Sports Injuries in the Pediatric Athlete: Considerations for the Stars of Tomorrow

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I, Eric D. Parks, MD DO NOT have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.
Outline

- Why Exercise?
- Epidemiology
- Pressures/Risk factors for injury
- Overuse Injuries
  - Osteochondroses
    - Knee
    - Pelvis
    - Elbow
    - Shoulder
    - Foot
  - Spondylolysis
  - Stress Fractures
- Concussion

Why Exercise?

- Regular exercise increases self-esteem, and reduces stress/anxiety
- Athletes are less likely to be heavy smokers and use drugs
  - Kino-Quebec. 2000. Physical Activity: a determinant of health in youth
  - Escobedo LG. *JAMA.* 2003
- Athletes are more likely to stay in school
  - Zill N. *Adolescent Time Use, Risky Behavior and Outcomes.* 1995
- Learn teamwork, self-discipline, sportsmanship, leadership, and socialization
  - Cahill BR. *Intensive Participation in Children’s Sports.* 1993
- Builds confidence, fitness, agility
Childhood Obesity

**Exercise**

- Current public health guidelines recommend 60 min of exercise/day
  - Strong WB. *J Pediatr*. 2005
- Physical activity declines significantly during adolescence
  - Brodersen NH. *Br J Sport Med*. 2006
- Overweight children perceive themselves to be just as active as their non-overweight contemporaries
  - Gillis LJ. *Clin J Sport Med*. 2006
- The energy expended playing active Wii Sports games was not intense enough to contribute to daily recommendations

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**We Have Some Active Kids on Our Hands!**

- ~45 million children/adolescents 6-18 yo participate in organized sports on a yearly basis
  - 1997- 32 million
  - 2008- 44 million

- 7 million adolescents participate in organized high-school sports on a yearly basis
  - 4.1 million males
  - 2.9 million females
The Next Big Thing?

### Table 1. Estimated numbers of participants in five organized team sports in the United States from youth to elite levels in 2000.6

<table>
<thead>
<tr>
<th>Sport</th>
<th>Age/Level</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basketball</td>
<td>Youth 6–17 yr</td>
<td>6,231,000</td>
<td>3,790,000</td>
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<td></td>
<td>High school varsity teams</td>
<td>541,130</td>
<td>451,600</td>
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<td></td>
<td>College teams</td>
<td>15,874</td>
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<td></td>
<td>NBA/WNBA 29/16 teams</td>
<td>440</td>
<td>208</td>
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<tr>
<td>Soccer</td>
<td>Youth 6–17 yr</td>
<td>5,400,000</td>
<td>4,190,000</td>
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<td></td>
<td>High school varsity teams</td>
<td>330,044</td>
<td>270,273</td>
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<tr>
<td></td>
<td>College teams</td>
<td>18,221</td>
<td>18,188</td>
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<tr>
<td></td>
<td>MLS 12 teams</td>
<td>268</td>
<td></td>
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<tr>
<td>Baseball</td>
<td>Youth 6–17 yr</td>
<td>6,836,000</td>
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<tr>
<td></td>
<td>High school varsity teams</td>
<td>453,055</td>
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<tr>
<td></td>
<td>College teams</td>
<td>25,938</td>
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<td></td>
<td>MLB 30 teams</td>
<td>1,200</td>
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<tr>
<td>Softball, fast pitch</td>
<td>Youth 6–17 yr</td>
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<td>1,339,000</td>
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<td>High school varsity teams</td>
<td>344,414</td>
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<td>College teams</td>
<td>15,157</td>
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<tr>
<td>Football</td>
<td>Youth 6–17 yr</td>
<td>2,867,000</td>
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<td></td>
<td>High school varsity teams</td>
<td>1,029,435</td>
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<td></td>
<td>College teams</td>
<td>57,593</td>
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<td></td>
<td>NFL 31 teams</td>
<td>1,643</td>
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Sports Injuries

Epidemiology

- 30-40% of all accidents in children occur during sports
- ~2.5 million sports injuries treated annually in ER for patients ≤18 yrs old
- Sports/over-exertion leading cause for all injury related visits to PCP
- Rate of sports injuries ~ 2.4 per 1000 exposures
- 22% of adolescents experience some sports-related injury
  - 62% occurred during organized sports
  - 20% during physical education classes
Sports Injuries

Epidemiology

- 40% occur during non-organized sports
  - Hergenroeder AC. Pediatrics. 1998

- males >> females

- 10-14 year olds at greatest risk
  - Males- football, basketball & bicycle injuries
  - Females- gymnastics/cheerleading, basketball, bicycle injuries

