Exercise Issues in the Pediatric and Adolescent Female Athlete



Sarah R. Gibson, MD
Pediatric Sports Medicine – Nemours Children's Hospital

2017 13th Annual Cutting Edge Concepts in Orthopaedics & Sports Medicine

Sarah R Gibson, MD

- Specialize in non-operative treatment of sports related injuries in patients of all ages
- Residency in PM&R at Spaulding/Harvard
- Fellowship trained in Pediatric Sports Medicine at Children's Hospital – Boston/Harvard Medical School

Nemours.

Overview

- Epidemiology – Youth Sports
- Considerations in the Pediatric Athlete
  - Anatomy
- Overuse Injuries
- Female Athlete Triad
- Spondylolysis
- 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

- Child's x-ray with growth plates

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

Anatomy

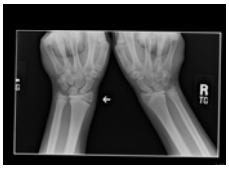
- Growth Plate/Physis – located near the ends of the long bones, are responsible for longitudinal bone growth
- Apophysis – found where major tendons attach to bone, provide contour and shape to growing bones without adding length
  - an example is the tibial tubercle – a bump on the front of the shin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

Anatomy

- 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 inlcude:
- 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

Progression from High School to College and Pro

	W Basketball	M Basketball	Baseball	M Hockey	Football	M Soccer
# HS	429,504	541,479	486,567	35,875	1,083,617	432,569
# NCAA	16,589	18,697	34,198	4,071	72,788	24,477
%HS →NCAA	3.9 %	3.5%	7%	11.3%	6.7%	5.7%
%HS → NCAA DI	1.2%	1.0%	2.1%	4.6%	2.6%	1.3%

	W Basketball	M Basketball	Baseball	M Hockey	Football	M Soccer
# drafted	36	60	1,215	210	256	75
# drafted from NCAA	33	46	738	60	256	75
%NCAA → pro	0.9%	1.1%	9.7%	6.6%	1.6%	1.4%
*%HS → pro	0.008%	0.008 - 0.01%	0.15 – 0.25%	0.2 – 0.59%	0.02%	0.02%

Early Sport Specialization

- 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 eligability remaining
  - Attended Monmouth University 2010-2011 and played football for 1 year – 22 years old
  - Undrafted free agent for the 49ers in 2011, then practice squad of Giants, 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 180 yards and 2 touch downs
  - 2017 – high profile player in Super Bowl

Early Sport Specialization and Overuse Injuries

- 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

Overtraining – 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

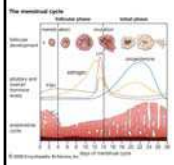
Female Athlete Triad

- First widely acknowledged 1997 ACSM and has since evolved so that 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 5 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:
  - Primary amenorrhea: no menarche by 15 y/o or the absence of other signs of pubertal development by 14 y/o
  - Secondary amenorrhea: the absence of menses for 3 consecutive months or longer in a female after menarche
  - Oligomenorrhea: menstrual cycles longer than 35 days
  - 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 occurs by 18 y/o, then can gain a little more in 20's, maintain in 30's, sharp drop at menopause, then gradual slow loss
- BMD measured by DXA scans – ACSM defines:
  - Low BMD as Z score between -1 and -2
  - Osteoporosis as Z score < -2
- Cannot use T score for young patients because they have not reached max bone density and all would look low
- Z score used b/c BMD is compared to age matched peers instead of T score (DXA scores 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 63% 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
- 'Relative Energy Deficiency in Sport' (RED-S), points to the complexity involved and the fact that male athletes are also affected
- The syndrome of 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.

Spondylolysis

- 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 spondylolysis

Spondylolysis

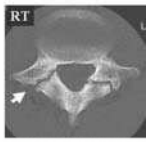
Diagnosis	Adult (>18)	Youth (<18)
Disc Herniation	48%	11%
Muscle Strain	27%	0%
Spondylolysis	5%	47%
Hyperlordosis	0%	26%

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

Spondylolysis

- 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



- 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

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

Sport	Injury Rate/1000 Athletic Exposures
Men's Basketball	0.07
Men's Soccer	0.09
Men's Lacrosse	0.12
Women's Lacrosse	0.17
Women's Basketball	0.23 (>3x male)
Women's Soccer	0.28 (>3x male)
* American Football*	0.18

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

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 – BJSM 2012 – Neuromuscular training program → 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 108 and for overall ACL injuries number needed to treat was 120
- Unfortunately improvements in movement quality after 12 weeks of training do not appear to be retained after the preventative training programs end

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Early Starts

- Michael Phelps – began swimming at age 7, qualified for the Olympics at 15 y/o (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

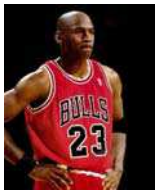
Smart Choices

- 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 y/o, 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 9th grade