Coaching Prepubertal Gymnasts – Why is it Different

Budapest Feb 2019
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GROWING Tissue Response to Training

- Tissues of growing children **do NOT** respond to training stimuli **the same as adult tissue**
- Boys & girls **differ** significantly around puberty
- **Body size** and **limb proportions** are constantly changing (especially puberty)
- **Physical** and **motor qualities** are constantly changing

GROWING Tissue Response to Training

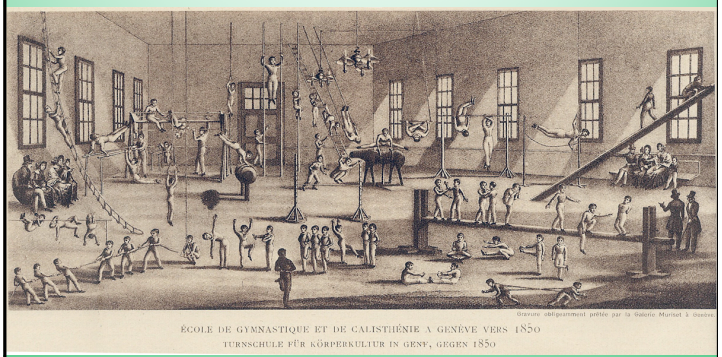
- Growing tissues are more **vulnerable to injury**
- Some injuries are **specific** and **unique** to growing tissues
- Coaches who do NOT understand growth **can cause serious injuries to gymnasts**
- Understanding growth greatly facilitates **planning, and can optimize training**

Why do we coach very young children

At very high volumes of training

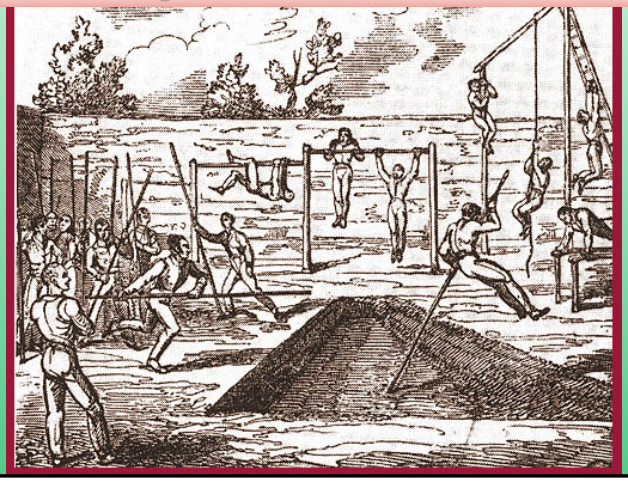
What WAS Gymnastics in the past ?