Sports Injuries

Financial Burden

- $588 million in direct expenses
- $6.6 billion indirect costs
- CDC estimates that ½ of all sports injuries in children are preventable
Sports Injuries

Epidemiology

■ 30-50% of adolescent sports-related injuries are overuse

■ 15% of all adolescent injuries are to the physes and apophyses
  • Pill SG. J Musculoskeletal Med. 2003;20:434-442

Definitions

■ Physis
  • Primary ossification center located at the ends of long bones
  • Responsible for longitudinal growth

■ Apophysis
  • Secondary ossification center located where major tendons attach to bone
  • Provide shape and contour to growing bone but add no length

■ Osteochondrosis
  • Disease of the ossification centers in children

■ Osteochondropathy
  • Disorders affecting bone and cartilage together

■ Apophysitis
  • Irritation of the musculotendinous attachment
Injury Patterns

- Cartilage is less resistant to tensile forces than bones, ligaments, and muscle-tendon units.

- Same injury leading to a muscle strain in an adult may result in growth center injuries in adolescents.
  - Physis- “the weak link”

- Bones grow faster than muscle-tendon units.

General Anatomy

Parts of a Growing Bone

- Epiphysis
- Physis (Growth Plate)
- Metaphysis
- Diaphysis

Wrist Bones
Ulna  Radius
Pathophysiology

- Repetitive tensile forces
- Stress to the physis
- Microtrauma leads to:
  - Pain
  - Inflammation
  - Widening
  - Avulsion
  - Microfracturing

- Long term complications exist for physeal injuries

Overuse

- “When microtrauma occurs to bone, muscle, or tendons as a result of repetitive stress with insufficient time to heal.”

- Risk Factors for Overuse Injuries
  - Intrinsic
  - Extrinsic
Risk Factors for Injury

Intrinsic

- ↑ vulnerability to stress in growing skeleton
- Peak *height* velocity precedes peak *flexibility* gains
- ↓ BMD in the 2-3 yrs preceding peak height velocity
- Inability to detect injury
- Skeletal variants
  - Pes planus/cavus, overpronation, patella alta, external tibial torsion

Risk Factors for Overuse

Extrinsic

- Pressure
- Training errors
- Improper technique
- Sports camps
- Year round training
- Single vs Multi-sport
- Early specialization
The Gradual Progression of Injury

- Multi-sport athlete
- Recent increase in activity
- Pain with activity, not with rest, still normal performance
- Pain with activity, rest, and decline in performance

Treatment

*General Principles*

- Relative rest
- Cross training
- Flexibility
- Ice
- Counter-balance bracing
- ?NSAIDS
- Surgical intervention when necessary
Apophysitis

- Inflammation/irritation of the musculotendinous attachment
- Peaks during years of high activity level
- Risk factors
- Locations:
  - Any joint with open physis (epiphysis vs apophysis)
- Cure: Skeletal maturity

Apophy-what?

- Osteochondrosis of Panner, Kienbock, Haas, Mauclaire, Burns, Brailsford, Kohler, Blount, Sinding-Larsen, Osgood-Schlatter, Diaz, Sever, Freiberg, Iselin, Haglund….
Pelvic Apophysitis

- 10-14 years old
- Insidious onset of hip pain or sudden sharp pain
  - Running, jumping, kicking sports
- Focal area of tenderness
- Pain with stretch or contraction of involved muscle
- Widening of physis vs avulsion of apophysis
Pelvic Apophysitis

- Ischial tuberosity 38%
  - Hamstrings & Adductor
- ASIS 32%
  - Sartorius
- AIIS 18%
  - Rectus Femoris
- Lesser trochanter 9%
  - Iliopsoas
- Iliac crest 3%
  - ITB/Tensor Fascia Latae
  - Abdominal muscles

ASIS Avulsion Fracture

Sartorius
ALLS Avulsion Fracture

Rectus Femoris

Ischial Tuberosity Avulsion

Fx

Adductors & Hamstrings
Pelvic Apophysitis

**Treatment**

- Relative rest until pain free (~4-6 weeks)
- WBAT without limping
- NSAIDs
- Ice
- Stretching & strengthening
- Progressive return to activities
- Rare need for surgery

Osgood-Schlatter’s Disease (OSD)

- Occurs in 20% of young athletes
  - most common pediatric overuse injury
- 20% of OSD is bilateral
- Girls 8–13yo
- Boys 10-15yo
- Aggravated by running, jumping, or other explosive activities
- Occasionally aggravated by kneeling or direct trauma
Osgood-Schlatter’s Disease (OSD)

