Considerations for the Adolescent Athlete

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Objectives

• Participants will be able to identify key components of the Pre-participation Exam (PPE).
• Individuals will be able to identify the location, estimated appearance and closure of growth structures of the skeletally immature athlete.
• Participants will be able to discuss and assess pathologies specific to the skeletally immature individual.
• Identify “red flags” associated with the Female Athlete Triad.
• Gain an understanding of the preventative measures that can be taken in managing heat related illness in the young athlete.

Overview

Greater than 30 million people between the ages of 5 and 22 participate in organized group sports. The importance of teaching leadership skills, group dynamics and encouraging a dedication to a lifetime of physical fitness should be our early emphasis. This is especially important at a time when childhood obesity has more than doubled in the last 30 years in the US.
Assessing level of Maturation

- Tanner Scale- a scale utilized to determine the level of physical development in children and adults.
- Risser Sign- based on extent of ossification of the human pelvis.
- Triradiate Cartilage-The secondary center of ossification of the acetabulum.

Sections of the Growing Long Bone

Apophysis

A bony prominence that is associated with the attachment of a muscle-tendon group. In the skeletally immature bone the apophysis is connected to the bone through a physeal plate.
Endochondral Ossification

The process whereby the cartilage in the hypertrophic zone of the growth plate is replaced by osseous tissue.

Comparison to Adult Bone

- Less mineral content
- More Porous
- More flexibility/plasticity- Greenstick fractures
- Thicker Periosteum -stabilizes fractures
- Increased vascularity -rapid rates of healing

Salter-Harris

Epiphyseal Growth Plate Fracture Classification System
Salter-Harris Type I

Transverse fracture through the physis

Salter-Harris Type II

Fracture through the physis and exiting out through the metaphysis with a fragment (corner sign)

Salter-Harris Type III

Fracture through the physis and exiting out through the epiphysis into the joint with a fragment
Salter-Harris Type IV

Vertical fracture through the epiphysis and physis and out through the metaphysis.

Salter-Harris Type V

Axial compression crush injury to the physis, not usually seen on the initial plain x-ray.

Salter-Harris Mnemonic

- S: Same. Fracture of the physis (Type I)
- A: Above. Fracture above the physis (Type II)
- L: Lower. Fracture below the physis (Type III)
- T: Through. Fracture through all 3 layers (Type IV)
- ER: Erased. Crushed (Type V)
The Pre-Participation Exam

www.fircreekpeds.com

The Pre-participation Examination

• As of June 2011, 50 of 51 States require PPE.
• NO standardized form exists
• Qualifications? MD, Chiropractor, NP, etc.
• Considered only to be a screen and not a replacement for regular medical check-ups.

The Pre-participation Examination Objectives

• Detection of underlying medical problems.
• Detection of physical deficiencies and education on preventative care.
• Completion of State and Local requirements.
• Assessment of General Health.
• Assess present baseline level of fitness.
• Provide counseling on health related issues.
The Pre-participation Examination

- As many as 78% of the athletes who use the PPE use it as their only health maintenance exam.
- Of all the athletes screened less than 2% fail to qualify for their chosen sport.
- Of these, 3.2-13.5% require follow-up exam and diagnostics.
- Many can be redirected to another sport

Redirect to Another Sport

The Pre-participation Examination

Red Flags
Cardiac Disease
- Sudden Cardiac Death secondary to cardiomegaly accounts for the majority of sports related fatalities. Five to 15 per 1,000,000 participants.
- Death of a family member less than 50 years of age.
- Family history of hypertrophic cardiomyopathy (HCM accounts for 50% of deaths)
- Marfan Syndrome
- Clinically important arrhythmias
The Pre-participation Examination

• Chronic Disease-Asthma, Hypertension, diabetes, epilepsy and bleeding disorders.
• Sickle cell traits-8% of all African-Americans. Increased risk for rhabdomyolysis. Counsel on how to manage under conditions of heat, altitude or humidity.
• Prior recognition of a heart murmur.

The Pre-participation Examination

- Heat Related Illness
  • Asthma
  • Concussion History
  • Seizure Disorder
  • Unilateral Organ
  • Contagious Skin Conditions
  • Use of Ergogenic Aides

The Pre-participation Examination

• Recent Mononucleosis
• Current Medications
• Menstrual History
• Past Injury
Musculoskeletal Assessment

- History of chronic ankle sprains
- Knee-PPFS, Osgood-Schlatter's, SLJD, ligamentous stability, OCD
- Shoulder or elbow pain and/or instability
- Unexplained LBP—primary site for metastatic disease in this age group.
- Scoliosis
- Spondylolisthesis
- Scheuermann's Kyphosis

Body Part Specific Considerations for the Adolescent Athlete

Spine

- Three Ossification Centers of each Vertebra
  - One for the vertebral body
  - Two for each neural arch

Fixscoliosis.com
Spine
Developmental Anatomy

• Each vertebra assumes its adult characteristics by the age of 8, and oblique pattern by the age of 15 years
• The vertebral body physis can be seen on X-ray by age 8 when they begin to ossify peripherally and are thicker peripherally at the ring apophysis.
• Ossification is completed by age 12.
• The physis begins to fuse with the vertebral body by age 14 and fusion is complete between the ages of 21 and 25.

