Pediatric Concussion and Overuse Injuries

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Organized Youth Sports

• Over 30 Million Pediatric and Adolescent Athletes in the US
• 4.5 Million injuries annually
• 1.4 Million serious (hospitalization, surgery, school absence)
• 35% of injuries in young athletes are related to sports participation
• Increase in Female athletes
• Younger age of competition
Concussion debate evolving

- Football deaths
  - 1919 – 53
  - 1968 – 36
  - Now – 5/yr
- NFL $765 million settlement
- Recognition
- Treatment
- ?Prevention
- Have athletes outpaced evolution?
- Has protective and improved equipment increased risk
- Debate currently dominated by treatment (? Influence of $$$)
- Treatment evolving too
NY HS football player dies after mild head injury 10/11

- High school lineman hit hard and falls to ground
- Rolls over and sits up on own
- Complains of severe headache
- Collapses when he stands
- Dies in ambulance on the way to ED
Concussion

- Immediate and transient impairment of neurologic function caused by trauma to the brain
- “dinged”
- “bell rung”
- Not usually seen on neuro-imaging (CT or MRI)
MN Youth Sports Concussion Law

• 9/1/11 MN concussion law
• All youth sports coaches must take and pass CDC online concussion course
• Any player with concussion symptoms must leave activity and not return until cleared by a “medical professional”
• No enforcement or punitive measures
• Focuses on recognition and treatment, not prevention
The long-term effects of multiple concussions may be severe and not immediately evident in the short-term.
Chronic Traumatic Encephalopathy (CTE)

- Accumulation of scarring proteins in the brain that leads to early cognitive deterioration, even if no symptoms existed in early adulthood.
- Related to repetitive concussions.
- Dave Duerson, ex-NFL player who committed suicide due to cognitive changes, CTE on autopsy.
- Derek Boogaard, NHL player with CTE on autopsy after drug overdose.
- NFL settled with players for $765 million.
Tau accumulation in repetitive concussions
(A–C) Whole mount 50-μm-thick coronal sections immunostained for tau (AT8) from case 1 (A), case 2 (B), case 3 (C) (counterstained with cresyl violet) showing extremely dense deposition of tau protein in the amygdala with increasing severity from left to right. (D–F) Microscopically, there is a moderate density of NFTs and astrocytic tangles in case 1 (D), the density is increased in case 2 (E), and extremely marked in case 3 (F), original magnification x350.

Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy following Repetitive Head Injury

CTE

• Tauopathy
• Dementia pugulistica (punch drunk)
• Preferential involvement of superficial cortical layers
• Irregular patchy distribution in frontal and temporal cortices
• Little beta-amyloid deposits common in Alzheimer’s
38 soccer players (ave. age: 30.8)
- Asked about “heading” frequency
- Assessed diffusion tensor imaging (DTI) MRI
- Assessed cognitive function
- Higher rate of heading showed DTI white matter pathology and worse cognitive testing
Most frequent symptoms

- headaches 40%
- dizziness 14%
- memory problems 13%
- weakness 10%
- foggy
- crying
Mild TBI symptoms

- school problems
- poor abstract, organizational, judgement skills
- depression
- headaches
- tics
- anxiety
- neck pain
- dizziness
- diplopia
- photophobia
Diagnosing mild TBI

- reports of symptoms c/w mild TBI
- PET scan (CT, MRI, usually of little help)
- evaluations by therapist (OT, speech, psychology)
- fMRI maybe helpful
- ImPACT
Clinical Protocol for ImPACT

- Baseline
- Concussion
- ImPACT testing within 24-72 hours
- Repeat testing in 5-10 days
- Repeat testing as needed
- Use normative data when baseline testing not available
# Post-Concussion Symptom Scale

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Minor</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<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>
</tr>
<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>
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<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Fatigue</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Trouble Falling Asleep</td>
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<td>2</td>
<td>3</td>
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<td>Sleeping More Than Usual</td>
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<tr>
<td>Drowsiness</td>
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<td>3</td>
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<tr>
<td>Sensitivity to Light</td>
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<td>3</td>
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<tr>
<td>Sensitivity to Noise</td>
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<td>3</td>
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<tr>
<td>Irritability</td>
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<td>3</td>
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<tr>
<td>Sadness</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>Nervousness</td>
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<tr>
<td>Feeling More Emotional</td>
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<td>3</td>
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<tr>
<td>Numbness or Tingling</td>
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<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>3</td>
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<tr>
<td>Difficulty Concentrating</td>
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<td>Difficulty Remembering</td>
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<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>
- Initially, the subject is presented with a screen that displays 9 common symbols.
- Then the symbols disappear from the top grid.
Significant difference between groups out to at least 8 days post-injury.

