

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.







AP Photo/Lenny Ignelzi





Derek Boogaard



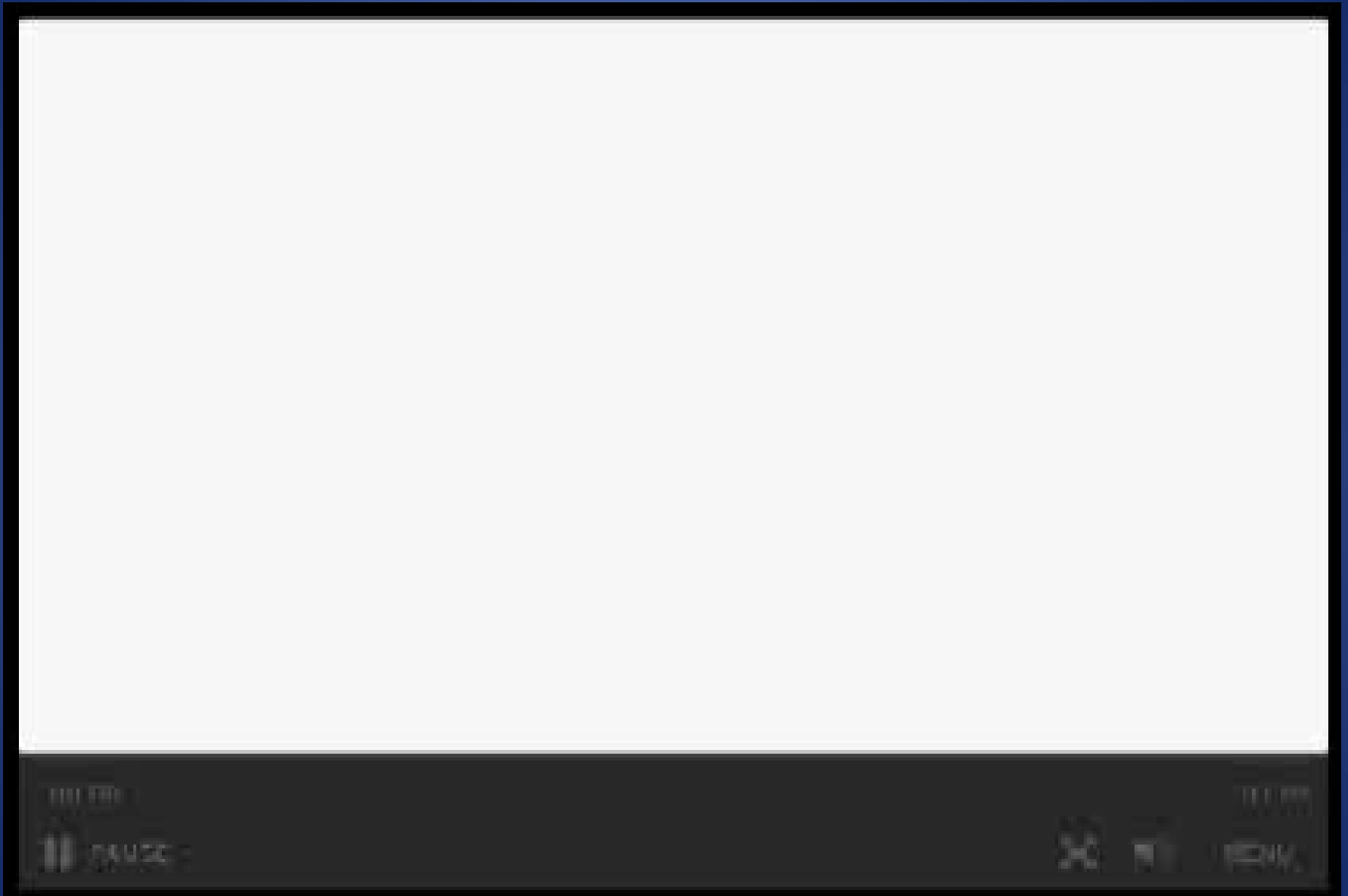
Dave Duerson

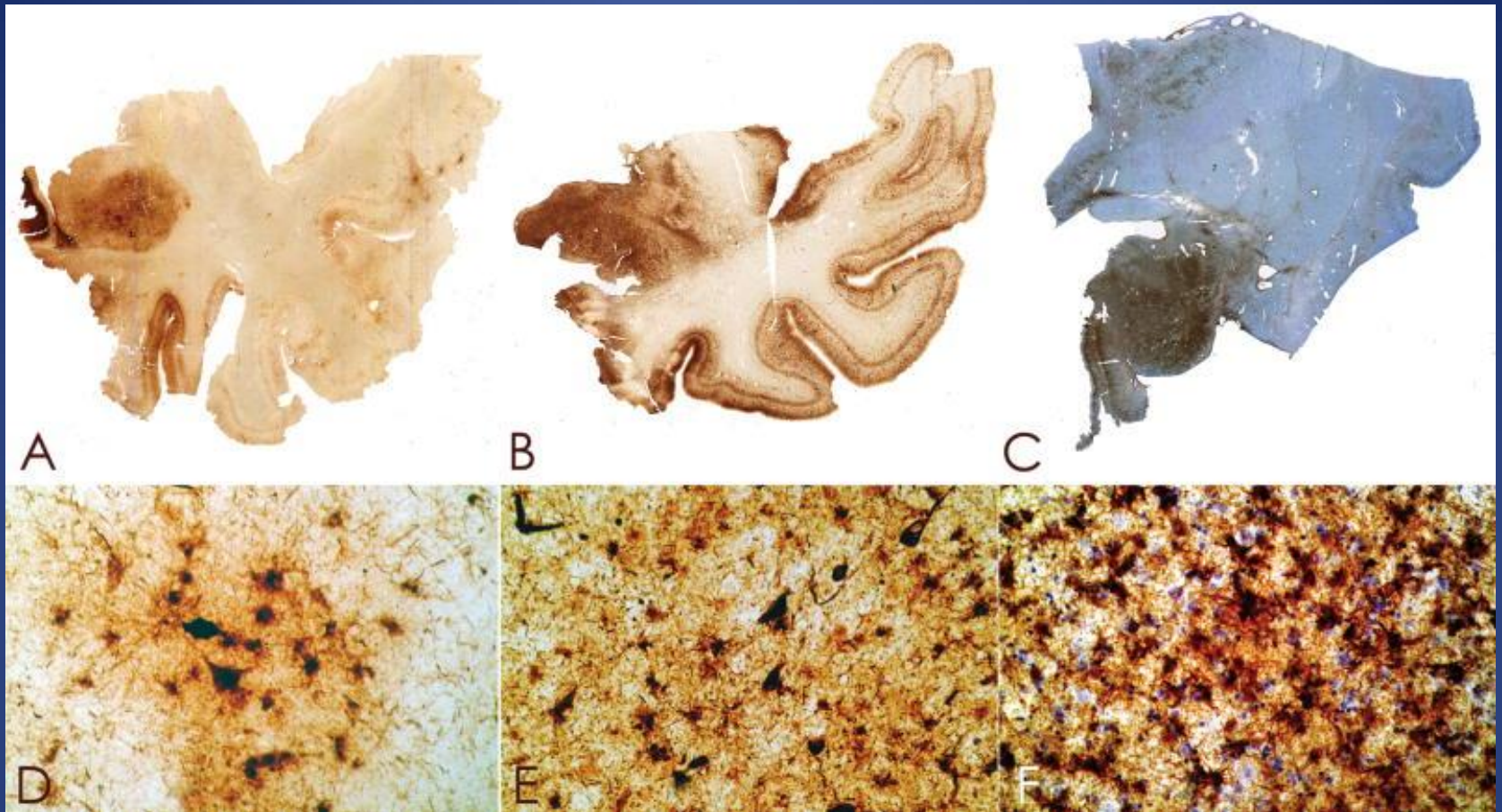


Chronic Traumatic Encephalopathy (CTE)

- 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](#)

J Neuropathol Exp Neurol. J Neuropathol Exp Neurol;68(7):709-735.