Spine
Developmental Anatomy

• The Nucleus Pulposus in the immature spine is more resilient and elastic because of its higher water content.
• Spinal canal achieves its adult volume by 6 years of age.
• The spinal cord ascends to T1 by age 1. SCI injury levels are the same in the adult as they are in the child after the age of 1.
• Spinal column can be stretched up to 5cm before it fails vs. 1cm in the adult spine.
• SCIWORA

Spine
Spear Tackling

[Image of two rams]
Spear Tackler Spine

- Loss of lordotic cure of the spine. Specifically in cervical region.
- Acquired from tackling with poor technique referred to as spearing. i.e. Leading with top of helmet.
- May present with neck pain or not.
- Any loss of cervical lordosis should be noted and referred on.
- www.cdc.gov/ncipc/tbi/coaches_tool_kit.htm

Spine.....
“Burners and Stingers”

- Burners and Stingers
  A transient injury to the brachial plexus

  - Mechanism of Injury
    - Acute axial load to the top of the head or shoulder
    - Traction-direct blow to the top of the shoulder with head turned away
    - Compression-spearing-type tackle with direct head to head contact
  - Symptoms
    - Burning pain and/or paresthesias into the arm, hand, fingers.
Spine.....
“Burners and Stingers”

Treatment/Management

- Any athlete reporting neck tenderness, stiffness, fear of moving neck needs to be immediately immobilized on a spine board.
- The athlete is removed from competition and complete quadrant examination performed.
- Assess for shoulder subluxation or dislocation.
- Bilateral symptoms may indicate that the cord has been traumatized and may suggest transient quadriplegia. Immobilize athlete and transport.
- NEVER REMOVE HELMET.
- www.nata.org/consumer/headsup.htm

Spine

Mechanisms of Injury

- Change in recent training regimen
- Poor Conditioning
- Core muscle weakness
- Decreased flexibility
- Increased lumbar lordosis/poor posture or training postures
- Improper sport technique
- Poor fit or use of equipment

Scheuermann Disease

Juvenile Disc Disease

chiropractic-help.com
Scheuermann Disease
Juvenile Disc Disease

- Characterized by a fixed kyphotic deformity of the thoracic spine.
  - The diagnostic wedging is not usually seen prior to 10 years of age and most common between the ages of 10 and 15.
  - Normal thoracic spine curve is between 20-40 degrees in the sagittal plane.
  - A kyphotic deformity exceeding 45 degrees is considered abnormal.
  - Males greater than females.
  - Most have a + family history.
  - No studies support higher prevalence in athletes.

Scheuermann Disease

- Mechanism
  - Genetic predisposition
  - Hormonal abnormalities
  - Collagen deficits
  - Juvenile osteoporosis
  - Vitamin deficiencies
  - Repetitive microtrauma

Scheuermann’s Kyphosis
Scheuermann’s Kyphosis

Clinical Presentation
- Poor posture
- Constant dull ache in T/S, between scapula
- Exacerbated by activity, prolonged sitting
- Pain tends to diminish as adolescent reaches skeletal maturity
- Will see IT tightness and an increased lumbar lordosis

Scheuermann’s Kyphosis

- Diagnostic Findings
  - Vertebral end-plate abnormalities
  - Narrowing of the intervertebral disc space
  - Anterior wedging (>5° of 3 consecutive vert)
  - Decreased height of the vertebra
  - Schmorl Nodes (protrusion of the n.p. into the vertebral body anteriorly)
- Classically, the apex of the kyphotic deformity is at T7-T8 levels

Scheuermann’s Kyphosis

Treatment
- Improve hamstring flexibility and flexibility in the thoracolumbar region
- Core strengthening
- Postural education
- Breathing instruction
- Treatment is also guided by the severity of the deformity and remaining growth potential based on skeletal maturity.
  - Kyphosis less than 50° is managed conservatively with exercise and diagnostic monitoring until skeletal maturity.
  - Bracing in skeletally immature with kyphosis >50°
  - Greater than 70° are surgical candidates
Thoracolumbar (Atypical) Scheuermann Disease

- Seen in adolescents who participate in sports that require repeated flexion and extension movements such as gymnastics, wrestling, football, weight lifting, rowing, swimming, tennis, bicycle racing and video games.
- It most frequently occurs in male athletes between the ages of 15 and 17.
- Wedging in the vertebra of the thoracolumbar spine causes a loss of the natural lumbar lordosis

Spondylolysis

- Stress fracture of the pars interarticularis
- Incidence is 6% in the general population and 50% in gymnasts.
- A higher incidence found in ballet, competitive cheerleaders, football linemen, weight lifting, wrestling, diving and volleyball
- Mean age of onset is age 15-16 but may occur earlier

Spondylolysis Mechanism

Repetitive axial loading, rotation and extension most specifically in the lumbar spine
Spondylolysis
Clinical Presentation

- Many are asymptomatic
- Insidious onset, activity-associated, recurrent LBP.
- Can also be sudden onset, localized to LB, dull to sharp pain.
- No neurologic symptoms
- Hamstring and thoracolumbar tightness
- Increased lumbar lordosis and core musculature weakness
- Pain can be reproduced by the Stork Test

Spondylolysis
Treatment

- Symptomatic athletes should refrain from sports involving hyperextension until pain-free
- Tri-planar core stabilization
- Improve flexibility
- Education on body mechanics and proper functional movement patterns.

Spondylolisthesis

A forward slipping of one vertebra over the vertebra below it due to a bilateral pars interarticularis defect.
Most common at L5-S1.
Spondylolisthesis

- Clinical Presentation
  - Same as spondylolysis
  - Step-off deformity may be palpated over the lumbar spine.
  - Lumbar radicular symptoms may be present in high-grade spondylolisthesis.
- Treatment
  - Close monitoring until skeletal maturity
  - Clinical management the same in low-grade cases
  - High-Grade cases should be referred to orthopedic surgeon for further workup and possible surgical options

Slipped Vertebral Apophysis
Fracture of Ring Apophysis

- A fracture through the weak osteocartilagenous junction between the vertebral body and its apophysis. May result in displacement and protrusion into the spinal canal of the fractured segment along with its associated intervertebral disc.
- Mechanism: acute or repetitive trauma from compressive loads applied to the spine during flexion

Sagepub.com
Slipped Vertebral Apophysis
Fracture of Ring Apophysis

- Clinical Presentation
  - Symptoms are similar to that of acute central disc herniation.
  - Acute lumbar pain with onset during an activity involving compressive loading and flexion to the spine.
  - Burning and radiating pain into the legs.
  - Sitting, coughing, sneezing. + SLR
  - Neurological findings are uncommon in most adolescents which may delay diagnosis.

- Treatment
  - Most consider surgical excision of the fractured fragments as treatment of choice.