N=410

*Lower score indicates poorer performance

Injured Brain Cells

• Vulnerable to repeat injuries in days and weeks post-concussion
• Repeat injuries can cause extensive neuronal loss
• Should initially rest like skeletal injuries
“Cognitive Rest”

- Limit academic and physical activities – no reading, video games, vigorous activities – TV OK
- Symptoms may increase with increased activities
- Cognitive deficits may persist after other symptoms resolve
- Gradually increase activities as symptoms improve – staged return
“Cognitive Rest”

• Should not keep out of school for more than 1 week if symptom free.
• If symptoms severe, may need to rest longer
• If symptoms severe more than 4 weeks, may need to “work through” it
• Return to activities should be less than 2 weeks if symptoms resolve quickly
Return to Physical Activity Plan

- **No physical activity** until __________ this includes no practice/games, no gym, no recess, no exercise, & no strenuous activity.

- Start **Stage 1 activity** beginning __________. Your target heart rate is ___________.
- Start **Stage 2 activity** beginning __________. Your target heart rate is ___________.
- Start **Stage 3 activity** beginning __________. Your target heart rate is ___________.
- Start **Stage 4 activity** beginning __________. Your target heart rate is ___________.
- Start **Stage 5 - full contact practice/play** beginning __________. Your target heart rate is ___________.
- **Repeat ImPACT testing** __________.
Cognitive rest
Moser, et al
J of Ped, 2012

• Retrospective review
• 49 athletes post-concussion
• All prescribed 1 week of rest
• Assessed if time between onset of concussion and start of rest period effects outcomes
• All groups improved even if rest started 1 month post concussion
Cognitive rest

• Retrospectively looked at 95 student athletes
• Divided into 5 groups according to immediate post-concussive activity level
• Strong correlation between high-intensity level and delayed neurocognitive recovery
• Moderate activity groups did best
Strict Rest Beneficial?
Thomas, et al, Pediatrics ‘15

- Randomized controlled trial
- 88 patients 11-22 y/o seen w/in 24hrs of concussion
- Treatment group got 5 days of strict rest
- Control group got 1-2 days of rest
- Measured symptoms, balance, neurocognitive function

- Symptoms better in control group
- No difference in balance or neurocognitive function
Cervico-vestibular therapy
Schneider, et al

- Blinded randomized control trial
- 31 athletes with prolonged symptoms of dizziness and headache or neck pain
- 1 group treated with vestibular and sensorimotor therapy (treatment group)
- 1 group treated with rest with gradual resumption of activities (control group)
- Blinded physician determined return to sport
- 1 of 14 (7%) of control group and 11 of 15 (74%) of treatment group returned to sport by 8 wks
Athletes with chronic symptoms
GyroStim chair
Resumption of activities per Silverberg, et al J Head Trauma Rehabil 2013

• Review article
• Bed rest shouldn’t be longer than 3 days
• Begin pre-injury activities as tolerated
• Delaying contact activities reduces overlap
• Risks from activities that cause symptoms unknown, severe sx may indicate harm
• Resume activities sub-sx level at first
• Work through sx if longer than 1 month
High School Football long-term risks
Savica, et al, 4/12

• High school football players in Rochester MN 1946-1956
• High school male band, glee, or choir control
• Looked for rates of dementia, Parkinson’s, and ALS
• No difference in incidence
• Increased rates in both groups for Parkinson’s but expected among farmers
Summary

• Rest for 1 week helps prevent overlap injuries
• Should begin to return to moderate activities at sub-symptom level as tolerated
• No activities or high intensity activities may be harmful
• May need to work through activity induced symptoms if present longer than 1 month
• Vestibular therapy may help with long-term sx
Summary

• Long term consequences of concussion still not fully understood.
• Long-term problems may only be significant with multiple concussions over many years, i.e. professional athletes
• Second impact syndrome rare but consequences severe
• Err on the side of caution
Overuse Injuries: Pediatric Athlete

- Cartilage
  - Articular
  - Growth Plates (Physis)
  - Tendon Attachment to bone (Apophysis)
- Susceptible to injury in children / adolescents
- Repetitive loads can alter the shape and anatomy of bones and joints
Pediatric Sports Injuries

