Pediatric Sports Medicine: Growth & Development

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The Scope

- Increasing numbers of children active in organized sports programs in the US
  - 30 million
- As these numbers increase, so has the number of sports-related injuries
  - 2.6 million emergency dept visits/yr
  - $1.8 billion /yr
There are also more sports...

- **“Classic” sports**
  - Football, basketball, soccer

- **Newer sports**
  - Lacrosse, skateboarding

- **Recreational activities**
  - Bicycling, playground, hiking and climbing
...and there are more girls playing sports!

- Adolescent girls are the fastest growing segment of kids participating in organized sports.
- Title IX -1972
  - From 300,000 high school female athletes in 1972 to 2.4 million in 2000.
Benefits of sports

- Goal setting
- Success and failure
- Positive correlation with academic performance
- Decreased risky behaviors
- Teaches importance of PA for a lifetime
- Disease prevention
Why do kids play sports?

1. Having fun
2. Improving skills
3. Develop fitness/exercise
4. Being with my friends
5. Experiencing thrills and excitement
6. Being on a team
7. Opportunities for personal accomplishment
8. Staying in shape
9. Doing something I’m good at
10. Winning

Ewing & Seafeldt, 1996
Why do kids quit sports?

1. Not having fun
2. Too much pressure from parents and peers
3. Too much emphasis on winning
4. Concerns about coaching
5. Not getting enough playing time

By age 15, 75% of kids in organized sports have dropped out…

Ewing & Seafeldt, 1996
Sport Readiness

- Children engage in “play” from early infancy
- Developmental limitations exist in 5-6 year olds
  - “Beehive soccer”
  - Coaching at this age limited
- Most understand “rules” by age 6
Sport Readiness

- Sports can build self-esteem and confidence
  - Can backfire if not physically ready
  - Expose kids to a wide variety of activities early on
- Motor skill development should match demands of the activity
- Children reach readiness at different times
Sport Readiness

- Age 4 – Only 20-30% of kids proficient in throwing and catching.
- Fundamental skills not acquired until early elementary school
  - Throwing, catching, kicking, running, jumping, hopping, skipping and striking
- Before age 6, most not ready for organized sports
Age appropriate activities

- Early Childhood – (2-5 years)
  - Focus on fundamental skills
  - Poor vision and balance
  - Emphasize fun
  - Limit instruction
  - Avoid competition
  - Running, swimming, tumbling, throwing, catching
Age appropriate activities

Middle Childhood – (6-9 years)
- Begin to master transitional skills = combining fundamental skills
- Visual system almost mature
- Short attention span
- Difficulties with direction of moving objects
- Best to do sports with few variables
- Minimal competition
- Entry-level soccer, baseball, tennis, gymnastics
Age appropriate activities

Late Childhood – (10-12 years)
- Understand strategies of sport
- Visual system mature
- Ready for more complex sports
- Still focus on skill development
- Pubertal growth spurt can cause temporary decline in coordination
- Large variation in size/ability at this stage
- Entry-level FB, basketball, hockey, volleyball
Early Sport Specialization

- Not recommended for most
- Limit hours per week to less than years old
- Results in overuse injuries and burnout
- Limits motor skill development
- Need to assess physical, developmental and emotional maturity to handle such

Gender Differences

- Sex-based differences in aerobic capacity and muscle strength don’t occur until puberty.
- Young boys and girls can safely participate in co-ed sports.
- After puberty, most opt for single-gender sports.
Tanner Staging

- Tanner I = Pre-pubescence
- Tanner II = Early puberty
- Tanner III = Mid-puberty
- Tanner IV = Late puberty
- Tanner V = Adult
95% of children enter early puberty and progress to developmental adulthood within 4 years.

- Girls progress between 8-14
- Boys progress between 10-15
Peak height and weight velocity

- **Girls**
  - Age 8-14
  - Peaks at Tanner stage III
  - Adult stature average at 17.3
  - Weight lags behind by ~6 mos

- **Boys**
  - Age 10-15
  - Peak at Tanner III-IV
  - Often a late growth spurt
  - Adult stature at 21.2
  - Weight follows height
Body composition

**Girls**
- Gain fat mass faster than boys during puberty
- End of puberty, most have 2x the % of body fat as boys
- Fat mass ~ 20-25%
- Gradual increase in muscle mass

**Boys**
- Muscle strength accelerates during puberty
- Fat mass ~ 12-16%
Aerobic and Anaerobic capacity

**Aerobic**
- Increases during puberty
- Increases in VO2 max strongly related to physical maturity
- Visceral and muscular growth have greatest impact