The Hip and Pelvis

- Proximal Femur has an epiphyseal plate at birth and later becomes the greater trochanteric and subcapital epiphyseal plate
- Femoral Head-ossification center appears at 4-6 months
- Greater Trochanteric ossification center appears at 2-5 years
- Lesser Trochanteric ossification center appears at 8-12 years
The Hip and Pelvis
Growth Centers

- Lesser and Greater Trochanteric Apophysis fuse between 16 and 18 years of age.
- Subcapital Femoral Epiphysis fuses at approximately 18 years of age.
- Primary ossification centers of the pubis, illium and ischium fuse to form the acetabulum.

The Hip and Pelvis
Apophyses (7) and associated muscular attachments

- Iliac Crest- Internal and External Obliques
- ASIS- Sartorius
- AIS- Rectus Femoris
- Ischium- Hamstring
- Lesser Trochanter-Psoas
- Greater Trochanter-Gluteus medius, maximus and hip external rotators.
- Pubic Symphysis-hip adductors, rectus abdominus

Apophysis of the Pelvis

[Image of the pelvis with labeled apophyses]
The Hip and Pelvis

- Apophyseal avulsion fractures are usually sports-related injuries in adolescents that occur during the time between appearance of and the fusion of these secondary ossification centers.
- MOI: Acute, sudden forceful eccentric or concentric contraction that occurs with rapid acceleration or deceleration forces or sudden extreme stretch or passive muscle lengthening.
- Symptoms: Localized pain and swelling over the affected area, muscle weakness, ROM limitations, pain with active joint motion, deceleration and resistance.

The Hip and Pelvis
Apophyseal Avulsion Injury Sites

Greater Trochanter

- Mechanism of Injury: Strong contraction of the hip abductors such as with cutting maneuvers.
- Symptoms: Pain is acute, localized and antalgic; gait is localized and antalgic. Reproduced with palpation, passive hip adduction or active abduction. May rest with hip in flexion and/or slight abduction.

The Hip and Pelvis
Apophyseal Avulsion Injury Sites

Lesser Trochanter

- Mechanism of Injury: Strong contraction during kicking, jumping or sprinting sports.
- Symptoms: Sudden pain in anterior hip and groin region. May have experienced a "pop" or snapping sensation in the groin. Leg may be positioned in Add/IR position for symptom relief. Symptoms are reproduced with palpation over avulsed area with resisted hip flexion.
- Ludloff Sign: when in seated position, patient will be unable to flex hip.
The Hip and Pelvis
Apophyseal Avulsion Injury Sites

Ischium
- Symptoms: Acute pain, difficulty sitting. Tenderness and possible palpable defect is felt.
- Symptoms are reproduced with SLR and with hip extension.

Anterior Superior Iliac Spine (ASIS)
- Mechanism of Injury: Strong contraction of the sartorius during running, hurdling or sprinting in which the hip is extended and knee is flexed.
- Symptoms: Can be bilateral. Pop or snap, acute pain, tenderness with possible palpable defect.
- Reproduced with passive hip extension or active hip flexion, flexion/ER.

Anterior Inferior Iliac Spine (AIIS)
- Mechanism of Injury: Runners or kicking sports when the hip is hyperextended and the knee is flexed. Abrupt stop from kicking turf.
- Symptoms: Acute anterior hip pain. Reproduced with palpation or with active hip flexion with knee extension or passive hyperextension of the hip.
The Hip and Pelvis
Apophyseal Avulsion Injury Sites

Iliac Crest

- Symptoms: Isolated tenderness over iliac crest. Reproduced with trunk rotation, lateral bending and resisted hip abduction.
  - Anteriorly: Internal and external obliques, TFL, gluteus medius, transverse abdominals.
  - Posteriorly: Gluteus maximus and some of the lattissimus.

The Hip and Pelvis
Apophyseal Avulsion Injuries

Treatment

Phase I (1-7 days) Rest, ice, positioning to relieve tension to the injured area. PWB.
Phase II (7-20 days) PWB, ice, PROM.
Phase III (21-30 days) AROM and mild resistance. 50% of strength vs. opposite side.
Phase IV (30-60 days) Multidirectional strengthening and proprioception training.
Phase V Full MMT, ROM, continue multidirectional strengthening. Return to sport participation.

Slipped Capital Femoral Epiphysis

- The femoral head stays within the acetabulum. The proximal femoral metaphysis displaces superior and anterolaterally on the femoral epiphysis.

metzmaker-pappas@massgeneral.org
Slipped Capital Femoral Epiphysis

- Possible Etiologies
  - Hormonal changes in adolescence
  - Puberty-related changes in physeal architecture and orientation
  - Obesity: 63% are >90th percentile in body weight
- Commonly idiopathic
- 20-40% bilateral
- 1.5 more common in males

Slipped Capital Femoral Epiphysis

- Clinical Presentation
  - Lower Extremity positioned in flexion, ER, ADD and possibly shortened.
  - Pain with IR/Limitations in IR
  - Pain with passive rotation of the hip
  - XR-AP and frog leg lateral views.
  - Possibly a vague history of trauma

Slipped Capital Femoral Epiphysis

Kleins Line

Emedmag.com
Slipped Capital Femoral Epiphysis

Treatment

• Goal: prevent further displacement until permanent closure of the physis.

• Stable: Most MD’s recommend fixation with a single screw if caught in early stages. Four to 6 weeks TDWB. RTS (contact) only when physis is closed.

• Unstable: Internal fixation. Most have a high chance of developing AVN.

Legg-Calve-Perthes Disease

• Also known as Avascular Necrosis of the proximal femoral epiphysis.

• Degenerative disease where loss of bone mass leads to some degree of collapse and deformity of the femoral head.