Physical Development

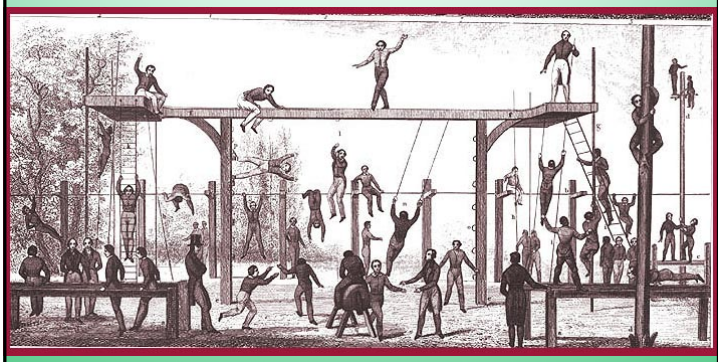


ÉCOLE DE GYMNASTIQUE ET DE CALISTHÉNIE A GENÈVE VERS 1850
TURNSCHULE FÜR KÖRPERKULTUR IN GENF, GEGEN 1850

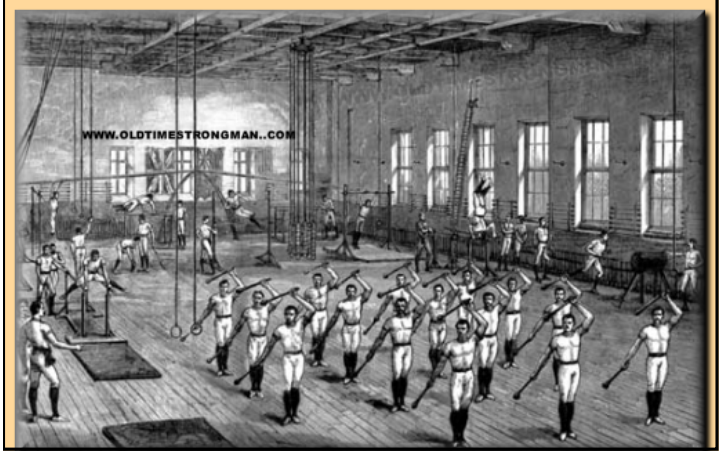
Physical Excellence



Skill, confidence, courage

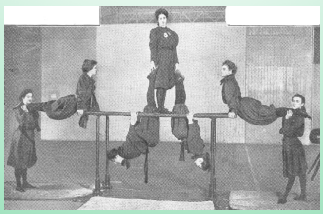


Well developed bodies

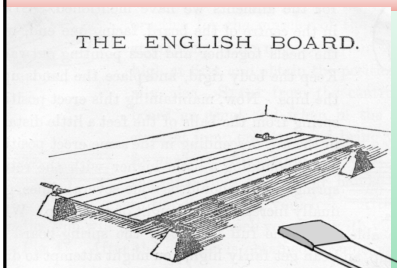


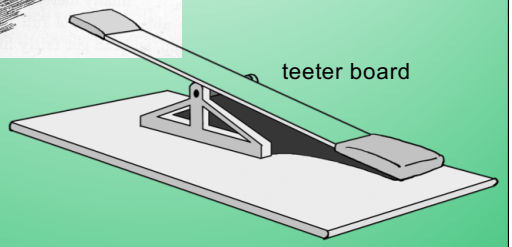
Uniformity, poise, fitness

Balance, strength, health



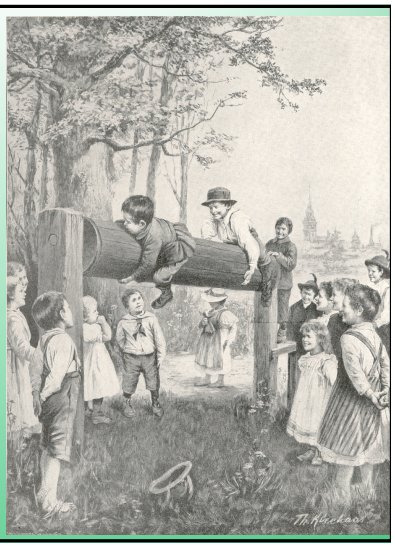
Aerial Skills

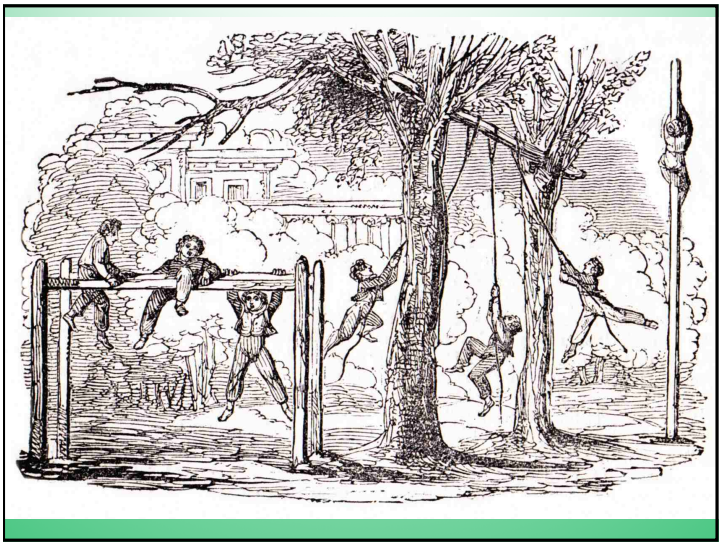




Gymnastics was the ultimate in physical perfection & beauty.