**Anaerobic**
- Increases more gradually
- Difficult to measure
Weightlifting/Strength Training

- Supervise for correct technique
- Correct equipment size and adjustment
- Low weight, high reps
- Good starting point for obese adolescents
- + strength gains, but not muscle bulk
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Aerobic Capacity</td>
<td>Less</td>
</tr>
<tr>
<td>Anaerobic Capacity</td>
<td>Less</td>
</tr>
<tr>
<td>Percent Body Fat</td>
<td>Less</td>
</tr>
<tr>
<td>Strength</td>
<td>Less</td>
</tr>
<tr>
<td>Hemoglobin/Hematocrit</td>
<td>Less</td>
</tr>
<tr>
<td>Thermoregulation</td>
<td>Less effective</td>
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</tbody>
</table>

Adapted from S. Hecht
Pediatric Thermoregulation

- Children more susceptible to issues
- Due to a larger body surface area to body mass ratio than adults
- Higher heat production per kg body weight
- Sweat rate is lower in children
- Dehydration exacerbates temperature rise more in children
Pediatric Concussions

- Brain takes longer to recover
- More difficult to discern symptoms
- Academic issues often persist
- New guidelines include pediatric SCAT
Children and Risk of Injury in Sport

- Motor skills and performance not fully developed
- Improper fit or lack of protective equipment
- Greater surface area to body mass ratio
- Disproportionately larger heads
- Growth plates susceptible to injury
Epidemiology of Pediatric Sports Injuries

- Bicycling has highest percentage of injury in kids
- Upper extremity fractures more common

- Children ages 0-21 (NHIS)
  - Males:Females 2:1
  - Injury rate 25/100

- High school sports (NAIRS)
  - Injury incidence 27-39%
    - American football (boys)
    - Soccer (girls)
  - Overuse > acute
  - 65% minor (0 days lost), 30% mild (1-7 days lost)
Epidemiology of Pediatric Sports Injuries

- Top 5 Areas most frequently injured:
  - Ankle and knee
  - Hand
  - Wrist
  - Elbow
  - Shin
Epidemiology of Pediatric Sports Injuries

- 66%-90% of fractures involve upper limbs
- Most common fracture locations:
  - Distal radius
  - Hand
  - Elbow
  - Clavicle
Epidemiology of Pediatric Sports Injuries

- 75% of injuries to muscles and bone in children 5-14 years old:
  - Bicycle riding
  - Basketball
  - Football
  - Roller sports
Musculoskeletal Issues in Children

- Salter Harris Fractures
- Apophyseal/Epiphyseal Fractures
- Apophysitis/Epiphysitis
- Osteochondritis Dessicans
- Osteonecrosis
Pediatric Orthopedics 101

Radiologic Pearls:
- Growth plates can mimic fractures
- Get comparison views
- Ossification centers
  - Present at birth – Distal femur, proximal tibia, calcaneus and talus
  - Elbow’s capitellum ossifies starting at age 1, add 2 years for each successive ossification center using eponym CRITOE
  - Medial clavicular ossification center is last to appear (~age 17) and last to fuse (~age age 25)
Pediatric Ortho 101

- Long bones
- Diaphysis = Shaft
  - Can bend through plastic deformation
  - Fracture through one end = Greenstick
  - Complete fracture
- Metaphysis = Flared end, cortex is thin in children
  - Axial load can cause buckle or torus fracture
- Epiphysis = Contributes to long bone formation & joint surface
  - Injury can impair bone growth and cause arthritis
**Pediatric Bones**

- Periosteum is thick
- Bows rather than fractures
- Results in faster healing
  - Greenstick fracture
  - Torus/buckle
Pediatric Bones

- During puberty, large increase in peak bone mineral density (BMD)
- Pubertal growth spurt occurs in girls 2 years earlier than boys
  - Tanner stages II-III: beginning of growth
  - Tanner stages III-IV: beginning of menarche
  - Tanner stage V: closure of epiphyses and apophyses
Pediatric Bones

Physis = Cartilaginous growth plate
- Weakest structure in growing skeleton

Apophysis = Growth center that serves as the attachment for a major tendon group
- Because apophysis does not contribute to long bone growth or joint formation, these injuries do not risk growth disturbance
Epiphyses vs. Apophyses?