• The most common cause of limping in the 4-10 year old age group.
Legg-Calve-Perthes Disease

Clinical Presentation

- Knee and groin pain/ache
- Decreased IR/ABD—may position in add/extension
- Antalgic gait that worsens with fatigue (trendelenburg)
- Quadricep atrophy
- Leg length discrepancy
- Boys 4:1
- Diagnosed between 5 and 12 years of age.
- X-ray—flattening of the femoral head

Four Stages of LCPD

- Femoral head becomes more dense with possible fracture of supporting bone
- Fragmentation and reabsorption of bone;
- Re-osification when new bone has regrown
- Healing, when new bone reshapes.

Treatment Goals:

- Reduce hip irritability
- Restore and maintain hip mobility
- Prevent the ball from extruding or collapsing
- Regain a spherical femoral head

National Osteonecrosis Foundation
Legg-Calve-Perthes Disease
Treatment

• Non-surgical
  ➢ Modified weight-bearing for pain management
  ➢ Instruct parents of gentle ROM activities to maintain the shape of the femoral head.

• Surgical
  ➢ Femoral Varus Osteotomy-repositioning the femoral head to redirect it into the acetabulum
  ➢ Shelf Arthroplasty-osteotomy to reposition the acetabulum to fit over the head of the femur to prevent further deformity.

Stress Fractures of the Hip
Femoral Neck Fractures

• Who?
  ➢ Classically occur in female athletes, primarily runners, with the classic Female Athlete Triad, and military recruits.

• Mechanism of Injury
  ➢ Chronic, repetitive microtrauma, biomechanical problems, poor core and hip strength and low bone density (adolescent osteopenia/osteoporosis)

Femoral Neck Fractures

• Types
  ➢ Tension Fracture-Lateral side. Higher risk for displacement and may require ORIF.
  ➢ Compression Fracture-more common in adolescents. Affects the inferior medial side.
Femoral Neck Fracture

- Clinical Presentation
  - Pain in knee or groin that is most severe when the foot strikes the ground or with exercises that place high stress on the hip such as kicking, sprinting or cutting.
  - Night pain
  - Negative palpation
  - Limited hip flexion and/or IR. A/PROM into abduction may recreate groin pain.
  - Possible Trendelenburg
  - + Hop test on landing
  - X-ray negative until approximately 3 weeks post onset of symptoms
  - + MRI

Femoral Neck Fractures

Treatment
- PWB/NWB-For up to 1 month. Stress importance to patient and parent to prevent further displacement and possible AVN.
- PT-improve core strength, tri-planar pelvic stabilization, instruct on proper landing mechanics, assist in determining underlying factors that may have contributed to this event.

The Adolescent Knee
The Adolescent Knee

Growth Regions

- The epiphyses of the distal femur and proximal tibia are present at birth.
- The proximal tibial and patellar ossification centers are not present until 3 to 4 years of age.
- The distal femoral physis acts as the proximal attachment of the MCL in the skeletally immature individual.
- The patella tendon inserts on the tibial tubercle apophysis
- Distal Patella Apophysis-we’ll talk more.

Epiphyseal Plates of the Distal Femur and Proximal Tibia

- The distal femoral physis contributes approximately 1cm of growth per year, responsible for 70% of the longitudinal growth of the femur and 37% of lower limb growth.
- The proximal tibial physis contributes .7cm of growth per year, approximately 55% of tibial growth and 25% of limb growth.
The Adolescent Knee

• ACL
• PFPS
• Patella Instability/Dislocation
• Osgood-Schlatter Disease
• Sindig-Larsen-Johanssen Disease (SLJ)
• Osteochondritis Dessicans (OCD)

The Adolescent ACL Treatment Options

• Nonoperative-Active Rehabilitation, activity limitations and bracing until skeletal maturity.
• Transphyseal (adult) Reconstruction—AJSM May 2012 40 1093-1098.
• Physeal Sparing Reconstruction

The Adolescent Knee Avulsion Fracture of the Tibial Spine

What would normally be an ACL tear in an older adolescent or adult may be an avulsion fracture of the tibial spine in the skeletally immature.

Tibial Spine or Intercondylar Eminence fractures/avulsions are seen most commonly between 8 and 15 years of age.

There is usually ACL involvement to a varying degree.
The Adolescent Knee
Avulsion Fracture of the Tibial Spine

• Mechanism of Injury-same as ACL
• Treatment-Initially closed with long leg cast with knee in slight flexion. Type III or IV may require surgical reduction and fixation.
• Outcomes-may leave the young athlete with residual instability, leading to future meniscal or osteochondral injuries. May require ACL reconstruction in the future.

The Adolescent Knee
Avulsion Fracture of the Tibial Spine

• Segond Fracture in an adult is an avulsion fracture of the lateral tibial condyle and is associated with tears of the ACL, medial meniscus and structures in the posterior lateral corner.
• Segond Fracture in an adolescent may also include the above structural involvement as well as a Salter-Harris IV fracture of the tibial plateau.
Osgood-Schlatter Disease

- Osgood-Schlatter Disease is a traction avulsion of the apophysis of the tibial tuberosity.
- OVERUSE INJURY-traction apophysitis
- More common in boys. Usually bilateral.
- Calcification usually begins around 8 or 9 in girls and 11 to 12 in boys. Complete fusion over the next 2 years.
- More common in athletes 21% vs non-athletes 4.5%.
- Basketball and other jumping sports

Mechanism of Injury

- Repetitive jumping
- Muscle strength/length imbalances
- Poor take-off and landing mechanics

Treatment

- Rest
- Ice
- Stretching of quadriceps and hamstrings.
- Proximal strengthening
- Emphasize the benign course of treatment
- No risk for complete avulsion.

Sinding-Larsen-Johansson Syndrome

radiographics.rsna.org
The Adolescent Knee
Sinding-Larsen-Johannsson Syndrome (SLJ)

- An overuse injury involving the apophysis at the inferior pole of the patella.
- Gradual onset. Usually no history of trauma.
- Caused by jumping and running activities.
- We see patella tendonitis, tendon avulsion and later localized calcification and fragmentation.
- Most commonly seen between the ages of 10 to 13.

