Exercise Issues in the Pediatric and Adolescent Female Athlete

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- Residency in PM&R at Spaulding/Harvard
- Fellowship trained in Pediatric Sports Medicine at Children’s Hospital – Boston/Harvard Medical School

Overview

- Epidemiology – Youth Sports
- Considerations in the Pediatric Athlete
  - Anatomy
  - Overuse Injuries
  - Female Athlete Triad
  - Spondyloysis
  - ACL*

Epidemiology – Youth Sports

- 30-45 million children participate in organized athletic programs each year in the US (2007)
- ~3 million pediatric sports injuries occur each year
- In 2013, 1.24 million children (19 y/o and under) were seen in an ER for a sport-related injury – that’s 3,397/day, and that’s 1 injury every 25 seconds
- ~10 million will have a sport related injury requiring medical attention before they are 18
- Annual cost estimated to be ~1.8 billion
Epidemiology – Youth Sports

- Peak age of injury is between 5-14 years of age
- Sports with the highest injury rates include:
  - Football
  - Soccer
  - Basketball
  - Cheerleading
- Injuries are more common in games than practices (about 3:1)
- Title IX

Considerations in the Pediatric Athlete

- Children are NOT ‘little adults’
- They may suffer some of the same injuries as adults, but physiological and biomechanical differences:
  - Make them more vulnerable to injury
  - Predispose them to additional injuries that are NOT seen in the adult population

Considerations in the Pediatric Athlete

- Certain injuries tend to be more common in certain sports
  - Gymnastics – back, wrist and elbow
  - Long distance running – shin, foot
  - Softball – shoulder and elbow
  - Soccer – knee, ankle and concussion
- Two major categories of injury
  - 1) Overuse Injuries
  - 2) Traumatic Injuries
- Overuse injuries are more common than acute traumatic injuries

Considerations in the Pediatric Athlete

- Various factors put pediatric athletes at risk for certain injuries:
  - Poor coordination
  - Open growth plates
  - Tightness secondary to growth spurts – bones grow faster than muscles and tendons
  - Growing cartilage may be more vulnerable to stresses
  - Incorrect form during athletics
  - Improper fitting equipment
Considerations in the Pediatric Athlete

- Adolescent growth spurt
  - Girls – start ~10-11, peak ~12, stop ~15-16
  - Boys – start ~12-13, peak ~14, stop ~19
- Most common types of injuries:
  - Young athletes: contusions and strains
  - Early adolescence: apophysitis

Anatomy

- Growth Plate/Physis – located near the ends of the long bones, are responsible for longitudinal bone growth
- Apophysis – found where major tendons attach to bone, provide contour and shape to growing bones without adding length
  - an example is the tibial tubercle – a bump on the front of the shin just below the knee where the patellar tendon attaches

- Child's x-ray with growth plates
- Adult's x-ray – growth open plates have closed

- Growth plates at both the physis and apophysis are “the weak link in the chain” – weaker than surrounding ligaments, tendons and muscle
- An injury to the physis may cause early closure of the growth plate resulting in that bone being shorter
- An injury to the apophysis will not affect the length of the bone
- “Apophysitis” is inflammation/irritation around the apophysis and near the site of tendon attachment – much more common than classic growth plate injuries
Physeal Injury of Distal Radius
• A young fencer training for the nationals with wrist pain – comparing side to side showed widened growth plate on sore wrist

Traction Apophysitis
• Due to repetitive stress ➔ pain, inflammation
• Akin to “growing pains” and usually improve with rest, gentle stretching
• Some common types of apophysitis include:
  • Osgood-Schlatter’s Apophysitis
  • Sever’s Apophysitis
  • Little League Elbow

Overuse Injuries
• Caused by microtrauma to a bone, muscle or tendon caused by repetitive stress without enough time for healing to occur
• 4 stages:
  • 1) Pain in the affected area AFTER physical activity
  • 2) Pain DURING the activity WITHOUT restricting performance
  • 3) Pain DURING the activity that DOES inhibit performance
  • 4) Pain at REST
• Overuse injuries can occur in adults as well, but the pediatric population is at risk for different injuries because their bones are still growing
• More common during peak growth periods and if there are underlying biomechanical problems [technique or body alignment]