CTE

- Tauopathy
- Dementia pugilistica (punch drunk)
- Preferential involvement of superficial cortical layers
- Irregular patchy distribution in frontal and temporal cortices
- Little beta-amyloid deposits common in Alzheimer's

Michael Lipton, et. al., Albert Einstein College
of Medicine,
Radiological Society of NA, 11/11

- 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

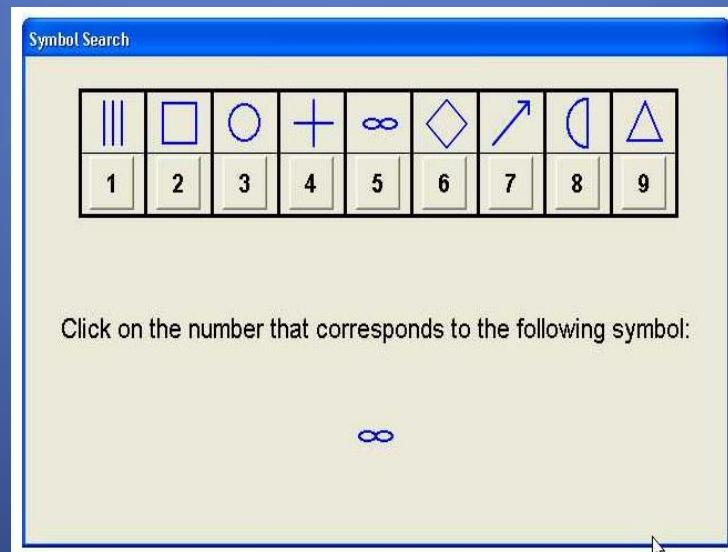
Post-Concussion Symptom Scale

Symptom	None	Minor		Moderate		Severe	
Headache	0	1	2	3	4	5	6
Nausea	0	1	2	3	4	5	6
Vomiting	0	1	2	3	4	5	6
Balance Problems	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Fatigue	0	1	2	3	4	5	6
Trouble Falling Asleep	0	1	2	3	4	5	6
Sleeping More Than Usual	0	1	2	3	4	5	6
Sleeping Less Than Usual	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Sensitivity to Light	0	1	2	3	4	5	6
Sensitivity to Noise	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervousness	0	1	2	3	4	5	6
Feeling More Emotional	0	1	2	3	4	5	6
Numbness or Tingling	0	1	2	3	4	5	6
Feeling Slowed Down	0	1	2	3	4	5	6
Feeling Mentally "Foggy"	0	1	2	3	4	5	6
Difficulty Concentrating	0	1	2	3	4	5	6
Difficulty Remembering	0	1	2	3	4	5	6
Visual Problems	0	1	2	3	4	5	6

Module 4

(Symbol Matching)

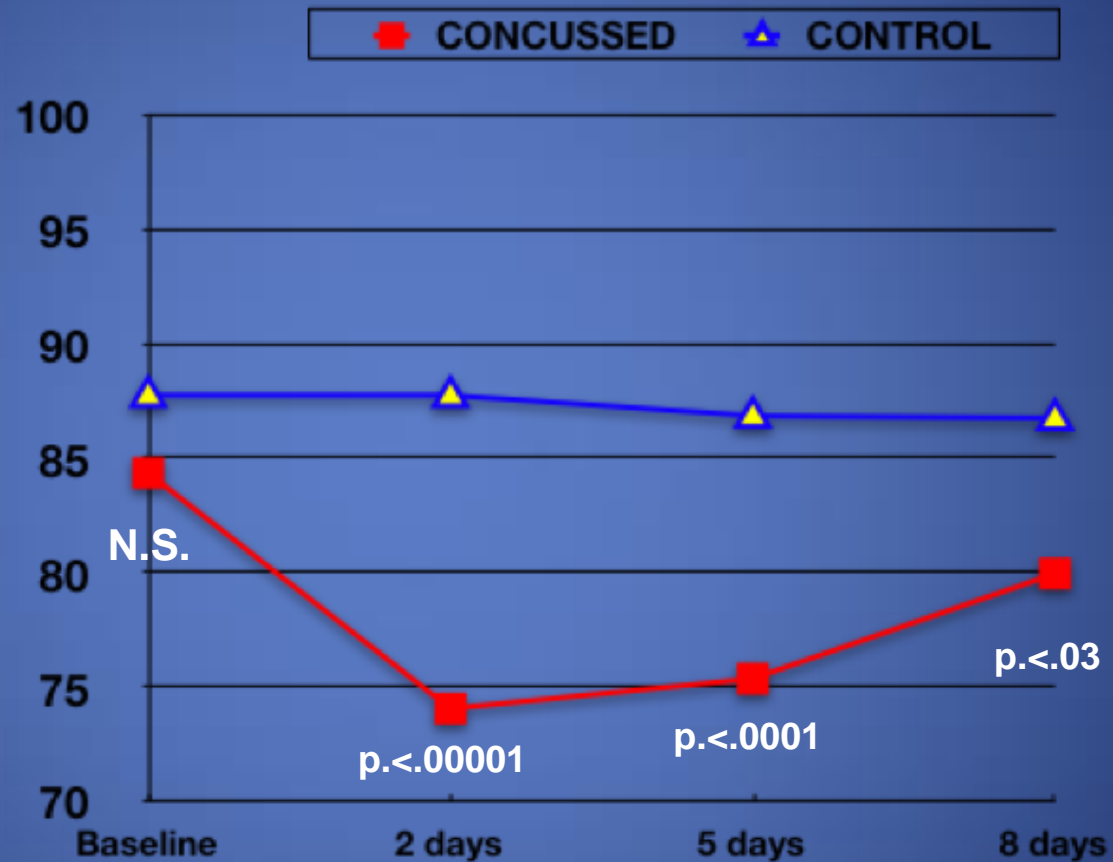
- Initially, the subject is presented with a screen that displays 9 common symbols.
- Then the symbols disappear from the top grid.