Clinical Presentation
- Anterior knee pain
- Worse with activity, jumping and cutting.
- Pain with localized palpation of the inferior pole of the patella with knee flexed to 90 deg.
- Hamstring tightness

Treatment
- Benign condition. Participate as tolerated.
- Rest, ice
- Hamstring stretching
- Correction of improper mechanics

The Adolescent Knee
Juvenile Osteochondritis Dissecans (JOCD)

- Delamination and localized necrosis of the subchondral bone, with or without the involvement of the overlying articular cartilage
- Most common site involved is the distal, lateral aspect of the medial femoral condyle, accounting for 75% of all JOCD lesions.
- The lateral femoral condyle and patella can also be affected.

Kocher, MS et al.
Juvenile Osteochondritis Dissecans (JOCD)

- **A**. Intact lesion
- **B**. Lesion showing signs of early separation
- **C**. Partially detached lesion
- **D**. Craters with loose bodies

**Unknown Etiology**

- Repetitive microtrauma
- Local bone vascular insufficiency
- Can be stable or unstable
- Can be bilateral in as many as 1/3 of all patients
- Four times more common in males

**Symptoms**

- Deep joint pain, chronic soreness, stiffness
- Physical examination often normal initially
- Late stages the articular cartilage has eroded, a fragment may separate and become an intra-articular loose body.

**Diagnosis**

- Plain Radiographs-AP, lateral and tunnel views.
- MRI

**Treatment**

- Conservative-complete rest. No sport activity.
- Advanced Disease-immobilization and determination of size and stability of the lesion. Surgery involves drilling, reattachment or excision of the osteochondral lesion.
- OCD autographs in the skeletally mature. OATS Procedure. (Osteoarticular Transverse System)
Adolescent Foot and Ankle

Foot and Ankle
Fractures of the Distal Tibial and Fibular Physis

- Second most common physeal fractures. 60% are sports related and account for 10-40% of all acute musculoskeletal injuries in the skeletally immature athlete.
- Tibial Physis close by the age of 15 in girls and 17 in boys
- Fibular Physis close between 10 and 14.

Foot and Ankle
Distal Tibial and Fibular Physis
Ankle ligaments are attached distally to the physis.

An ankle sprain in an adult may often be a physeal fracture in the skeletally immature athlete.

Fractures are classified according to the anatomical configuration and the mechanism of injury.

Salter Harris I and II are usually managed non-operatively.

The distal tibial physis closes sequentially over a period of 18 months:
- Center
- Medially
- Laterally
Foot and Ankle Fractures

This 18 month period results in a "transitional pattern" of the distal tibial physis fractures.

- Triplane (Salter-Harris III) Fractures
- Juvenile Tillaux (Salter-Harris IV)

- Clinical Presentation
  - Point tenderness at the physis
  - Usually unable to weight bear
  - Swelling
  - Ecchymosis

- Treatment
  - PWB/NWB 4-6 weeks
  - Surgery 30-50% of time (>2mm displacement)
  - Splinting/casting
  - Progressive RTS following
  - Follow up XR at 6 months if concerned about growth arrest.
### Foot and Ankle
**Metatarsal Fractures**

- Physis of the metatarsals are located distally with exception of the first, which is located proximally.
- Closes age 12-15. (2 years after appearance)

**Metatarsal Shaft Fractures**

- Fifth metatarsal fractures are the most common. They comprise 90% of the metatarsal fractures in children over the age of 10.

**Adult** - Tuberosity avulsion fractures.

**Metatarsal head fracture**-within 1.5cm of tuberosity. AKA Jones Fracture

**Adolescent** - The styloid process is the apophysis for the peroneus brevis.

- Mechanism of Injury - Inversion of PF foot.
- Clinical Presentation - Point tenderness, swelling, limited ability to WB.

### Differentiation between Jones Fracture and Apopyseal Fracture

Jones Fracture is seen perpendicular to the 5th metatarsal.
Differentiation between Jones Fracture and Apophyseal Fracture

Apophyseal fracture is oriented parallel to the 5th metatarsal.

Overuse Injuries of the Foot

- Sever Disease—Traction apophysitis of the calcaneal apophysis.
- Iselin Disease—Traction apophysitis of the base of the 5th metatarsal.
- Metatarsal Stress Fractures
- Tibial Stress Fractures
- Chronic Exertional Compartment Syndrome

Sever Disease

- The secondary center of ossification of the calcaneus appears around age 9 and fuses at approximately 16 years of age.
- Vertical orientation
- Subjected to shearing and traction stresses from repetitive contractions of the gastroc-solus complex.
- Seen in preteen to early teen years in gymnasts, soccer and basketball players.
Sever's Apophysitis

Sever Disease

- Clinical Presentation
  - Diffuse pain and swelling
  - Worsens with activity and dorsiflexion
  - Painful ambulation
  - Focal bony tenderness at the posterior aspect of the heel.
- Mechanism of Injury
  - Usually with the start of a new season
  - Increase in running time/distance/inclines
  - Tightness gastroc-soleus complex
  - Growth spurt

Sever Disease

- Management
  - Rest and/or activity modification
  - Stretching gastroc-soleus complex
  - Ice
  - If athlete must return to play, consider heel lift or inserts bilaterally.
  - 85% of athletes return to sport within 2 months of onset of symptoms with above interventions.
Metatarsal Stress Fractures

* A stress fracture is a fatigue fracture resulting from repetitive, excessive load applied to a normal bone.
* An insufficiency fracture refers to a “normal” amount of load applied to a weak or structurally abnormal bone.
* A stress reaction is a focal site of tenderness within the bone that is initiated by accelerated osteoclast breakdown. If allowed to continue, the bone will fracture.


Metatarsal Stress Fractures

- Most common in 2nd and 3rd metatarsals. Known as “Dancer’s Fractures” or “March Fractures” in military personnel.
- Onset is at early stages of training or a transitional time heading into a performance
- A stress fracture should always prompt clinical concern as the underlying cause.

