Can we prevent and manage tendon injuries in young athletes?

**Jill Cook**
Defining tendon injury in children and adolescents

• There are a lot of problems here!
• Are we talking apophysis or tendon?
• Are we talking pain or pathology?
• Are we considering biological or chronological age?
• They come with a lot of strange names
• European men from long ago
• Messieurs
• Sever
• Osgood
• Schlatter
• Sinding-Larsen
• Johannson

There are a lot of problems here!

• What age does pathology and/or pain first present?
• This is our first problem
• Relationship between pain and pathology is not strong
• Our second problem is diagnosis
• Variety of diagnostic criteria
• Imaging, reported pain, pain on examination
• Offer up pain on holding in a diagnosis
• Any diagnostic criteria for tendon pain?
• Load related pain, local pain
• Classic ‘imaging and palpation’ diagnosis
• Interesting that the pain is local in tendinopathy

Do you get only apophyseal injuries or do you get tendon injuries?

• How good are our diagnostic criteria?
• What are our diagnostic criteria?
• Did you know that the only criteria for the diagnosis of Sever’s is pain on squeezing the calcaneus?
• There are no objective imaging or pain criteria
• Define apophyseal injury
• Pain?
• Structural change?
• Long term structural change?
Slide 7

What is apophysitis?

- What is the structure of the apophysis?
  - Area of hyaline cartilage that hypertrophies and then ossifies with maturation
  - Footprint is large
  - Muscles exert force on the apophysis
  - Area of insertion
  - Source of pain

- How do tendons develop?
  - Linked to normal bone and muscle growth
  - Affected by congenital diseases
  - Normal forces placed on the skeleton
  - Affected by activity
  - Will reach a lower threshold
  - Positive effect of exercise
  - Can be limb dependent

Slide 8

What is the pathology of apophyseal injuries?

- Where does it occur?
- What pathology exists?
- Does it affect the tendon itself?
- What happens in apophysitis?
  - Muscular forces tractioning the fibrocartilage away from the bone
  - Source of pain unknown
  - Fat pad, bursa and tendon implicated
  - Associated with vascularity (Sailly)
  - Increased pain, overuse, overuse
  - Presence of inflammation not confirmed

- Why is this unknown?
  - Getting tissue
  - Comparative animal models
  - Limited capacity of imaging
  - Relationship to pain
  - The self-limiting aspect of the condition constrains research

Slide 9

Where do apophyseal injuries occur?

- Everywhere!
  - Prevalent
  - Tibial tuberosity
  - Calcaneus
  - Less prevalent
  - Feet, elbows, pelvis
  - Rare
  - Shoulders, hands
  - Prevalent but not considered
  - Spine, Scheurrmans disease

- 4% in adult population
  - Makurthou et al 2013
Slide 10

Which ones are problematic?

- Not/rarely
- Sever's, OIS
- Sometimes
  - If large/strong muscle attachment
  - Pes due to large separation
  - If under repetitive load
- Often
  - Medial elbow
- ?

Slide 11

Controversial apophyseal injuries

- Sinding-Larsen--Johanssen disease
  - Rare
  - There is no apophysis here
  - Likely a form of patellar tendon pathology
    - The envelope away is high load adolescents

Slide 12

What load causes tendon/apophyseal injury?

- Tensile
  - Maintains fibrous tissue
- Compressive
  - Forms/maintains cartilage
- Friction/shear
- Combination
  - Forms martian bone
Are all tendons the same?