Risk Factors

- Repetitive explosive activities
- Recent increase in activities
- Recent growth spurt
- Tight quadriceps and/or hip flexors
- Alignment issues
  - External tibial torsion
  - Patella alta

Tibial Tubercle Apophysitis

- Point tender +/- swelling at tibial tubercle
- Pain with quadriceps stretch or contraction, poor quad flexibility
- Tight quadriceps or hip flexors
  - Positive Thomas test
- Widened physis or fragmented tibial tubercle on radiographs
Osgood-Schlatter’s Disease

Sequela

Radiographs

Osgood-Schlatter’s Disease (OSD)

Radiographs
Osgood-Schlatter’s Disease (OSD)

- Relative rest
- Quadriceps and hip flexor stretching
- Ice
- NSAIDs
- Cho-Pat strap
- Knee pads

Sinding-Larsen-Johansson Syndrome (SLJ)

- “Adolescent Jumper’s Knee”
- Apophysitis at the inferior pole of the patella
- 10-12 years old
- Most common in running & jumping athletes
  - Basketball, soccer, gymnastics
Sinding-Larsen-Johansson Syndrome (SLJ)

- Tenderness at the inferior pole of the patella
- Pain worsens with explosive activity
- Tight quadriceps
- Radiographs may reveal fragmentation of the inferior pole and/or calcification at the proximal patella tendon
Patella Sleeve Fracture

Sinding-Larsen-Johansson Syndrome (SLJ)

Treatment

- Relative rest
- Quadriceps/hamstring stretching
- Ice
- NSAIDs
- Cho-Pat strap
Patellofemoral Friction Syndrome (PFS)

- Most common cause of anterior knee pain
- Estimated prevalence of 20%
- Mean age 14 years
- “The Great Imitator” of symptoms
  - Location and quality of pain
- Walking stairs, incline/decline, squatting
- “Theatre sign”
PFS
Risk Factors and Treatment

- Muscle imbalances
- Flexibility issues
- Over-pronation, pes planus
- Specific sports

- Treat from the hip to the waist
- Medications, cryotherapy
- Orthotics, bracing, taping, surgery?

Osteochondritis Dessicans

- Avascular necrosis of cartilage bed
- May be result of direct trauma vs iatrogenic
- MC location- lateral portion of medial femoral condyle
- Age 9-18 years old
- Consider in adolescent presenting with painless effusion
Osteochondritis Desiccans

**Evaluation**

- Often no tenderness to palpation
- Effusion
- Wilson’s test

**Radiographs**

- 4 views - AP, lateral, sunrise, and tunnel
- MRI
Osteochondritis Dessicans

Treatment

- Treatment will depend on the stability of the lesion
- Protected/NWB for 6 weeks
- Bracing
- Follow up imaging
- Unstable - surgical

Sever’s Disease
Calcaneal Apophysitis

- Affects boys and girls equally
- Ages 8-13 years
- Most common in soccer, basketball, & gymnastics
  - Repetitive heel impact & traction stress from the achilles tendon
- Bilateral in 60% of cases
Sever’s Disease
Calcaneal Apophysitis

- Heel pain worsened with activity
- Often no swelling
- Point tender at posterior calcaneus
- Pain with medial-lateral compression
- Pain with calf stretch or contraction against resistance
- Tight heel cord, weak dorsiflexors, subtalar overpronation

Sever’s Disease
Risk Factors

- Repetitive explosive activities
  - Jumping, landing, cleats, etc.
- Recent increase in activities
  - Tight heel cord
- Before/during rapid periods of growth
  - Beginning of new season
Sever’s Disease

Calcaneal Apophysitis

**Sever’s Disease**

*Treatment*

- Relative rest
- Heel cord stretching
- Ice
- Heel cups
- NSAIDs
Incidence of baseball overuse injuries is 2-8% annually

Annual incidence of elbow pain in 9-12 y/o baseball players is 20-40%
- Walter K. Contem Ped. 2002

In adolescents, 52% & 86% increased risk of shoulder and elbow pain respectively if throwing curve ball or slider
- Lyman. USA Baseball. 2002

67% of HS UCL reconstructions began throwing curve ball before age 14
- Petty 2004

6 fold increase in elbow surgeries b/t '94-'99 and '00-'04
- Fleisig GL. ASMI. 2005
Medial Epicondyle Apophysitis