Children were shown in play situations, not in competitive sport





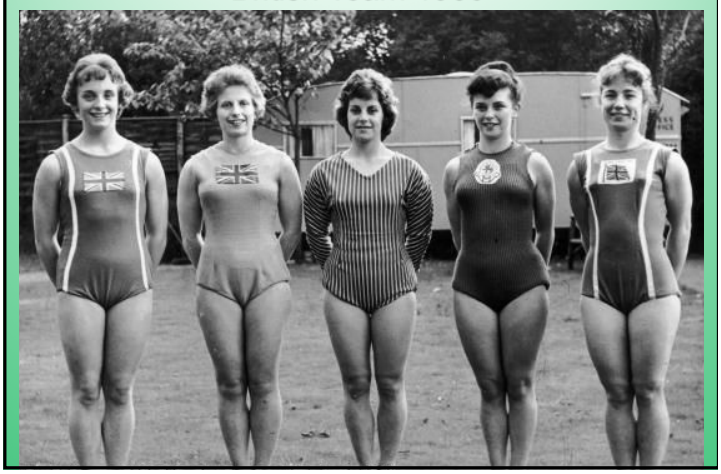
The Arrival of Gymnastics Sports

- Formation of International Federations
- Formalized competitions
  - Various Int'l Gymnastics Federations
- Rule books
- Judges education
- Compulsory Routines
- Convergence of Federations

The Olympic events were designed to develop the natural ALL AROUND ATHLETE

BEFORE

BEFORE
British Team 1960



Russian team - 2010

What changed ?

Gymnastics changed !

Gymnastics changed…

1. Age has decreased dramatically
2. Training hours increased greatly
3. Training loads increased greatly
4. Skill levels increased dramatically

Gymnastics changed…

Children now doing more & more repetitions

of fewer & fewer skills.

WAG - convergence of movement patterns. Beam is no longer unique. Females do the same tumbling on beam, floor, vault = overuse injuries.

MAG & WAG - apparatus specialization

So, here we are...

- We coach young children in high performance sport...
- At training volumes and skill levels previously unheard of...
- How can we do this safely?

Educate Educate Educate Legislate

It is probably impossible to turn clock back...
But, there are ways to reduce negative trends:

- Understand growth
- Understand causes of injury

Overview of Physical Growth

First we must understand the difference between:

Chronological Age

Biological Age

- Skeletal (wrist x-ray) - gold stand

female newborn

female 5 years

female 11 years

female 14 years

Which is more skeletally advanced? Why?

A

B

Chronological Age
Biological Age

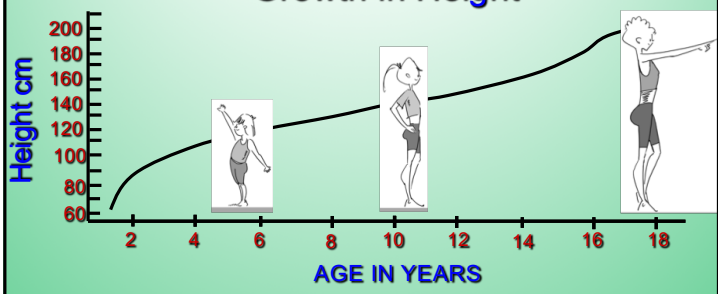
In a typical school class of 8 year olds (grade 3)

There if often a 5 - 6 year variation in maturity (biological age)...