Not at any age and at any level
- Forces and the anatomy vary at the
  insertion and the mid tendon
- The load that are placed on them at different ages
- Patellar tendinopathy does not occur after age 40
- Cannot load the tendon enough
- Achilles tendinopathy rare in adolescents
- Except in high load (usually track and field) athletes

Where does puberty fit?
- Peri-pubertal years
  - Girls enter puberty earlier and grow earlier in puberty
  - Late to puberty, 15-17 years
  - Abnormal in two key areas
    - Tall athletes
    - Late to puberty
  - In higher load sports due to critical age
  - All tendons where menarche is delayed
  - Maturation is delayed in girls
  - Low body weight sports
  - Some apophyses are late to mature
  - Suggestion early to mid 20's in boys

The tendon wants to maintain itself at all costs
- The amount of carbon14 in your Achilles tendon
- Correlates best with your exposure up to the age of 17 years
- Heimeyer et al 2013
That tendon pathology exists in adolescents

- Elite adolescent volleyball players
  - 22 had patellar tendon pathology age 16 starting in an elite program
  - 26 had patellar tendon pathology 3 years later
  - MOST had the condition at 16 years old
  - Gisslen et al

- Elite adolescent basketball players
  - 23% of the participants aged 14–18 years had patellar tendon pathology
  - In adults it was 29%
  - Cook et al

That women have less tendon issues than men

- From adolescence
  - Effect of oestrogen
    - Tendinopathy is more prevalent in post-menopausal women
  - Effect of testosterone
    - Muscle bulk and strength
  - Loading???
    - Volleyball players jumping more
  - Men jumped 11,000 times, women 3000 times
  - Bahr et al

So..........

- Is adolescence a critical time for tendons?
  - You develop 25% of your bone mass in the 2 years pre-puberty
  - Another 25% up to end of puberty
  - Tendon tissue is really similar to bone

- Achilles tendon CSA in people with and without foot pronation
  - Those with pronated foot had thinner Achilles tendon
  - Tendon failure limits push off and therefore develop less tissue mass in adolescence
  - Also had thinner peroneal and tibiceps tendons
  - Murley et al 2014
Is puberty a critical time for tendon maturation?

- How does load and gender affect tendon maturation?
- Tendon size increases throughout puberty
  - More in boys
  - Affected by load
  - Tennis players had bigger tendons than controls
  - Controls had bigger tendons in dominant arm
- Spurrier et al (unpublished)

Osgood-Schlatter Disease

- Higher prevalence in boys
- Age range:
  - 12-15 yrs in boys
  - 8-12 yrs in girls
- Blankstein et al., 2001; Orava et al., 2000

Ultrasound imaging in the diagnosis of OSD

- Ossicles do not always represent sequelae of Osgood-Schlatter disease
  - Bloom et al., 1993
- Ossicles were reported to be a normal stage of development in the Achilles tendon insertion
  - Grechenig et al., 2004; Volpon et al., 2002
- 33 young tennis players imaged over 12 months
Ultrasound Appearance of the PT: 3 Stages of maturation

1. CARTILAGE PHASE
2. ATTACHMENT PHASE
3. MATURE ENTHESIS

Tendon attachment (symptoms) and pubertal status

<table>
<thead>
<tr>
<th></th>
<th>Fibrocartilage phase</th>
<th>Attachment phase</th>
<th>Mature enthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- prepubertal</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>- peripubertal</td>
<td>6</td>
<td>11(2)</td>
<td>2</td>
</tr>
<tr>
<td>- postpubertal</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Girls</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- prepubertal</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>- peripubertal</td>
<td>0</td>
<td>5(1)</td>
<td>3</td>
</tr>
<tr>
<td>- postpubertal</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Comparison of PT appearance in players with/without OSD

12.9 yr old boy
No symptoms

12.8 yr old boy
OSD with onset in October 2005
Slide 25
Comparison of PT appearance in players with/without OSD

14-yr old boy
No symptoms

12.8-yr old boy
OSD with onset in October 2005

Slide 26
Is puberty a critical time for tendon maturation?
• Preliminary findings in the patellar tendon
  • Evidence that tendon pathology develops in the 2 years post PHV
  • Likely load disrupts normal tendon maturation
• What we do know clinically is a tall, young, talented athlete with patellar tendinopathy will do badly
  • Will not unload
  • Multiple high level teams
  • Not seen many good outcomes

Slide 27
What determines if and when apophyseal pain occurs
• Aside from gender and biological age......
  • Load
    • Change in load
      • Can be subtle if high load athlete
      • Change in shoes, terrain
    • Excess load
  • What sort of load?
    • In tendon - energy storage and release
    • In enthesis - compression
    • In apophysitis - sensitive to all load types
Is surgery an option for either condition?