• Traumatic Injuries
  • Less Common
    • ? Size, speed, strength, intensity

• Overuse Injuries
  • Common
Growth Plate

Cartilage is an area of relative weakness.
Traumatic Injuries: Pediatric Athlete

- Growth plates and apophyses are areas of relative weakness
- Ligaments and tendons are frequently stronger than the growth plates around joints
- Fractures are more common than severe sprains around joints, especially the ankle, wrist, and knee, and lower back
- High index of suspicion for physeal injuries
Overuse Injuries

- Repetitive use
- Year round sports
- Sports specific training
Organized Youth Sports

- Year round leagues/practices
- ‘Personal’ coaches/trainers
- Private camps/summer camps
- Sport specific training
Overuse Injuries: Varies by sport

- Contact Sports
  - Higher percent traumatic
  - (Soccer, basketball, etc.)
- Non-contact Sports
  - Higher percent overuse
  - (swimming, dance, etc.)
Tissue Response to Exercise

- Repetitive sub-maximal loading
- Fatigue of Tissue
- Micro-fracture or Micro-tear
- Rest

Rest >> RECOVERY
- repair, regeneration, hypertrophy, strengthening
Tissue Response to Exercise

- Repetitive sub-maximal loading
- Fatigue of Tissue
- Micro-fracture or Micro-tear

- Inadequate Rest
  - local inflammation, structural weakness, degeneration, pain, loss of motion, muscle weakness
Overuse Injuries:
Pediatric Athlete

• Rapid Growth in Children
• Can lead to joint tightness and decreased range of motion
• Inflexibility can lead to increase tension on tendon attachments to bone
• Physiologic requirements for rapid growth
Overuse Injuries: Pediatric Athlete

- Children develop at different rates
  - Strength
  - Coordination
  - Balance
Overuse Injuries: Pediatric Athlete

• Evaluation
  – Onset (before, during, after activity)
  – Training Conditions/Surfaces
  – Change in equipment/technique
  – Past Injuries
  – Last shoe purchase
  – Other Joints (JRA)
Overuse Injuries: Pediatric Athlete

- Examination
- Localize the complaint
  - Child
  - Parent
- Gait: Asymmetry, Limp
- Alignment
- Swelling
- Range of motion / flexibility
Overuse Injuries: Pediatric Athlete

- Examination
- Muscle strength
- Palpation of injury area
- Recreate the loading pattern
- Examine the child after sports activity or when symptomatic
- Vague complaints or poorly localized symptoms seen with overuse injuries
Overuse Injuries: Pediatric Athlete

• Evaluation
• Radiographs
  • Comparison Views >> helpful – x-ray both sides
  • Bone Scan
  • MRI, CT-Scans
Overuse Injuries: Pediatric Athlete

- Cartilage Injuries (apophysitis)
- Gymnast Wrist
- Little League Elbow
- Little League Shoulder
- Osgood-Schlatter Disease
- Sever’s Disease
- 5th metatarsal fx
- Spondylolysis/lithesis (pars articularis fx)
Spondylysis and Spondylolisthesis

- Superior articular facets (face postero-medially)
- Spinal canal
- Transverse process
- Pedicle
- Body
- Inferior articular facet (faces antero-laterally)

- Spondylysis
  - Break in bony ring of vertebra
  - Forward slippage

- Spondylolisthesis
  - Body of vertebra
  - Lumbar spine

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Spondy

• Spondylolysis – fracture of lumbar pars articularis
• Spondylolithesis – subluxation of lumbar vertebrae forward
• Most common in teenage athletes
• Teenagers typically don’t have chronic back pain
• Good prognosis with rest
Spondy

- **Spondylolysis**
  - usually occurs with sudden extension of lower back or repetitive stress
  - Pain most common symptom
  - Can worsen with repeat trauma
  - Heals readily with 4-6 weeks of full rest and gradual return to activity
  - Surgery rarely needed
  - Non-unions can be asymptomatic for years
Spondy

• Spondylololithesis
  – Can occur if bilateral fractures that don’t heal
  – Often chronic but asymptomatic
  – Grade I and II usual respond to conservative tx
  – Grade III and IV may need surgery if sx
  – Initially try PT, strengthening, ROM, etc.
Gymnast Wrist