■ Most common in 9 to 14 y/o overhead athletes
■ ~18-29% incidence of elbow pain in youth and HS baseball players
■ Point tenderness over medial epicondyle
■ Classically worsened by repetitive throwing
■ Hypertrophy of medial epicondyle
■ Flexion contracture
■ Pain with ligamentous stressing

Classic Little League Elbow is an apophysitis of the medial epicondylar growth plate

Constellation of Findings:
- Apophysitis of Medial Epicondyle
- Medial Epicondylitis
- UCL Injury rare
- Cubital Tunnel Syndrome
- Capitellar OCD
- Premature closure of proximal radial physis
Medial Epicondyle Apophysitis

Little League Elbow

■ Mechanism:
  • Traction injury
  • Strong contraction of the flexor-pronator muscle attachments as the arm is started forward
  • Valgus stress causes tension on the UCL

■ Valgus moment with throwing:
  • Lateral compression at radiocapitellar joint
  • Medial tension at epicondyle and UCL
  • Posterior shear
  • Hyperextension valgus overload syndrome

The Throwing Cycle
Medial Epicondyle Apophysitis

- X-rays may reveal widening of medial epicondyle apophysis &/or fragmentation of medial epiphysis
- 85% of X-rays are normal

Medial Epicondyle Avulsions
Little League Elbow

Treatment

- If apophysis not significantly displaced (<5mm)
  - (Relative) rest 4 - 6 weeks
  - Stretching and strengthening program
  - Throwing mechanics evaluation
  - Gradual return to throwing after 6 - 12 weeks
    - Interval Throwing Program
    - Follow pitch counts & types
- If apophysis significantly displaced (>5mm) surgery is warranted

Little League Shoulder

Proximal Humeral Epiphysiolysis

- Fatigue fracture of the proximal humeral physis
  - Does not fuse until ages 14-20
- 9-14 years old
- Typically high-performance male pitchers
- Rotatory torque stresses to the epiphyseal growth plate
- Pain and inability to perform
- Decreased ROM
- TTP at anterior proximal humerus
- Remember– physis is the weak link!
Little League Shoulder

Proximal Humeral Epiphysiolysis

- Treatment
  - Relative rest for 4-6 weeks
  - Interval throwing program
  - Thrower’s 10 program
## Little League Pitch Counts

<table>
<thead>
<tr>
<th>Age</th>
<th>Pitches per day</th>
</tr>
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<tbody>
<tr>
<td>17-18</td>
<td>105</td>
</tr>
<tr>
<td>13-16</td>
<td>95</td>
</tr>
<tr>
<td>11-12</td>
<td>85</td>
</tr>
<tr>
<td>9-10</td>
<td>75</td>
</tr>
<tr>
<td>7-8</td>
<td>50</td>
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</table>

## Pitch Smart

[Table showing pitch counts by age group]
Spondylolysis

- Lesion in the pars interarticularis of the neural arch.
**Spondylolysis**

**Epidemiology**

- 30% in 11-17 year old athletes will experience LBP
- Incidence of 6-8% in general population
- Overall incidence of 4.4% by age 6, 5.2% by age 12, and 6% by adulthood
- No cases of spondylolysis in non-ambulatory (n=143)
  - Rosenberg NJ. *Spine.* Jan-Feb 1981
- Males>>>Females
- 85-95% occur at L5 with the remainder typically at L4

**Spondylolysis**

**Clinical Presentation**

- Insidious back pain exacerbated by strenuous activity
- Occasional radiation to the buttocks
- Rising to an upright posture against resistance elicits pain
- Pain exacerbated by hyperextension & rotation bilateral, unilateral
- Hamstring tightness in 80% of patients
- Tenderness in lumbar spine to palpation
- Hyperlordosis
Spondylolysis

- X-rays
- Bone scan
- SPECT scan
- Thin-sliced CT scan
- MRI
Spondylolysis

Treatment

- Relative rest & activity modification
- Time (>3 months)
- Flexion-based core strengthening
- NSAIDs
- Bracing?
  - If still painful after the above
- Surgery

Stress Fractures

- Mechanism
  - repeated forceful impact and repetitive loading on immature trabecular bone
  - repeated microtrauma is greater than ability to repair
Stress Fractures

**History**

- Recent change in activity level, equipment, or playing surface
- Insidious onset of pain
- Worse with activity
- Improves with rest
- Prior stress fractures
- Menstrual irregularities, weight changes, eating disorder, nutrition
  - Female Athlete Triad

**Clinical Examination**

- Focal tenderness may be elicited with compression or percussion
- Fulcrum test, Hop test, & Tuning fork
- Plain x-rays often normal early in disease course
  - New bone formation after 2-3 weeks
- Further imaging may be needed
  - Bone scan or MRI
Stress Fractures