That is, their chronological ages are all 8

But their biological ages are from 6 - 11

Growth in Height

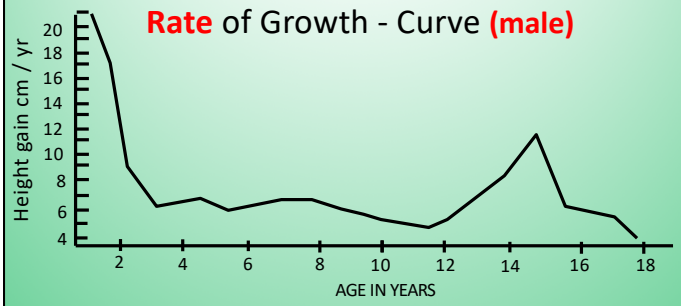


After 2 years, growth is steady until puberty

HEIGHT 5 cm / year

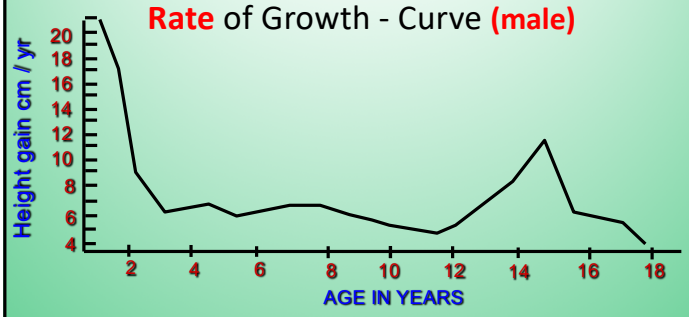
WEIGHT 2.5 kg / year

Rate of Growth - Curve (male)



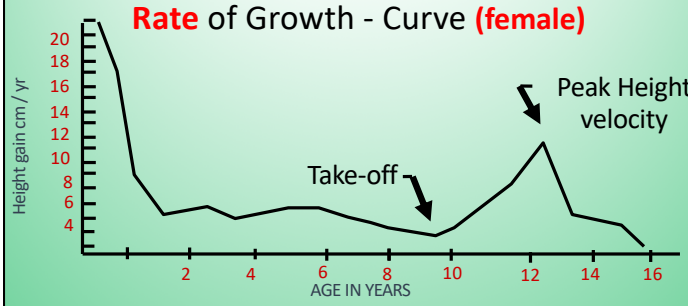
- The above graph shows the **velocity** (rate) of growth from birth to adulthood
- We **grow fastest prenatally**, then growth slows until about 2 years old. It is then **steady** (5 cm per year) until **puberty - where it accelerates dramatically**

Rate of Growth - Curve (male)



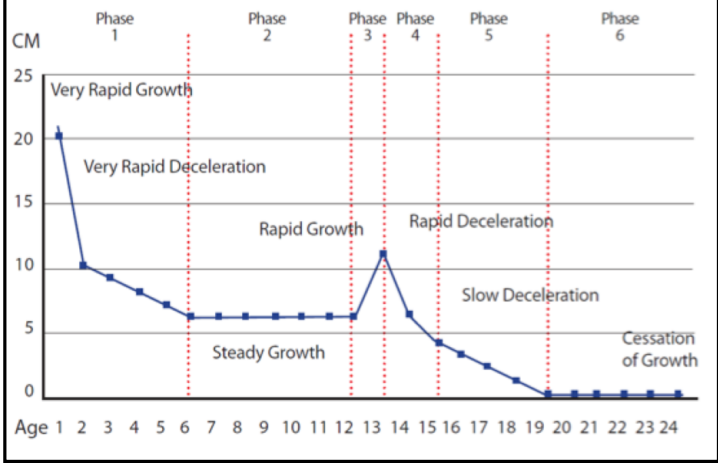
- Every child passes through same stages…
- But the tempo & timing is highly variable
- Approximately 25% of human life is growing

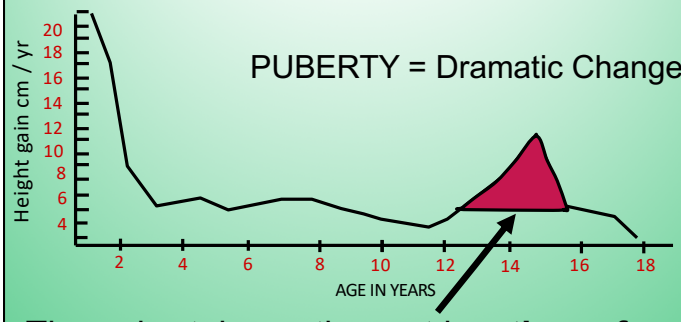
Rate of Growth - Curve (female)