- Each is a cartilaginous ossification center responsible for the growth of bone.
- Epiphyses are located at the ends of bones.
  - In children, the shaft of the bone and the epiphysis is separated by an epiphyseal cartilage or plate.
  - The epiphyseal cartilage provides the means for the bone to increase in length.
  - More vulnerable to injury.
Epiphyses vs. Apophyses?

- Apophyses are found at attachments of muscles
  - Adds to contour and shape of the bone
  - Allows tendon and muscle attachments to keep up with growth.
- BOTH can be affected by "osteochondrosis", a disease affecting the progress of bone growth
  - Leads to destruction and altered architecture of bones
  - Some type of trauma is needed to begin this process, such as repetitious activity
  - In adolescents, this is referred to as apophysitis, where the trauma is occurring at the tendon or ligament insertion into a bone.
<table>
<thead>
<tr>
<th>Apophysis</th>
<th>Associated Muscle</th>
<th>Age at Appearance of Apophysis (yrs)</th>
<th>Age at Fusion of Apophysis (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant Superior Iliac Spine</td>
<td>Sartorius</td>
<td>13-15</td>
<td>16-18</td>
</tr>
<tr>
<td>Anterior Inferior Iliac Spine</td>
<td>Quadriceps</td>
<td>13-15</td>
<td>16-18</td>
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<tr>
<td>Iliac Crest</td>
<td>Obliques, IT band</td>
<td>13-15</td>
<td>21-25</td>
</tr>
<tr>
<td>Ischium</td>
<td>Hamstrings</td>
<td>13-15</td>
<td>20-22</td>
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<tr>
<td>Tibial Tubercle</td>
<td>Patellar tendon</td>
<td>12-13</td>
<td>15-17</td>
</tr>
<tr>
<td>Calcaneus</td>
<td>Achilles tendon, plantar fascia</td>
<td>7-9</td>
<td>12-14</td>
</tr>
<tr>
<td>Fifth Metatarsal</td>
<td>Peroneal brevis</td>
<td>7-9</td>
<td>12-14</td>
</tr>
<tr>
<td>Medial Epicondyle</td>
<td>Common flexor tendon</td>
<td>8-10</td>
<td>13-15</td>
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Adopted from the Care of the Young Athlete,
Salter-Harris Fractures

- I = Through the physis (Sublux)
- II = Through physis and metaphysis (Above)
- III = Through physis and epiphysis (Lower)
- IV = Through metaphysis and epiphysis (Through)
- V = Crush injury to physis

- I and V hardest to see on x-ray
- Need to monitor growth
- Risk increases with increasing number
- Degree of deformity and amt of remaining growth also need to be considered
“SALT-R”

The Salter-Harris Classification of Growth Plate Injuries
Osteochondritis Dessicans

- Developmental, or sometimes traumatic, condition where blood supply is diminished to a portion of the articular surface of growing joint
- Tends to occur during periods of rapid bony growth
- Can have features of both an acute injury and overuse injury
OCD Lesions

- Patella and Femoral Condyle usually without history of overuse
  - 75% of lesions occur in the knee
  - 85% of knee lesions affect the medial femoral condyle
- Notch view on x-ray to demonstrate lesion (bent knee)
OCD lesions

- Capitellum and Talus usually occur with repetitive trauma (pitching, handsprings)
  - Capitellum age 11-16
  - Lateral elbow pain from chronic compression
  - Talus is ankle sprain that doesn’t get better
OCD Lesions

- MRI to grade lesion
- Grades I-IV
- Grades I-II stable
- Grades III and IV unstable
- Unstable lesions referred to ortho

- Stable lesions are to modify activity and rest from sport for 6-8 weeks
- PT to maintain strength
- Goal is Pain-free ADLs
- Follow at 3 month intervals
Osteonecrosis

- Often a missed diagnosis
- Avascular necrosis
- Kohler’s Disease- Navicular bone, ages 6-9
- Panner’s Disease- Capitellum, ages 5-11
Other Cartilage Injuries

- **Freiberg's Infarction**
  - second metatarsal most commonly affected
  - girls 13 years and older

- **Kienbock’s Disease**
  - trauma can disrupt blood flow to lunate
  - Young adults ages 15 and up
Prevention

- Limit the volume and intensity of training and competition for young athletes
- Discourage specialization in a single sport at an early age
- Ensure high quality coaching and adult leadership
- Remember that sports should be FUN!
References

- Harris SS, Anderson SJ, eds. Care of the Young Athlete, 2nd ed. AAP. 2010.
Thank you!