- ‘Walking’ on the hand
- Repetitive compressive loads across physis

- Flattening of articular cartilage
- Widening of growth cartilage or growth plate
Gymnast Wrist

• Treatment
  – Activity Modifications / Limitations
  – Bracing / Taping - Trainer/Coach

• Referral
  – Mechanical symptoms, significant growth plate irregularities
Osgood-Schlatter Disease

- Apophysitis: Tibial Tubercle
  - Localized pain
  - Activity related
  - Males > Females
  - Swelling
  - Frequently bilateral
  - Resolves with maturity and fusion of growth center
Osgood-Schlatter Disease

- Examination:
  - tibial tubercle
  - patellar tendon
Osgood-Schlatter Disease: Treatment

• Non-operative
• Activity modification (training regimen, different position)
• Stretching
• Anti-inflammatory medications
‘Little Leaguers Shoulder’

- Overuse injury of proximal humerus
- Repetitive Torsional Stress
- History of vague shoulder pain
- Physeal injury
- Widening
- Irregularity
- Comparison views
• Throwing Arm
• Irregular Physis
• Physeal Widening

• Non-Throwing Arm
‘Little Leaguers Shoulder’

• Treatment
  – Limiting number of innings/pitchers
  – Rest
  – Therapy?
  – Switching Positions

• Referral
  – No response to rx, radiographic abnormalities
‘Little Leaguers Elbow’

• Overuse injury of distal humerus/elbow
• Repetitive Valgus Stress across elbow
• Similar patterns of injury seen in gymnastics
• Clinical Presentation
  – Pain, loss of motion, locking, mechanical symptoms, effusion
‘Little Leaguers Elbow’

• Treatment
  • Limiting number of innings/pitchers
  • Rest
  • Therapy?
  • Switching Positions

• Referral
  – No response to rx, radiographic abnormalities, mechanical symptoms
Overuse Injuries-Pediatric Athlete: Stress Fractures

- Especially older children
- Tibia
- Calcaneus
- Femur (Shaft and Neck)
- Humerus
- Metatarsal
Overuse Injuries-Pediatric Athlete: Stress Fractures

• Always consider this if long bone pain
• Athletes using hard surfaces (dancers, runners)

• Evaluation
  – Radiographs - frequently negative
  – Bone Scan, CT, MRI
Periosteal Stress Reaction
Overuse Injuries-Pediatric Athlete: Stress Fractures

• Treatment
  – Activity Modifications/Limitations

• Referral
  – If symptoms persist
Overuse Injuries: Pediatric Athlete

- **Treatment**
  - Rest or change in activity
  - Based upon degree of symptoms
  - Based upon recovery
- Often needs casting or splints for adequate rest
- Gradual return to activity
- Usually 3-4 weeks
Overuse Injuries: Pediatric Athlete

• Rest >> *Does not always mean stopping the activity completely*

• Reduction of loading at injured site
• Alternate training regimens
• Maintain fitness, flexibility, strength
Overuse Injuries: Pediatric Athlete

• Goal:
  – Allow the body's normal healing response to intervene
  – Reduce the loading to below the threshold for pain
Overuse Injuries: Pediatric Athlete

• Training Programs
  – Should incorporate scheduled rest intervals
  – Proper Equipment
    • Shoes: loose 40-50 % of shock-absorption after 250-500 miles
Overuse Injuries: Pediatric Athlete

- Treatment
  - Ice
    - decreases swelling
    - reduces pain
    - 10-20 minute sessions over 24-72 hours post activity
Overuse Injuries: Pediatric Athlete

• Treatment
• Rehabilitation – Supervised
  • Range of motion
  • Strengthening
  • Flexibility Exercises
  • Aerobic Conditioning
  • Return to sport
Preventing Overuse Injuries: Pediatric Athlete

• Avoiding Re-injury
  – Training
  – Appropriate Rest
  – Equipment Use
  – Shoes/Orthoses
  – Proper Technique
  – Cross-training
ACL Tears in Female Athletes

• Female: Male - 3 - 4 : 1

• Causes:
  – Anatomy of Knotch
  – Diameter of Ligament
  – Ligamentous laxity
  – Hormonal differences
  – Muscle weakness
Summary

• Overuse injuries common in pediatric sports
• Overtraining of growing bodies increases risks
• Prolonged similar activities increases risk
• Areas of rapid growth at highest risk (apophysis or growth cartilage)
• Rest, strengthening exercises, stretching, altering activities the best treatment
• Still need low stress reps