Emerging Topics in Concussion Treatment:
Lower Extremity Injury and Active Recovery

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Objectives

• Describe the correlation between post-concussion athletes and lower extremity injuries.

• Explain active recovery and the application of protocol for concussed athletes.
Overview

• Estimated 1.6 to 3.8 million sport-related concussions in US yearly
• After sport-related concussion probability of 2\textsuperscript{nd} increases 3-fold
• Most clinical symptoms resolving by 7 days

• Emerging evidence that brain and motor function persists well beyond resolution of clinical recovery / deficits in cerebral performance
  – Reaction time
  – Processing speed
  – Verbal and visual memory
  – Gait patterns
  – Movement patterns
• Correlation of deficits s/p concussion to increased risk of LE musculoskeletal injury
Concussion Increases Odds of Sustaining a LE Musculoskeletal Injury After RTP Among Collegiate Athletes

- **Study:** UW-Madison D1 soccer, football, hockey, basketball, wrestling, volleyball, softball
- **87 concussions** (all compared with 1 – 3 controls)
- **LE injuries**
  - Acute fractures, muscle strains/tears, ligament sprains/ruptures
  - Hip, groin, thigh, knee, shin, ankle, feet
  - Odds of sustaining LE injury within 90 days s/p concussion
- **Results:** Odds of sustaining a LE injury are 2.48 times higher in concussed athletes than in controls
- **Discussion:**
  - Detraining due to missed time for recovery from concussion
  - Altered gait patterns
  - Decreased capacity for motor planning

Brooks et al, 2016
Acute LE Injury Rates Increase after Concussion in College Athletes

• Study: North Carolina XC, field hockey, football, lacrosse, soccer, swimming, rowing, softball, wrestling, basketball, tennis
• 44 concussion group (compared to 58 controls)
• LE injuries at 90 day / 180 day / 365 days s/p concussion
• Results: Significantly higher rate of acute LE injury s/p concussion at 180 days, 365 days. No significant difference at 90 day
• Discussion:
  – Time away from training due to recovery?
  – Athletes with concussion more injury prone?
  – Reduced cortical excitability associated with functional disability?
    • Disruption of cortical pathways increase interval time between reaction and movement time
    • Difficult to measure. Static balance testing not sensitive enough to detect impairments
    • More pronounce (difficult to measure) during athletic tasks

Lynall et al, 2015
Sports Related Concussion Increases the Risk of Subsequent Injury by about 50% in Elite Male Football Players

• Study: Union of European Football Associations
  – Long term prospective observational cohort study
  – 46 professional European football teams form 10 countries
  – All injuries preventing players from full participation recorded
  – Following 1 year s/p concussion

• Results: 66 players with concussion were more prone to injury than the rest of cohort (11.5 vs. 5.0 injuries)
  – 66 players sustained 127 injuries prior to concussion, 153 injuries post
    • Increased risk for sudden onset injuries, not gradual onset injuries
    • More prone to injury in general
    • 2.2 times greater risk s/p concussion

• Discussion: current tests insufficiently sensitive to subtle changes in neuropsychological domains (reaction time, decision making, perception)

Nordstrom et al, 2014
Concussion May Increase the Risk of Subsequent LE Musculoskeletal Injury in Collegiate Athletes

• Study: U of FL DI football, women’s basketball, soccer, lax
  – 90 cases of concussion in 73 athletes (52 male, 21 female)
  – 90 day follow up s/p concussion
  – Same period studied in 1 – 2 control athletes
    • Based on sport, starting status, position
• Results: 3.39 times higher odds of sustaining LE injury s/p concussion
  – 45/90 concussed athletes vs. 30/148 non-concussed athletes
• First study to demonstrate increased odds of in-season LE injury after RTP s/p concussion in females greater than in males
• Athletes who have had ACL injuries previously been found to have worse performance in all components of pre-season neurocognitive testing
  – Poor testing is predictive of LE strains and sprain in college football players
• Discussion: Future research should include age, sport, sex as modifiers

Herman et al, 2016
LE Stiffness Changes after Concussion in Collegiate Football Players

• Study: DI Football players
  – 13 concussed, 26 uninjured
  – Pre-season / post-season testing
  – LE stiffness changes during jump-landing tasks
    • Jumping on 1 limb onto force plate. Stiffness measured at hip, knee, ankle

• Results: Concussion group had increase in hip stiffness, decrease in knee stiffness, no change at ankle

• Discussion: LE stiffness changes could contribute to increased injury risk
  – Stiffness of LE is controlled by the neuromuscular system
    • Findings provide further evidence of changes in the neuromuscular function after return to play from concussion
    • Landing with decreased knee angular excursion reflects an attempt to increase knee stability / rely more on ligamentous tissue for stability
    • Gait changes s/p concussion, athletes adopting more conservative movement patterns
Analysis of Central and Peripheral Vision Reaction Times in Patients with Postconcussion Visual Dysfunction

• Visual dysfunctions s/p concussion
  – Peripheral vision most concerning due to athlete safety
    • RTP considerations
  – Visual dysfunction associated with patient feeling slowed down,
    • slower reaction time
    • “feeling one step behind themselves”

• Study: 23 concussion patients with post-concussive visual symptoms
  – Tested 3 days to 11 months s/p injury
  – Compared to 30 control individuals