Metatarsal Stress Fractures

- Exam-subjective
  - Family history
  - Menstrual history
  - Dietary habits
  - Training history
- Treatment
  - Stop activity
  - Ice
  - Rigid shoe or walking boot, NWB if severe
  - If nonunion after 4-6 weeks, may require DREF.
  - Initiate RTS only after painfree. Innate and kinetic chain strengthening.
Differential Diagnosis

- Medial Tibial Stress Syndrome - diffuse posterior-medial shin tenderness with palpation.
- Stress Fracture - Focal pain with palpation in the posterior-medial tibia. + Hop Test.
- Exertional Compartment Syndrome - tenderness in the muscular compartments around the tibia, no tenderness on the tibia.

The Adolescent Shoulder

Growth Plate Locations

Humerus

- Proximal Humeral Physis accounts for 80% of humeral growth.
- Distal humeral physis accounts for 20%.
- Distal (Lateral) Clavicle physis accounts for 20-30% of clavicle growth.
- Proximal (Medial) Clavicle physis is responsible for 80% of the clavicles growth.
Proximal Humeral Growth Plate

Proximal Humeral Epiphysis

- Proximal Humeral Epiphyseal Ossification Center appears during the first year.
- Greater Tuberosity appears by 3 years of age.
- Lesser tuberosity appears by 5 years of age.

These centers coalesce between the ages of 5-7 to form the Proximal Humeral Epiphysis

Proximal Humeral Epiphysis

- Ossification occurs (epiphysis to metaphysis)
  - Between the ages of 14 and 17 in girls
  - Between the ages of 16-18 in boys*
- Ossification is more dependent on skeletal maturity than age

Fractures in the proximal humeral epiphysis are rare, representing only 4% of all physeal fractures.
Distal Clavicle Physis

- Centers of ossification usually appear at the age of 11.
- Closes at approximately 20 years of age.
- A direct fall for a child usually results more in physeal fracture instead of an AC joint separation.
- Surgical or non-surgical intervention both work well

Proximal Clavicle Physis

- Secondary ossification centers appear at approximately age 17.
- Close between the ages of 18 and 24.
- Seldom dislocated. More common to see physeal disruptions due to impact or lateral falls onto shoulder.
  - Anterior dislocations require closed reduction
  - Posterior dislocations require emergent reduction due to possible impingement on major vessels, trachea or esophagus.

Humeral Head Retroversion
Humeral Head Retroversion

Forces Between Ages 10 and 15
- Internal Rotation Acceleration 6900±1050 deg/sec. (Fleisig et al)
- Distraction of 1090N (108% body weight) (Sabick)
- Peak humeral head torques of 18N-m. This is 400 times greater than the sheer strength of epiphyseal cartilage

Humeral Head Retroversion

Position
- Between the age of 8 and 16, the humeral head rests in approximately 78 degrees of retroversion.
- By the age of 25, the humeral head rests in approximately 25-30 degrees of retroversion.

"Throwing restricts the normal physiological de-rotation process of the humeral head during growth."

Yamamoto 2006
Humeral Head Retroversion

- Crocket-AJSM 2002
- Reagan-AJSM 2002

Both concluded that the humerus actually torques with repetitive throwing, causing an increase in humeral retroversion.

Humeral Head Retroversion

- Forward Elevation/Total ROM decreases with age.
- Most dramatic decline in ROM is at 13-14 years of age.
- Peak incidence of little league shoulder occurs at age 14-15.

Little League Shoulder
Little League Shoulder
Extrinsic Factors

- Fatigue—not enough rest between starts
- Numbers of pitches per game/season (>80/game)
- Types of pitches thrown
- Pitching more than 9 months out of the year
- Showcase Pitching
- Playing through pain
- Taller/heavier pitchers who throw with greater velocities
- Poor biomechanics

Little League Shoulder
Mechanism of Injury
Distraction

- Deceleration at the end of ball release as the RC musculature contracts to center the humeral head on the glenoid.
- The RC inserts proximal to the humeral physis and the RC acts to structurally stabilize the humeral head in the glenoid, while the extended lever arm of the UE is moving forward into an IR position.
- Distraction accounts for 5% of the stress on the humeral physis during throwing.

Little League Shoulder
Mechanism of Injury
Torsion

- Rotational stresses are placed at the proximal humerus particularly during the late cocking phase.
- ER torque peaks at the end of arm cocking and the beginning of acceleration phase.
Little League Shoulder
Mechanism of Injury

“The shear stress caused by torsion alone represents approximately 400% of the shear strength of the epiphyseal cartilage and is probably enough to deform the cartilage of the proximal humeral epiphysis. The growth plate is more resistant to tension and least resistant to torsion.”

Sabick, MB

Little League Shoulder
Intrinsic Factors

• Joint Laxity
• Underdeveloped stabilizing and centering musculature
• Open epiphyseal plate—weak point in all static and dynamic stabilizers of the shoulder.

Little League Shoulder
Clinical Presentation

• Pain localized to the proximal humerus
• Pain with throwing
• Pain with resisted strength testing
• Radiographic findings of widening of the proximal humeral physis
• Usually painfree at rest
Little League Shoulder

What we do not see

- Swelling
- Weakness
- Atrophy
- Loss of ROM

Little League Shoulder

Treatment

- Activity Modification
- Maintenance of AROM and MMT
- Biomechanical Assessment
- Return to throwing/pitching programs
- PREVENTION is the best treatment!

*Growth healing may occur prior to normalization of radiographs.
Little League Shoulder

In Summary:

• Overuse injury resulting from a high rate of frequency and intensity in a skeletally immature, prone to injury body.
• Improper throwing mechanics.
• Parents and coaches must be on board and use solid judgment in adhering to pitch counts and adopt realistic and safe expectations.

Injury Prevention

- American Sports Medicine Institute (ASMI) Guidelines
  > www.ASMI.org
  > Suggest:
  > Total body warm-up
  > No throwing four months a year (pitching)
  > Off season conditioning programs focused on development of a strong athletic foundation
  > Initiation of interval throwing programs (See ref.)
  > Interval pitching programs (See ref.)
  > Strict adherence to Little League Pitch Count guidelines put forth by ASMI.