- **Take-off** is when **rapid pubertal growth** begins (**feet** start **first**, then legs, hands, etc.)
- **Peak velocity** is when growth **rate** (in height) is **highest**, after which growth continues - but slows until cessation of growth

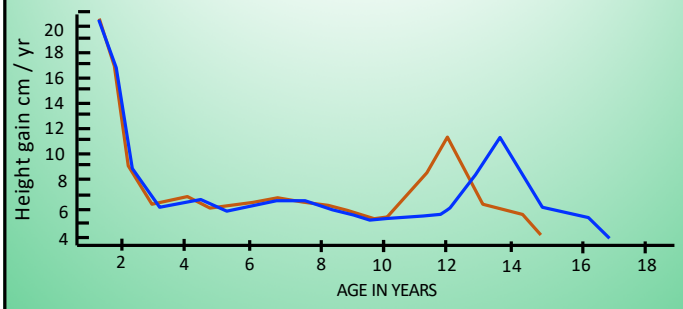
Normal Growth



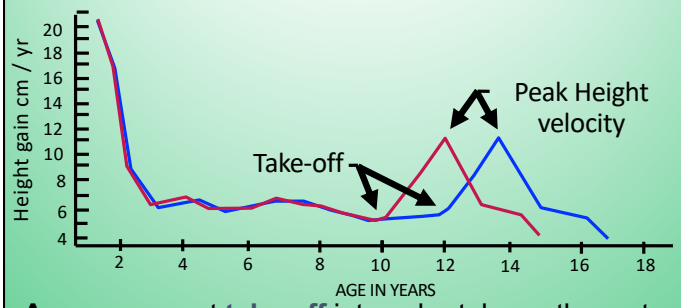


PUBERTY = Dramatic Change

The pubertal growth spurt is a **time of dramatic changes** in gymnasts

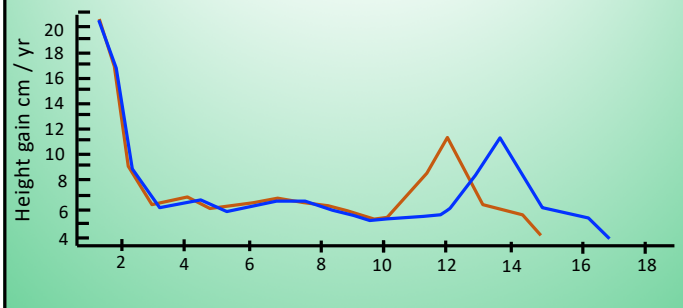


On average, girls are 2 years in advance of boys



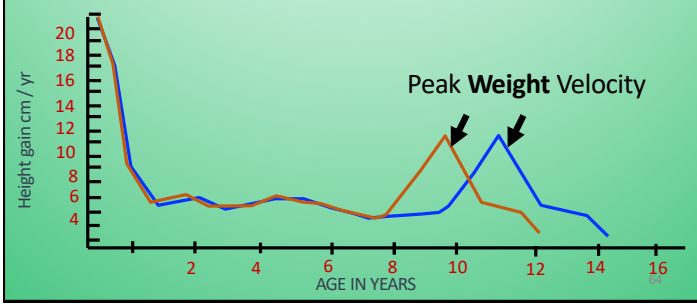
Average age at **take-off** into pubertal growth spurt
- **girls 10 years**
- **boys 12 years**

Average age at **peak height velocity** (PHV)
the time when gymnast is growing at the fastest rate
- **girls 12 years**
- **boys 14 years**