- Major assumptions here
- Structure on imaging is the cause of pain
- Ducher study in OSD would suggest otherwise
- That does not stop interventions to remove ossification and to fix structure

What are the risk factors?

- Demographics
  - Taller, heavier, more pronated, less dorsiflexion
- Clearly excess load
  - Too much high load activity
  - Too heavy a load on the risk system somewhere to cope with it
  - Too much power
  - Excessive loading on one structure
  - Limited dorsiflexion
  - Excess body weight
  - Hypomobility
    - Affected muscle
      - Rectus femoris shortening in OSD

What are the risk factors?

- For all overuse injuries in young people
  - Hypermobility
  - Low strength and resultant biomechanics
  - Low body mass
  - Sport and age of success
    - Early specialisation
    - Early success
    - Playing at multiple levels
Excess body mass

- Is the effect just mechanical?
- In tendons there are systemic factors associated with tendinopathy
  - Systemic inflammation
  - Stress on distant areas
  - May be associated with high carbohydrate diet

What about long term outcomes?

- Lower levels of ability on daily living and sports activities scores
  - Ross and Villard 2003
  - 2 years after OSD incomplete recovery of power and function
  - Kaya et al
  - Scheuermann
  - Long-term back pain
  - Tenoris and Zander
  - Ristolainen et al 2012

- Sever’s QOL
  - Not much agreement between parents and child’s evaluation

What about prevention?

- Evidence is really poor
  - In adult tendons adding eccentric load in season resulted in poorer outcomes
  - Visnes and Fredberg
  - The key clinical factor in onset of pain in both tendons and apophyses is change in load
  - To prevent it maybe avoid load changes
  - How do you do that in children and adolescents?
  - It is childhood!
What about prevention?

- Identify and act on risk factors
  - Boys more than girls
  - Not sure what to do here
  - Key peri-pubertal time
  - What about factors such as dorsiflexion?
  - What about foot posture
  - Orthotics not much use for tendinopathy in adults
  - More important in children and adolescents if they can load more and develop more tendon tissue
  - What about body mass?

Limit exposure to high loads

- Gradual increase with age
- Baseball
  - No. of pitches limited each week
- Cricket
  - No. of balls bowled each week
  - Carried through into elite adults

How do we stick with this?

- Talented adolescents have multiple commitments
- Every team/coach thinks they are the most important

Management of apophyseal pain

- Limited by little research
  - Clinically the condition is self-limiting
  - Research is difficult
  - Case series
  - Few controlled trials
  - Single interventions such as corticosteroids
  - Muscle imbalance
  - Socioeconomic (poorer shoes) or psychological (fear of movement)
**Slide 37**

### Management of apophyseal pain

- Decrease load
  - Symptom-free
- Do not completely rest
- Improve strength and power
  - Re-function
- Any adjuncts that help

### Sever’s
-RCT 2x2 footwear and orthotics
- 12 month follow-up
- In 2 months heel raises helped
- At 12 months children and parents reported
  - Better outcome with athletic shoes at 12 months (parent)
  - Better outcome with usual footwear (child)

**Slide 38**

### Management of tendinopathy

- Correct diagnosis
  - Tendinopathy can occur in children and adolescents
  - High level sports
    - Gymnastics, squash
  - Seen total rupture in a 17 year old
  - Tendon must be completely degenerative to rupture
  - Prevalent in the patellar tendon
    - Degenerative tendons by 10 in young highly loaded athletes

**Slide 39**

### Summary

- We are a long way from understanding tendon/apophyseal injuries in young people
- Research is limited and poor quality
- Our management and prevention strategies are therefore based on adult interventions
  - And intuition
  - And clinical reasoning
  - And our preferences