ImPACT[®] MEMORY COMPOSITE Control vs. Concussed Athletes

Significant
difference
between
groups out to at
least 8 days
post-injury

N=410



***Lower score indicates poorer performance**

Collins MW, Lovell MR, Maroon et al. Medicine and Science in Sports Exercise, 34:5;2002

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 Activity

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

Majerske, et al, 2013

- 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, neurocogn fxn
- ***Symptoms better in control group***
- No difference in balance or neurocognitive fxn

Cervico-vestibular therapy

Schneider, et al

Br J of Sports Med, 2013

- 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

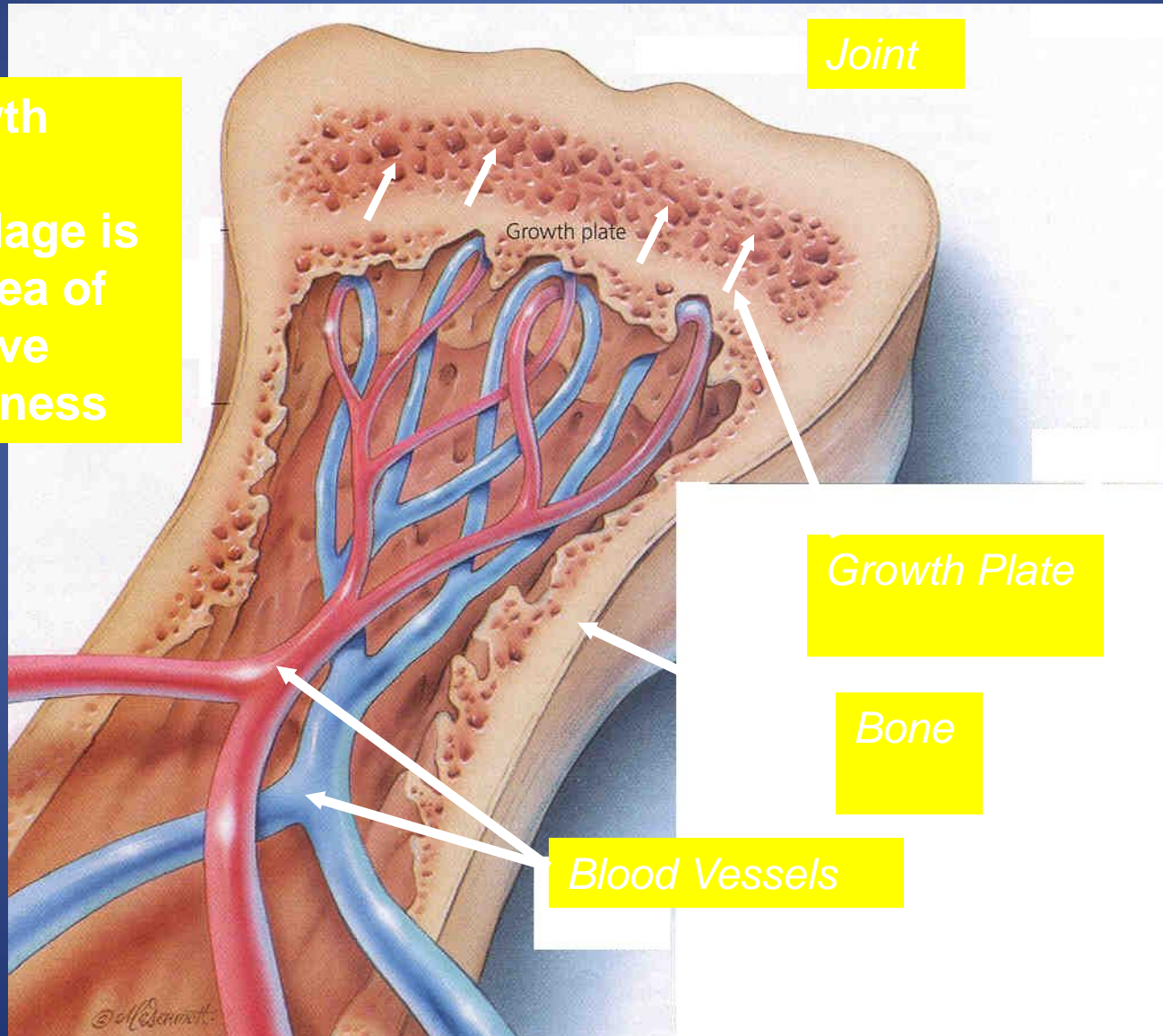
- Cartilage
 - Articular
 - Growth Plates (Physis)
 - Tendon Attachment to bone (Apophysis)
- Susceptible to injury in children / adolescents
- Repetitive loads can alter the shape and anatomy of bones and joints