• Results: CVRT and PVRT are both prolonged in patients with post-concussive visual dysfunction, PVRT being proportionately prolonged

• Discussion: Prolonged CVRT and PVRT may have RTP implications
  – Show improvement over time, indicating improvement in post-concussive symptoms

Clark et al, 2017
Sex Differences in Vestibular/Ocular and Neurocognitive Outcomes after Sport-Related Concussion

- Female athletes reporting greater symptoms and slower resolution of symptoms s/p SRC
  - Symptoms reported more cognitive symptoms, migraine, dizziness
  - Greater decline in neurocognitive scores compared to baseline scores
- 60-70% of children experience vestibular and/or oculomotor impairments s/p SRC
- Study:
  - Assessed with VOMS, VOR, PCSS, BESS, ImPACT <21 days s/p injury
  - 64 athletes age 9 – 18 (36 male, 28 female)
- Results: Higher mean total concussion symptoms reported for females on VOR of VOMS
- Discussion: Clinicians should pay close attention to VOR in females after injury,
  - Sex differences may be specific to certain types of vestibular/oculomotor impairments and symptoms

Sufrinko, et al, 2017
Summary

- History of concussion shows correlation with increased risk for acute musculoskeletal LE injuries

- Research moving forward:
  - What specifically is causing increased risk
  - How long is the duration of increased risk
  - How does gender play a role
  - How will our practice for concussion care change as a result

- Considering the increased risk of LE injury after concussion, RTP guidelines may be improved by the inclusion of neuromuscular evaluations
References


Current consensus
5th International Consensus Statement, Berlin 2016

• Timing and amount of rest after a concussion is not established
  – Excessive cognitive and physical activity after injury may exacerbate symptoms and delay recovery
  – However, relying on exercise exacerbated symptoms and symptoms resolution may be counterproductive
• Initial period relative physical and cognitive rest in the acute symptomatic period following the injury (24-48 hours) is recommended
• Duration of rest after a SRC is generally interpreted as “until asymptomatic” and includes both physical and cognitive rest
• However, too much rest may contribute to prolonged symptoms and result in adverse physiological and psychological consequences
  – Physical deconditioning, metabolic disturbances, depression/anxiety, fatigue, stress
## Graduated Return-to-Sport Strategy
*(McCrory et al. 2017)*

<table>
<thead>
<tr>
<th>Stage</th>
<th>Aim</th>
<th>Activity</th>
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<tbody>
<tr>
<td>1</td>
<td>Symptom-Limited Activity</td>
<td>Daily activities that do not provoke symptoms</td>
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<tr>
<td>2</td>
<td>Light-aerobic activity</td>
<td>Walking or cycling at slow to medium pace</td>
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<tr>
<td>3</td>
<td>Sport-specific activity</td>
<td>Running or skating drills. No head impact drills</td>
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<tr>
<td>4</td>
<td>Non-contact training drills</td>
<td>Harder training drills. Start progressive resistance training</td>
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<td>5</td>
<td>Full-contact practice</td>
<td>Normal training activities</td>
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<tr>
<td>6</td>
<td>Return to sport</td>
<td>Normal game play</td>
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What is active recovery?

• Active
  – adjective
    1. engaged in action; characterized by energetic work, participation, etc.; busy
    2. being in a state of existence, progress, or motion
• Ex. Partial or full school attendance, normal daily and social activities, attending/watching sport practices and games, etc.
• (Dictionary.com, n.d.)
Current Support in Research

• Benefits of exercise include:
  – Upregulation of brain-derived neurotropic factor
  – Improved cognitive performance
  – Increased cardiovascular fitness
  – Improved control of brain perfusion
  – Reduced fatigue, stress, anxiety
  – Improved mood
  – Increased self-esteem

• Brain injury is shown to alter autonomic nervous system
  – Blood pressure, heart rate variability, etc.

• (Kozlowski, 2014)
Current Support in Research

• Patients ages 11-22 within 24 hours of injury
• 5 days of strict rest vs. 1-2 days of strict rest
• No clinically significant difference in neurocognitive or balance outcomes
• 5 day group reported more daily post-concussive symptoms and slower symptoms resolution
• (Thomas et al. referenced in Leddy et al. 2016)
Current Support in Research

• Berlin et al. (2006) found an increase in negative mood states following a 2-week removal from habitual endurance exercise
  – Participants with the highest level of baseline fitness had the greatest increase in depressive mood and fatigue

• Retraining ANS to maintain homeostasis during exercise to improve tolerance to activity and stress
  – Buffalo Concussion Treadmill Test
    • Assist with differential diagnoses, physiological dysfunction, and quantify clinical severity
  – Exercise intolerance is a sign of ongoing physiological dysfunction

• (Kozlowski, 2014; Leddy et al. 2016)
RTL and RTP Considerations for Now and the Future

- Advocate for setting up RTL plans/guidelines for concussed athletes
- Encourage athlete to return to daily activities as tolerated

- Include active treatments in protocols
  - Sub threshold exercise
  - Cervical, vestibular, cognitive, behavioral, and/or vision therapy
- Utilize exercise tolerance as a way to determine differential diagnoses for prolonged recovery
  - Administer and follow Buffalo protocol
- SCAT 5
  - (Leddy et al. 2016)
Future Research

- Appropriate timing, mode, and duration of rest
- Timeline, intensity, and frequency of exercise
References


Questions?
Thank You