Treatment

- Relative rest
  - Cross-training
  - Limit impact activities

- Immobilization

- Gradual return to play

- May take 6-8 weeks

- Be aware of tenuous stress fractures
  - Anterior tibial cortex, tension-sided femoral neck, Jones, etc.
Overuse Summary

- 60 minutes of exercise is recommended daily
- Video gaming is not intense enough
- Adolescents are not little adults
- Overuse injuries occur frequently in adolescents

Head Injury Epidemiology

- 1.4 million people/yr with traumatic brain injury
- Concussion - Most common head injury
- Direct and indirect medical costs for TBI ~$60 billion
Epidemiology in Sports

- 1.6-3.8 million concussions/yr
- 15-20% HS football players annually
  - 0.14-3.66 injuries/100 player seasons at HS level
- 34% college football players have had at least 1
  - 0.5-3.0 injuries/1000 athlete exposures at collegiate level
- ~26,000 ER visits/yr due to cheerleading accidents
  - 6% concussion
Concussion Defined
- 4th Int’l Conference on Concussion

- A transient neurological event that occurs following a blow to or twisting of the head and may be characterized by confusion, disorientation, and retrograde or antegrade amnesia.

Key Characteristics

- Direct blow results in an impulsive force transmitted to the head
- Rapid onset of short lived neurological function that resolves spontaneously
- Graded set of clinical symptoms +/- LOC
- No abnormality on standard structural imaging
- Pathophysiology is a functional issue, not structural
Pathophysiology

- Clinical symptoms largely reflect a *functional disturbance* rather than a *structural injury*

Common Features: Cognitive

- Confusion
- Posttraumatic Amnesia
- Retrograde Amnesia
- Disorientation
- Vacant stare
- Inability to focus
- Fogginess
- LOC
- Delayed verbal and motor responses
- Slurred/incoherent speech
- Excessive drowsiness
Common Features: Somatic

- Headache
- Fatigue
- Disequilibrium
- Dizziness
- Nausea/vomiting
- Visual disturbance
- Phonophobia

Common Features: Affective

- Emotional lability
- Irritability
Common Features: Physical

- +/- LOC
- Poor motor coordination
- Concussive convulsions
- Sluggish pupils

General Management Principles

- A majority resolve within 7-10 days
- 10-30% may have prolonged symptoms
- No universal guidelines on how to treat
  - Zurich Consensus Statement
- Return to learning before return to sport
Initial Treatment

- Management begins at the moment of diagnosis & primary survey
- Is transfer warranted?
- If no health care provider available - urgent referral

Sideline Management

- Removal from play, no same day return
- Essential to exclude focal deficits that warrant referral
- Monitor for worsening condition/deterioration
- Do not leave alone following the injury
- Medication use on sideline?
- Keep the parents/guardians informed
Indications for ER Referral

- Progressive symptoms
- Change in vital signs
- Difficulty maintaining arousal
- Worsening headache
- Very drowsy
- Difficulty recognition of place or people
- Development of seizure activity
- Slurring speech
- Unsteady gait
- Focal deficits

Advanced Imaging?

- Not recommended as routine part of sports related concussion management
- CT modality of choice to rule out acute intracranial injury
- MRI for shear injury to the white matter
- Other functional scans in development
Rest

- Cornerstone of treatment
- 2 areas of Focus
  - Physical and Cognitive
  - Goal is to limit activities that prolong or exacerbate symptoms
  - majority resolve 7-10 days
Graded Return to Learn

- A gradual return is advocated
- 1/2 days, class load accommodations, frequent breaks, extra time for assignments, delay exams
- Frequent breaks, quiet areas to work, limit time reading books/computer work
- Avoid noisy areas (lunchroom, band room, pep rallies)

Medications for Concussion Symptoms

- No effective pharmacological treatment speeds recovery from a traumatic brain injury
- Ok to medicate to treat symptoms, but must be off medications before RTP
- Headache, sleep disturbances
Return to Play (RTP)

- Controversial and difficult decision
- Same day RTP is no longer recommended
  - Incomplete neurocognitive recovery in the asymptomatic patients
- No gold standard measure of brain disturbance and recovery
- Rest, monitor symptoms/signs of recovery, use NP testing to estimate cognitive function, graduated RTP with close monitoring
- No more of the ‘tough it out’ mentality

Prevention

- No evidence that protective gear prevents concussions
- Education
- Legislation
- Rule Changes
- Preparticipation Physical
Thank You!

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