that produce concussion symptoms, as this might increase the recovery time.
  - Lengthy mental activities requiring concentration (ie. Homework, schoolwork, job-related work, and extended video game playing) as these activities worsen symptoms and prolong recovery.
- Sleep: Get good sleep and take naps if tired. No late nights or sleepovers. It is NOT necessary to wake up periodically.
- The injured person should not participate in ANY high risk activities that might result in head injury until examined and cleared by a qualified health professional. High risk activities include sports, physical
Activity-Rest Management

Concussion in Sports: Postconcussive Activity Levels, Symptoms, and Neurocognitive Performance

Cynthia W. Majerske, MD, MS*; Jason P. Mihalik, MS, CAT(C), ATC†; Dianxu Ren, PhD*; Michael W. Collins, PhD*; Cara Camiolo Reddy, MD*; Mark R. Lovell, PhD*; Amy K. Wagner, MD*

**Objective:** To examine the role postinjury activity level plays in postconcussive symptoms and performance on neurocognitive tests in a population of student-athletes.

**Design:** Retrospective cohort study with repeated measures of neurocognitive performance, with postinjury activity intensity scale retrospectively assigned to 1 of 5 groups based on a postinjury activity intensity scale.

**Results:** Level of exertion was significantly related to all outcome variables (P < .02 for all comparisons). With multivariate analysis, activity intensity remained significant with respect to visual memory (P = .003) and reaction time (P < .001).

**Conclusions:** Activity level after concussion affected symptoms and neurocognitive recovery. Athletes engaging in high levels of activity after concussion demonstrated worse neurocognitive performance. For these tasks, those engaging in moderate levels of activity demonstrated the best performance.
“Active” Aerobic Rehabilitation
(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.

“Treatment with controlled exercise is a safe program that appears to improve PCS symptoms when compared with a no-treatment baseline.” (Leddy et al., 2010)

Active rehabilitation for children who are slow to recover following sport-related concussion

ISABELLE GAGNON1,2, CARLO GALLI1, DEBBIE FRIEDMAN1, LISA GRILLI1, & GRANT L. IVERSON3

1Montreal Children’s Hospital, Montreal, Canada; 2McGill University, Montreal, Canada, and 3University of British Columbia and British Columbia Mental Health & Addiction Services, Vancouver, Canada

(REceived 25 February 2009; revised 29 August 2009; accepted 27 September 2009)

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

John J. Leddy, MD,1,‡ Karl Kozlowski, PhD,¶ James P. Donnelly, PhD,§
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).

Methods and procedures: Development of the intervention was done using multiple perspectives including that of the literature, of experts in the field of traumatic brain injury and of experienced clinicians involved with the paediatric and adolescent MTBI clientele. A logic model was developed providing sound theoretical background to the intervention. The intervention was implemented and evaluated with a sample of 16 children and adolescents.

Main outcomes and results: The presented cases suggest that involvement in controlled and closely monitored rehabilitation in the post-acute period may promote recovery in children and adolescents who present with atypical recovery following a concussion. All 16 of the children and adolescents who participated in the programme experienced a relatively rapid recovery and returned to their normal lifestyles and sport participation.

Conclusions: A gradual, closely-supervised active rehabilitation programme in the post-acute period (i.e. after 1 month post-injury) appears promising to improve the care provided to children who are slow to recover.

INTRODUCTION

The majority of patients with sport-related concussion recover within 7 to 10 days1 and nonathletes within the first 3 months.2 There is, however, a significant minority of athlete3 and nonathlete4 patients who continue to experience symptoms beyond this, called post-concussion syndrome (PCS). The World Health Organization defines PCS as persistence of 3 or more of the following after head injury: headache, dizziness, fatigue, irritability, insomnia, concentration difficulty, and memory difficulty. The primary forms of PCS treatment have been cognitive based and include: cognitive behavioral therapy, education, and counseling.
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
Pictorial Children’s Effort Rating Table (PCERT)
# STR Progress Log

<table>
<thead>
<tr>
<th>Name</th>
<th>Therapist</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Site:</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
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<td><strong>DATE</strong></td>
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<tr>
<td><strong>LOCATION</strong> <em>(circle one)</em></td>
<td>Clinic Home</td>
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<td>Clinic Home</td>
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<td>RESTING/POST-ACTIV HR</td>
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<td>Effort Rating Level (1-10)</td>
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<tr>
<td>AEROBIC ACTIVITY:</td>
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<tr>
<td>DURATION:</td>
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<tr>
<td><strong>SYMPTOM (PRE/POST)</strong></td>
<td>Rate 0-10</td>
<td>Rate 0-10</td>
<td>Rate 0-10</td>
<td>Rate 0-10</td>
<td>Rate 0-10</td>
<td>Rate 0-10</td>
<td>Rate 0-10</td>
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<tr>
<td>HEADACHE</td>
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<tr>
<td>FATIGUE</td>
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<tr>
<td>DIZZY/BALANCE</td>
<td></td>
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<tr>
<td>LIGHT/NOISE SENSITIVITY</td>
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<tr>
<td>FOGGINESS</td>
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<tr>
<td>Other:</td>
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<td></td>
<td></td>
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<tr>
<td><strong>SPORT COORDINATION EXERCISES:</strong></td>
<td>Completed? Yes/No</td>
<td>Completed? Yes/No</td>
<td>Completed? Yes/No</td>
<td>Completed? Yes/No</td>
<td>Completed? Yes/No</td>
<td>Completed? Yes/No</td>
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</tr>
<tr>
<td>Time:</td>
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</tbody>
</table>
## Gradual Return to School
### Six Stages w Recommended Activity Level & Criteria for Movement