Increased Risk of Overuse Injury With Early Sport Specialization
• Success by athletes like Tiger Woods and Venus and Serena Williams has encouraged many parents to push their children into early specialization
• BUT depending on the sport — 0.2-0.5% of high school athletes ever make it to the professional level
Early Sport Specialization

- Single sport year-round training and competition is becoming more common for children and adolescents
- More pressure to grab a piece of the "professional pie," to obtain a college scholarship, go pro or make the Olympic team
- Research has shown that well-rounded multi-sport athletes have the highest potential to achieve the goal of lifelong fitness
- 70% of young athletes give up on youth sports by age 13 – one of the primary reasons = burnout – too much pressure and not enough fun

Early Sport Specialization and Overuse Injuries

- Not a female athlete, but a good current example that you DON’T HAVE to specialize early to succeed...
- Chris Hogan – WR for NE Patriots
  - High school played both lacrosse and football
  - Decided to play lacrosse at Penn State
  - Missed 2008 season due to ankle injury
  - Graduated in 2010 with 1 year of eligibility remaining
  - Attended Monmouth University 2010-2011 and played football for 1 year – 22 years old
  - Undrafted free agent for the Bills in 2011, then practice squad of Chiefs, Dolphins and Bills
  - Break out year 2015 for Bills
  - 2016 signed for 3 years with Patriots
  - 2017 – franchise record for AFC Championship game with 9 catches for 186 yards and 2 touch downs
  - 2017 – high profile player in Super Bowl

Progression from High School to College and Pro

<table>
<thead>
<tr>
<th></th>
<th>HS BB</th>
<th>HS Basketball</th>
<th>HS Football</th>
<th>HS Soccer</th>
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<tr>
<td># HS</td>
<td>0.00%</td>
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<tr>
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<td>NCAA-8</td>
<td>1.2%</td>
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<td>2.1%</td>
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<th>HS Football</th>
<th>HS Soccer</th>
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<td># drafted from HS</td>
<td>36</td>
<td>60</td>
<td>210</td>
<td>256</td>
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<tr>
<td># drafted from NCAA</td>
<td>33</td>
<td>46</td>
<td>768</td>
<td>46</td>
</tr>
<tr>
<td>NCAA-9</td>
<td>0.3%</td>
<td>1.3%</td>
<td>9.7%</td>
<td>6.6%</td>
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<tr>
<td>NCAA-8</td>
<td>0.2%</td>
<td>0.008 - 0.025</td>
<td>0.15 - 0.25%</td>
<td>0.3 - 0.39%</td>
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</tbody>
</table>

*%HS → NCAA = 0.008% – 0.01% – 0.15% – 0.25% – 0.02% – 0.02%

Study by Timothy McGuine, PhD ATC at PRISM – 1544 students grade 9-12 – injury risk for multisport athletes 12% versus specialized 20%

- However, multisport athletes who do not get sufficient rest between daily activities or if they do not take a break between seasons will still be at risk for overuse injuries
- Additionally, multisport athletes who participate in 2 or more sports that emphasize use of the same body part (eg. Tennis and swimming – both put a high demand on the shoulder) will also be at risk for overuse injuries
Overtreatment – How Much Is Too Much?

- No scientifically determined guidelines
- American Academy of Pediatrics Council on Sports Medicine Recommends:
  1. Limit any sporting activity to a maximum of 5 days per week
  2. Take at least 1 day a week off from all organized sports/athletic activities
  3. Take at least 2-3 months off per year from a particular sport
- Also - 10% rule: do not increase the amount or intensity of training more than 10% per week

Female Athlete Triad

- First widely acknowledged 1997 ACSM and has since evolved so each component of the triad exists on a spectrum
  1. Disordered Eating → Insufficient energy availability (EA)
  2. Amenorrhea → Menstrual dysfunction
  3. Osteoporosis → Decreased bone mineral density (BMD)
- May occur in ANY sport but increased risk in endurance sports, weight class and aesthetic sports that emphasize and reward leanness
- High school estimates: 1% of females overall, 1-16% of female athletes have full triad, 4-18% have 2 components and 16-54% have 1 component
- 2009 study – only 20% of pediatricians could name all 3 components of the triad correctly