Pediatric Sports Injuries

- Traumatic Injuries
 - Less Common
 - ? Size, speed, strength, intensity
- Overuse Injuries
 - Common

Growth Plate

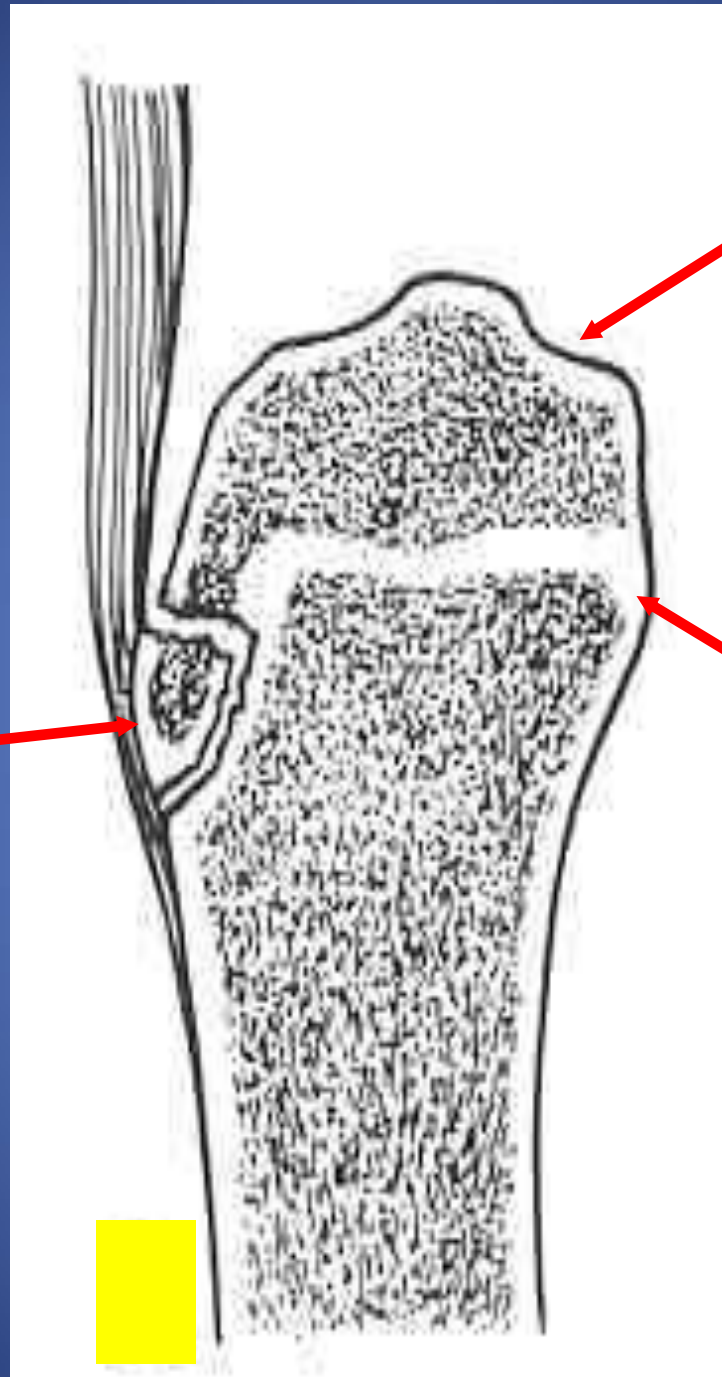
Growth Plate
Cartilage is an area of relative weakness