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Activity Level</th>
<th>Criteria to Move to Next Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No return, at home</td>
<td>Day 1 - Maintain low level cognitive and physical activity. No prolonged concentration. Cognitive Readiness Challenge: As symptoms improve, try reading or math challenge task for 10-30 minutes; assess for symptom increase.</td>
<td>To Move To Stage 1: (1) Student can sustain concentration for 30 minutes before significant symptom exacerbation, AND (2) Symptoms reduce or disappear with cognitive rest breaks* allowing return to activity.</td>
</tr>
<tr>
<td>1</td>
<td>Return to School, Partial Day (1-3 hours)</td>
<td>Attend 1-3 classes, intersperse rest breaks. No tests or homework. Minimal expectations for productivity.</td>
<td>To Move To Stage 2: Symptom status improving, tolerates 4-5 hours of activity-rest cycles; 2-3 cognitive rest breaks built into school day.</td>
</tr>
<tr>
<td>2</td>
<td>Full Day, Maximal Supports (required throughout day)</td>
<td>Attend most classes, with 2-3 rest breaks (20-30’), no tests. Minimal HW (&lt; 60’). Minimal-moderate expectations for productivity.</td>
<td>To Move To Stage 3: Symptom number &amp; severity improving, needs 1-2 cognitive rest breaks built into school day.</td>
</tr>
<tr>
<td>3</td>
<td>Return to Full Day, Moderate Supports (provided in response to symptoms during day)</td>
<td>Attend all classes with 1-2 rest breaks (20-30’); begin quizzes. Moderate HW (60-90’) Moderate expectations for productivity. Design schedule for make-up work.</td>
<td>To Move To Stage 4: Continued symptom improvement, needs no more than 1 cognitive rest break per day</td>
</tr>
<tr>
<td>4</td>
<td>Return to Full Day, Minimal Supports (Monitor final recovery)</td>
<td>Attend all classes with 0-1 rest breaks (20-30’); begin modified tests (breaks, extra time). HW (90+’) Moderate- maximum expectations for productivity.</td>
<td>To Move To Stage 5: No active symptoms, no exertional effects across the full school day.</td>
</tr>
<tr>
<td>5</td>
<td>Full Return, No Supports Needed</td>
<td>Full class schedule, no rest breaks. Max. expectations for productivity.</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Summary
Active Treatment

• Multiple factors appear to relate to recovery duration in mTBI
• Most children and adolescents recover within 1-3 weeks
• INITIAL rest (& getting good sleep) appears to have support
• Active Education & reassurance from Day 1 has support
• Activity-Exertion Management
  – Teaching positive symptom monitoring, promoting self-efficacy
  – Addressing emotional response to injury
  – Find the activity “sweet spot”
  – Optimized activity w/o over-exertion: Not too much BUT not too little
• Physical activation protocols have promise
• Return to School as soon as tolerable, gradually
Rest and Concussion Management

- Marc P. DiFazio, MD
- Medical Director
- Children's National Outpatient Center
- of Montgomery County, MD (ROC)
Rest and Concussion Management: Current State

• Post-concussion
  – Often told to avoid school, physical activities, technology
  – If during activities return of symptoms, instructed to stop
  – Implication: *continued symptoms represent ongoing concussion related injury/exacerbation*
“At home, ‘cocoon therapy’ may be wisest – no physical activity, no reading, no screen time on computer, no video games, quiet and dark room, lots of sleep for the first few days, no driving (or even riding in a vehicle), no loud music, minimal television (no violence)
Is it possible to put the brain to rest?

- Volitionally? no.
- Impossible to “stop thinking” or consuming substrate
- No evidence technology (“Screen time”) more prone to consuming substrate
- No evidence that exercise “steals” healing capabilities or substrate from the brain
- Sleep states often more active versus wakefulness

Nofzinger 1997
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.”

Allen 1999
Self-Perpetuating Cycle

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

- **Experimental Bed Rest**
  - 3-6 days: Headache, dizziness, mood changes, restlessness, poor sleep

Fortney 2011
Are we worsening 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.”
Are we in part responsible for prolonged post-concussive symptoms?