Female Athlete Triad – Energy Availability (EA)

- EA = daily dietary energy intake minus daily exercise energy expenditure corrected for fat-free mass (FFM)
- Optimal EA is 45 kcal/kg FFM per day but may be even higher in growing female adolescents
- EA less than 30 kcal/kg → disruption of menstrual function and bone mineralization
- Luteinizing hormone levels are adversely affected after only 3 days of EA < 30 kcal/kg
- 6% of female athletes had an EA < 30 and 39% of female athletes had an EA < 45
- Disordered eating peaks in adolescence when a female’s body is changing most dramatically
- EA deficits may not always reflect disordered eating – eg. a 15 y/o runner who with her training had a requirement of 4700 kcal/day

Female Athlete Triad – Menstrual Dysfunction

- Dysfunction can take many forms:
  1. Primary amenorrhea = no menstrual by 15 y/o or the absence of other signs of sexual development by 14 y/o
  2. Secondary amenorrhea: the absence of periods for 3 consecutive months or longer in a female after menarche
  3. Oligomenorrhea: menstrual cycles longer than 35 days
  4. Others: Luteal phase deficiency and anovulation are asymptomatic
- Menstrual irregularities common in teens – 21% of sedentary female teens and 54% female teen athletes
- In adolescent female athletes primary amenorrhea = 1-6%, secondary amenorrhea = 5-30%, and oligomenorrhea = 5-18%
- Why does this matter? Amenorrheic adolescent athletes have a significantly lower BMD than eumenorrheic adolescent athletes and sedentary controls
- Having normal menstrual cycles b/c athlete is on a birth control pill is NOT protective
**Female Athlete Triad – Bone Mineral Density (BMD)**

- Lower BMD is a risk factor for stress fracture in athletes.
- Energy deficiency and low estrogen → low BMD, but even in the absence of amenorrhea disordered eating and low BMI are strong predictors of low BMD.
- Why does it matter? 90% of peak bone mass occur by 18 y/o, then can gain a little more in 20s, maintain in 30s, sharp drop at menopause, then gradual slow loss.
- BMD measured by DXA scans – ACSM defines:
  - Low BMD as 2 score between -1 and -2.
  - Osteopenia as 2 score < -2.
- Cannot use T score for young patients because they have not reached max bone density.
- Lower bone mass compared to age matched peers.
- Z score useful: BMD is compared to age matched peers instead of T score (DXA score of post-menopausal women compared to healthy females in early 20s).

**Female Athlete Triad**

- Treatment = improving EA – normal menses return and BMD will improve, though may never fully catch up to their genetic potential so early and aggressive treatment is required.
- A gradual increase of 200-600 kcal/day and a reduction in training volume of 1 day per week are usually sufficient to attain appropriate EA and increase weight.
- Resumption of menses may take a year or longer.
- “The carrot works better than the stick”
- Need to emphasize improved performance instead of increased risk of osteoporosis to get most athletes on board with treatment.
- 294 high school cheerleaders 2006-2007, ~20% had menstrual irregularity and 6% had an injury – severe injury rate was higher in those with menstrual dysfunction.

**Female Athlete Triad – Relative Energy Deficiency in Sports**

- Similar condition in male athletes – low EA and low BMI → low testosterone.
- RED-S = Relative Energy Deficiency in Sports.
- RED-S refers to impaired physiological function including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular health caused by relative energy deficiency.