Apophysis Cartilage

Articular Cartilage

Growth Cartilage/
Epiphysis



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 >> RECOVERY
 - repair, regeneration, hypertrophy, strengthening

Tissue Response to Exercise

- Repetitive sub-maximal loading >>
- Fatigue of Tissue >>
- Micro-fracture or Micro-tear >>
- *Inadequate Rest >> TISSUE BREAKDOWN*
 - 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

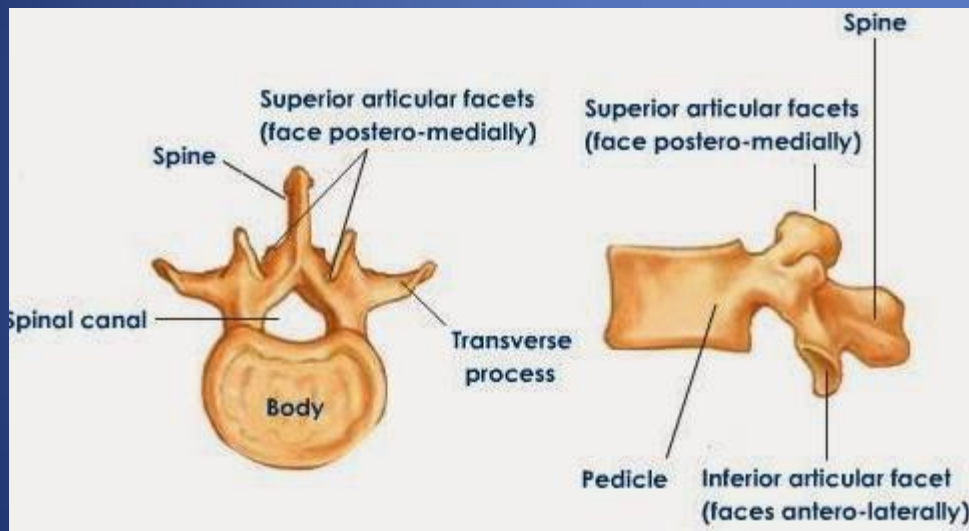
Overuse Injuries: Pediatric Athlete

- Evaluation
- Radiographs
 - Comparison Views >> helpful – x-ray both sides
 - Bone Scan
 - MRI, CT-Scans