“The Activity Restriction Model of Depressed Affect
Antecedents and Consequences of Restricted Normal Activities

GAIL M. WILLIAMSON and DAVID R. SHAFFER

“Stated explicitly, health-related stressors appear to affect depressive symptoms largely (and sometimes, only) to the extent that they restrict ability to conduct routine activities.”
CONCLUSION: Our findings suggest that an SFWP did not intrinsically influence clinical recovery or reduce risk of a repeat concussion. The overall risk of same-season repeat concussion seems to be relatively low, but there may be a period of vulnerability that increases risk of repeat concussion during the first 7 to 10 days postinjury. Further study is required to investigate this preliminary finding and help determine whether this risk can be reduced further with specific injury-management strategies.
Is Rest After Concussion “The Best Medicine?”: Recommendations for Activity Resumption Following Concussion in Athletes, Civilians, and Military Service Members

- Bernhardt 2008
  - Example: Stroke
    - Early mobilization/activity/engagement
      - Maximizing independence, decreased depression

- “Being sedentary after an injury or illness is one of the most consistent risk factors for chronic disability”

Silverberg and Iverson 2013
Minimize your recommendations for Rest

“...Authors caution against assuming that rest is helpful and suggest that it be subject to the same methodologically rigorous evaluation as any other intervention”

Iverson 2013
Complicated/Atypical/Slow to Recover Cases: What’s not in the guidelines (yet)?

- Elizabeth Wells, MD, MHSc
- Pediatric Neurologist
- Assistant Professor, Pediatrics, Neurology & Integrative Systems Biology
Talk Objectives

• Management of patients with pre-existing neurologic conditions
• When to refer to subspecialists
• What to expect from consultation
• Approach to slow to recover cases
Children’s National Concussion Team

- SCORE Neuropsychology
- Neurology
- Behavioral Medicine/Pain Psychology
- Physical Medicine
- Sleep Medicine
- Neuro-Ophthalmology
- Neuro-Radiology
- Emergency Department
Beyond Standard Management

• Who needs neurology referral?
  – Pre-existing neurologic conditions with question of post-injury involvement and management
  – ?worse injury or other acute problem (red flags)
  – Atypical symptom pattern
  – Slow to recover
  – Any patients you want us to see

• Referral sources
  – Concussion clinic (SCORE), PMD, other specialists, families

• Research is lacking
Pre-Existing Neurologic Conditions

• Chronic headaches, ADHD, mood disorders, sleep disorders, movement disorders, epilepsy, other conditions may worsen post concussion

• Concussion may be “tipping point”- need for intensified management

• Patients benefit from having provider who best knows their medical and social history involved in their concussion care (PMD or subspecialist)
Pre-Existing Neurologic Conditions

- Start with reassurance (most kids do fine) and standard management
- Clearance = return to pre-injury baseline
- Continue chronic therapies/medication
- See primary neurologist (or psychiatrist/psychologist/sleep specialist/pain doc) if not improved shortly after injury
Pre-Existing ADHD

- May hold stimulants for 1-2 days but not necessary
- Discontinuing stimulants may worsen mental fogginess, executive dysfunction, moodiness
- Complicates assessments
- Previously untreated may worsen post-concussion – consider 504/IEP or medication if prolonged
Pre-Existing Chronic Headaches

• Reinforce preventative care
  – Hydration
  – Sleep
  – Not skipping meals

• Address triggers
  – Noise/sound/crowds
  – Stress management (including new stressors: change in routine, missed school, sitting out sports)
  – Overexertion

• Continue preventative medications

• Abortive therapy often ineffective with concussion; watch for medication-overuse headaches
Slow to Recover Assessments

• Is this “concussion”?  
  – Pattern of symptoms  
  – Serial neuropsychological assessments  
  – Personal/family history  
  – Psychosocial factors  

• Identify any driving symptoms (pain, cognition, mood, sleep)  

• Comprehensive evaluation  
  – Consider concussion context/timecourse  
  – Broaden differential/assess as if the concussion didn’t happen
Slow to Recover Management

• Symptomatic care
  – Non-medicinal therapies/lifestyle modification/exercise
  – Medications
    • Headache prevention (3 month minimum)
    • Temporary stimulants for cognitive exertion (discuss timecourse)
    • None proven

• Other subspecialists: behavioral medicine, physical medicine, psychiatry, sleep medicine, etc

• Clearance for contact – complicated
  – Balance concern for worse symptoms from additional impact versus benefit of returning to “normal”
  – Requires coordination between PMD, concussion team and other specialists
Approach to Challenging Concussion Cases: Summary

- PMD plays key role
- Refer early to comprehensive concussion clinic
- Serial assessments help
- Notify/refer to patients’ own subspecialists
- Need individualized assessment, plan, support
- Keep moving forward
- Clearance point = pre-injury baseline
- Goal: restore normal function (academic, athletic)