**Spondylylosis**

- There are significant differences in the cause of low back pain in adults versus children and adolescents.
- This leads to frequent misdiagnosis and delay of diagnosis of the true cause of back pain in young athletes.
- Relatively high incidence of a type of stress fracture in the spine called spondylylosis.
Spondylolysis

- Sports and activities that require repetitive hyperextension of the spine put athletes at risk for spondylolysis

- Treatment is controversial - usually bracing for 2-4 months with rest and physical therapy
- Gradual return to sports in brace usually by 6-8 weeks
- Wean out of brace usually ~3-4 months if clinically improved or healing on imaging

- Excessive curving of the low back puts extra stress on the pars interarticularis
- Can have swelling in the bone (stress reaction) that if ignored can develop into a stress fracture
- In some cases → slippage of vertebrae = spondylolisthesis

Spondylolysis

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Adult (&gt;18)</th>
<th>Youth (&lt;18)</th>
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<tbody>
<tr>
<td>Disc Herniation</td>
<td>46%</td>
<td>11%</td>
</tr>
<tr>
<td>Muscle Strain</td>
<td>27%</td>
<td>0%</td>
</tr>
<tr>
<td>Spondylolysis</td>
<td>5%</td>
<td>47%</td>
</tr>
<tr>
<td>Hyperlordosis</td>
<td>0%</td>
<td>26%</td>
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ACL Injuries in the Young Female Athlete

- Mechanism of most ACL injuries is non-contact with deceleration or change of direction, less frequently contact/direct blow
- Female athletes have a higher incidence of ACL injuries than their male counterparts
- Why? Risk factors are believed to include:
  - Having a smaller intercondylar notch width
  - Being in the pre-ovulatory phase of the menstrual cycle
  - Increased knee abduction moment (valgus torque) during impact on landing
- Data also revealed an even greater difference in male vs. female ACL injury in basketball in the 14-18 y/o age group with female injury rate 4x higher than males

<table>
<thead>
<tr>
<th>Sport</th>
<th>Injury Rate/1000 Athlete Exposures</th>
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<tbody>
<tr>
<td>Men's Basketball</td>
<td>0.07</td>
</tr>
<tr>
<td>Men's Soccer</td>
<td>0.09</td>
</tr>
<tr>
<td>Men's Lacrosse</td>
<td>0.12</td>
</tr>
<tr>
<td>Women's Lacrosse</td>
<td>0.17</td>
</tr>
<tr>
<td>Women's Basketball</td>
<td>0.23 (4x male)</td>
</tr>
<tr>
<td>Women's Soccer</td>
<td>0.28 (4x male)</td>
</tr>
<tr>
<td>American Football</td>
<td>*0.18</td>
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*American Football* data from 1988-89 – 2003/04

NCAA data over 16 years – 1988/89 – 2003/04

ACL Injuries in the Young Female Athlete
ACL Injuries in the Young Female Athlete

- Prevention programs have been proven to work - typically attempt to alter dynamic loading of the tibiofemoral joint through neuromuscular and proprioceptive training.
- For successful outcomes need minimum of 2-3x/week for 10-15 minutes.
- Sugimoto et al - BISM 2012 - Neuromuscular training program to relative risk reduction of about 73% for non-contact ACL injuries and 43% for overall ACL injuries in female athletes.
- Same study - number needed to treat to prevent one non-contact ACL injury was 158 and for overall ACL injuries number needed to treat was 12.
- Unfortunately improvements in movement quality after 12 weeks of training do not appear to be retained after the preventative training program ends.

References


Early Starts

- Michael Phelps — began swimming at age 7, qualified for the Olympics at 15 yrs (didn’t medal that time) but also signed an endorsement deal with Speedo that year.
Early Starts

• Andre Agassi – father gave him a racquet as a toddler, made him practice several hours everyday at a very young age, dropped out of school in the 9th grade and turned pro at 16 years of age.

Smart Choices

• When he was younger – Roger Federer loved both soccer and tennis, but decided to focus solely on tennis at the age of 12 – although he still is a soccer fan!

Smart Choices

• At the age of 12, Rafael Nadal was a top youth soccer player and tennis player – his father didn’t want sports taking up so much time that his grades suffered, so he made Rafa pick one sport... Rafa chose tennis...

Late Bloomers

• Michael Jordan – three sport athlete – baseball (true love), basketball and football – “Mr. Baseball” by his youth baseball league at 12 1/2, didn’t take basketball seriously until he was cut from the varsity team in 10th grade (around 14-15 y/o)
Late Bloomers

* Tim Duncan – was a swimmer, didn't begin playing basketball until 5th grade