Injury Prevention and Education

Sports Health Survey of youth coaches about their knowledge of safety guidelines established by the USA Baseball Medical and Safety Advisory Committee.

Coaches answered 43% of questions correctly
27% of coaches didn’t know safety guidelines
53% of coaches felt guidelines were being followed.
19% reported that they allowed a player to pitch with a sore shoulder or elbow.

Elbow and Wrist

• It is estimated that 20% of all upper extremity injuries involve the elbow and 10% involve the wrist.

• Most common UE injuries occur in:
  ➢ Gymnastics
  ➢ Racquet Sports
  ➢ Throwing Sports
  ➢ Football and Basketball for hand and wrist

Elbow

• Secondary Ossification Centers Include:
  ➢ Capitullum-forms age 2
  ➢ Radial Head-forms age 4-5
  ➢ Medial Epicondyle-forms age 6-7
  ➢ Lateral Epicondyle-forms age 12-13
  ➢ Olecranon-forms age 11
  ➢ Trochlea-forms age 9-10

• These centers generally fuse between the ages of 14 and 17.

Elbow

• Subjective Exam
  ➢ Mechanism of Injury
  ➢ Where/when during the cycle does pain occur
  ➢ Severity and duration of symptoms
  ➢ Swelling, catching, locking in the joint
  ➢ Training Routine-Hours/wk, intensity, pitch count, changes in throwing mechanics
  ➢ Paresthesias
Elbow

- **Objective Exam**
  - ROM: Flexion contracture may be present.
  - Swelling: limited
  - Paresthesias: ulnar nerve involvement.
  - Observe for symmetry between sides
  - Assess End Feel
  - Palpation: major ligaments, ulnar nerve
  - Check pulses

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**Elbow Carrying Angle**

The Carrying Angle is the angle made by a line drawn along the axis of the humerus and a line drawn along the axis of the forearm with the forearm supinated and elbow extended.

- Normal Men = 11 deg
- Normal Women = 13 deg
- Competitive Athletes may have up to 15 deg or more.

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**Elbow Major Ligaments**

- Medial (Ulnar) Collateral Ligament
- Lateral (Radial) Collateral Ligament

Palpate both ligaments with the elbow positioned in approximately 50 deg of flexion.

Valgus Stress Testing: performed with the elbow in 20-30 degrees of flexion

Valgus Extension Overload Test: The elbow is repeatedly extended from slight flexion while applying a valgus stress at the same time.
Medial Epicondyle Apophysitis aka Little League Elbow

• Mechanism of Injury

Repeated tension stress over the attachment of the UCL of the elbow on the medial epicondyne from the valgus movement and the repetitive forceful contractions of the flexor-pronator muscle mass.

Repeated stress may ultimately lead to failure of the medial epicondyle apophysis resulting in avulsion or fracture.

Avulsion Fracture of the Medial Epicondyle

Medial Epicondyle Apophysitis

• Clinical Presentation
  ➢ Medial elbow pain with overhead activity progressing to persistent pain
  ➢ Diminished ability to throw, loss of velocity, distance and duration.
  ➢ Pain with late cocking, early acceleration
  ➢ Point tenderness
  ➢ Pain with resisted wrist flexion and valgus testing
  ➢ May have heard a “pop” with onset of pain
  ➢ X-ray reveals widening or fragmentation of the medial apophysis
Medial Epicondyle Apophysitis

- Treatment
  - Stop throwing for a minimum of 6 weeks. Short course of immobilization in sling of symptoms are severe
  - Ice
  - Address flexion contracture
  - Kinetic chain strengthening
  - Stretching and progressive strengthening
  - When completely asymptomatic begin supervised interval throwing program.
  - Address faulty mechanics and training errors.
  - Encourage off-season injury prevention/strengthening/conditioning program.

OCD of Capitellum

- Mechanism of Injury
  - The articular cartilage over the capitellum is subjected to repetitive compressive stress during the acceleration and follow through phases of pitching.

Most commonly seen in young male pitchers and competitive gymnasts.
Most commonly occurs between the ages of 11 and 15 years.

OCD of Capitellum

- Clinical Presentation
  - Swollen, painful elbow laterally
  - TTP along the radiocapitellar joint
  - Decreased performance
  - Elbow flexion contracture
  - X-ray may show fragmentation
  - Painful pronation and supination with elbow in full-extension.
OCD of Capitellum

Treatment
- Immobilization in a sling until symptoms are no longer present
- Kinetic chain strengthening
- Assessment of throwing mechanics
- Interval throwing program
- Operative intervention in the presence of catching or locking symptoms.

Panner Disease

- Panner disease, or osteochondrosis, is a disruption of the growth center of a child, usually between the ages of 7 and 12, due to the AVN and degeneration of the capitellum at the humerus
- The necrosis is followed by recalcification of this area
- No known mechanism of injury
Panner Disease

- Clinical Presentation
  - Child complains of achy elbow pain that increases with activity
  - Swelling
  - Minimal loss of motion—little limitation of extension
  - Focal lesion of the subchondral bone of the capitellum and the overlying articular cartilage.
  - X-ray—the anterior central capitellum is the most common location of involvement because the head of the radius articulates with the capitellum in this area.

Panner Disease

- Treatment
  - Rest, ice
  - Activity modification
  - Gradual return to play only when painfree
  - Attention to pitch counts, mechanics, pitch styles.
  - Self-limiting with few long-term issues
  - Avoid excessive impact and shear loading

Radiocapitellar Compression Syndrome

- Repetitive valgus stress.
- Associated with chronic medial elbow instability. Repetitive throwing inhibits healing of the UCL. As a result, the elbow develops UCL insufficiency due to microtrauma, posterior elbow compression, and radiocapitellar joint compression.
- This lateral compression causes the radial head to press against the capitellum.

[Reference: Shaw, J., O'Connor, F. G.]
Radiocapitellar Compression Syndrome

- Clinical Presentation
  - Medial and lateral elbow pain with OH activity.
  - Decreased velocities
  - Valgus stress testing is usually positive
  - May present with ulnar neuritis due to instability
  - X-ray may show osteophytes, loose bodies, olecranon hypertrophy, avulsion fractures and ossification within the ligament.