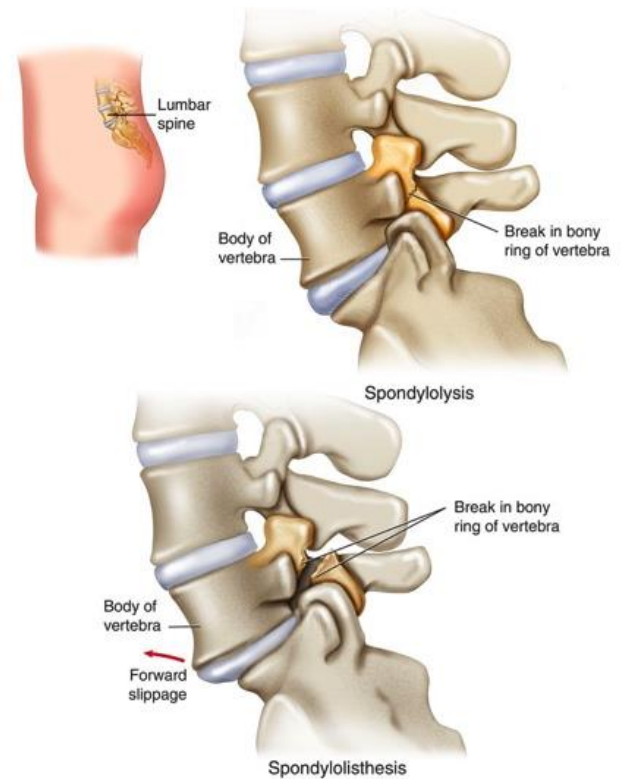
Overuse Injuries: Pediatric Athlete

- 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)

Spondy



Spondylolysis and Spondylolisthesis



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Spondy

- Spondylolysis – fracture of lumbar pars interarticularis
- Spondylolisthesis – subluxation of lumbar vertebrae forward
- Most common in teenage athletes
- Teenagers typically don't have chronic back pain
- Good prognosis with rest

Spondy



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

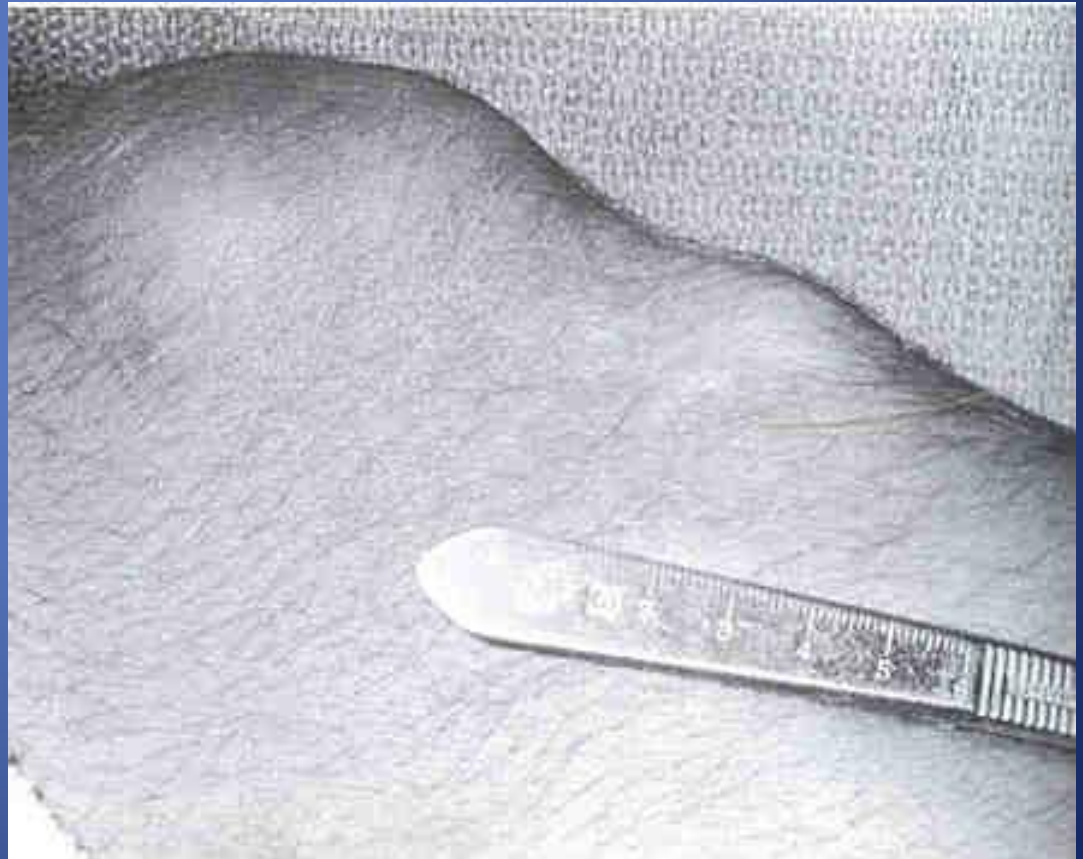
- Treatment
 - Activity Modifications / Limitations
 - Bracing / Taping - Trainer/Coach
- Referral
 - Mechanical symptoms, significant growth plate irregularities

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 bodies 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: lose 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 Notch
 - 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