Radiocapitellar Compression Syndrome

- Treatment
  - Rest and ice
  - Initiate stretching and strengthening when asymptomatic
  - Supervised interval throwing program.
  - Mechanics
    - If there has been UCL involvement, treatment more extensive. Surgery (Tommy John) may be indicated.

Distal Radial and Ulnar Physes

- Distal Radial Epiphysis
  - Appears at 6 months to 2 years
  - Generally closes around 16 in girls, 17 in boys

- Distal Ulnar Epiphysis
  - Appears around 7 years of age
  - Ulna typically closes prior to the radius
Stress Injury of the Distal Radial Physis

Common in the female gymnast between the ages of 12 and 14.
Affects 25-80% of gymnasts.

- Mechanism of Injury
  - When the hand and wrist become weight bearing surfaces, the excessive, repetitive loading activity in a dorsiflexed position (in excess of 35 hours per week) predisposes distal radial physis to injury.

Stress Injury of the Distal Radial Physis

- Clinical Presentation
  - Presents with recurrent, chronic wrist pain, exacerbated by weight bearing on the wrist in dorsiflexion.
  - Bilateral in up to 30% of gymnasts
  - May report forearm pain.
  - Floor exercise and vault are worst offenders in females. Floor exercise and pommel horse in males.
  - Ulnar variance

Stress Injury of the Distal Radial Physis

Ulnar Variance

![Image](https://imaging.counsel.com)
Stress Injury of the Distal Radial Physis

- Treatment
  - Avoid wrist loading for 2-4 weeks
  - Return to sport gradually. Stop if sx reoccur.
  - Correction of improper technique
  - Use of a dorsiflexion block
  - Severe symptoms-wrist immobilization
  - Long-term complications involve premature fusion of the distal radial physis and radial shortening.

The Female Athlete Triad

- Anorexia
- Amenorrhea
- Osteoporosis

The Female Athlete Triad
Anorexia/Bulimia

- Caloric intake must match energy demands
- Restriction of food intake of less than 1200k/cal/day is criteria for Anorexia Athletica
- Calcium intake of 1200-1500mg/day and 400 IU of Vitamin D required for adolescent each day.
  - Peak bone mass is determined by age 17-20 in the adolescent female
- Weight loss greater than 5% of expected body weight
The Female Athlete Triad

Amenorrhea

- Primary Amenorrhea- Absence of menses until the age of 16.
- Secondary- Absence/light menses for greater than 6 months following the onset of menstruation.

The Female Athlete Triad

Osteoporosis

- Adolescents achieve 90% of their lifetime bone density by the age of 18.
- Both the loss of bone mass during adolescence or failure to acquire bone mass during adolescence has been implicated as contributing to the cause of osteopenia and osteoporosis in the juvenile and adult.

Heat Related Illness in Young Athletes

Morphologic and Physiologic differences between adults and children place them at greater risk for heat related illnesses.

- Higher metabolic rates-capable of producing more heat per body mass than adults
- Larger external surface area to body mass ratio than adults.
- Lower sweating capacity than adults
Heat Related Illness in Young Athletes

Heat Cramps
Cause: Usually related to excessive water and electrolyte loss
Symptoms: Muscle twitching and cramps in the large, heavily worked muscle groups, such as the arms, legs, abdomen.
Treatment: Rest, ice massage, mild stretching, replacement of electrolytes.

Heat Related Illness in Young Athletes

Heat Edema
Cause: Poor acclimatization to heat
Symptoms: Swelling of the extremities
Treatment: Elevation and acclimatization

Heat Related Illness in Young Athletes

Heat Syncope
• Cause: Long term exposure to heat and vasodilation of superficial vessels, hypotension or pooling of blood in the extremities
• Symptoms: Same mechanism as heat edema but peripheral vasodilation is severe enough to cause dizziness, nausea and fainting.
• Treatment: Hydration, removal from hot environment and rest. Elevation of LE's may prevent LOC if caught early enough.
Heat Related Illness in Young Athletes

Heat Exhaustion
- Cause: Prolonged sweating leading to dehydration and inability to sustain cardiac output.
- Symptoms: Excessive thirst, weight loss, fatigue, weakness, incoordination, mental dullness, low urine volume, darkened urine.
- Treatment: Bed rest in cool room, IV fluids if unable to take orally, cool the athlete. Restore to normal body weight with fluid intake.

Exertional Heat Stroke
- Cause: Sudden onset failure of thermoregulatory system.
- Symptoms: Abrupt onset of CNS abnormalities. Rapid rise in CBT (104). Athlete feels as though they are burning up. No longer sweating.
- Treatment: Immediate emergency measures to cool the athlete. Ice immersion, cool water mist with fan over body, massage limbs. To ER ASAP.

Prevention of Heat Related Illness
- Identify at-risk athletes (PPE)
- Modify activity accordingly
- Athlete/Parent/Coaching education-early signs
- Cool/Flavored Liquids-mandatory water breaks
- Awareness of recent febrile, respiratory or GI illnesses
- Gradual Acclimatization-10 days to 2 weeks
Prehabilitation

• Identify areas of concern prior to injury
• Address training errors aimed at correcting correctable musculoskeletal malalignments that may lead to injury.
• Emphasis on technique and form.
• Mandatory coaching education.
• Parental education
• Less emphasis on early specificity in sport and more emphasis on development of a solid athletic foundation

Thank You

Learn More

- American Sports Medicine Institute (ASMI)
  www.asmi.org
- American Orthopedic Society for Sports Medicine (AOSSM) and its partners have started a youth injury prevention site.
  www.STOPSportInjuries.org
- Little League Pitch Count Rules can be found at
  www.LittleLeague.org/media/pitch_count_publication.pdf
  or www.asmi.org/youth/pitchcount/2001YOUTH.pdf
- National Athletic Trainers' Association (NATA)
  www.nata.org
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