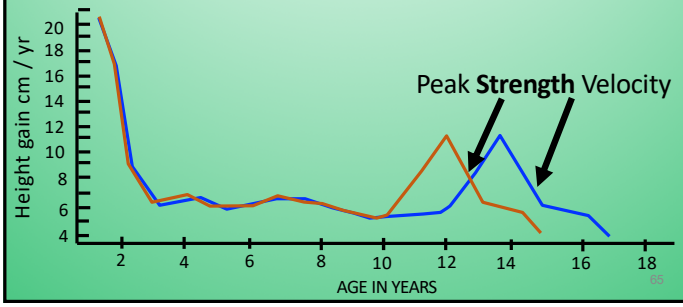
- Boys have additional **2 years pre-pubertal** growth (5 cm/yr for 2 yrs = average 10 cm taller than girls)
- Girls stop growing on average by age **16** while boys continue until age **18**

- Peak **Weight** gain **follows** Peak **Height** gain by about **3 months** (grow upward, then outward)
- This is when the child is gaining weight (from growth) at the fastest rate in his/her life



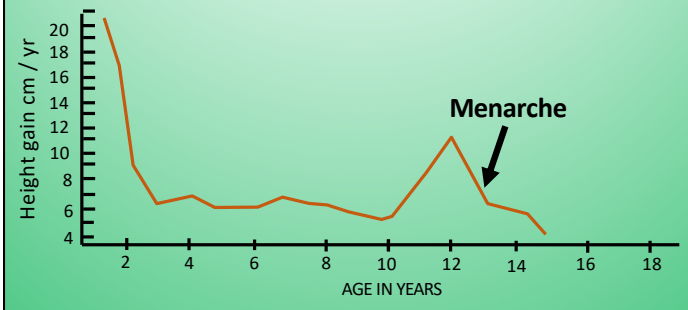
Peak **Strength gain** follows PHV by about:
- **8 months in females**
- **1 year in males**

That is, the child is gaining **strength** - from growth - at the fastest rate in his/her life



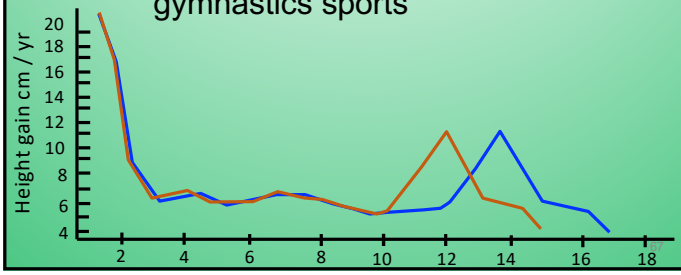
Menarche (first menstrual cycle)

follows PHV by about **1 year**



66

- In the general population, hospitalized injuries **peak exactly at PHV** in males and females
- This is true in gymnastics sports as well
- And, because growth plates are widest at PHV, **growth plates injuries are highest then**
- PHV is the time of highest **DROP OUT** from gymnastics sports



Body Composition

- Before puberty, girls have 10 - 15% more body fat (adipose) than boys
- After puberty, girls have 50% more body fat (adipose) than boys
- This has important **implications** for **gymnasts (**both **physically** and **psychologically)**
- An **increased %** of body weight as **adipose** means a **decrease in relative strength** (strength relative to body weight)

68

Body Composition

Coaches can mitigate this post pubertal decrease in relative strength in females by:

- Increasing strength training
- Planning weight stabilization / nutrition sessions with nutrition professionals
- Psychologically prepare gymnasts for change
- Change routines to more 'mature' versions

Male gymnasts have a hormonally stimulated **growth spurt** in **muscle tissue**, thus their **relative strength** increases throughout puberty

69

Body Composition

- The pubertal growth period is critical time for **bone accretion (accumulation)**
- **25% of total adult bone mineral** is laid down in the **2 peak years** of pubertal growth
- This is as much bone mineral as **will be lost** in all **post-menopausal years** in females
- **Good nutrition** is critical to this...
- ...so this is **NOT** a time to have severe, or poor weight loss strategies from restricted diets

70

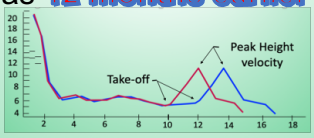
A big complication is:

- Individuals VARY tremendously in the **magnitude and timing** of their growth

71

Early Maturing

is defined as **12 months earlier** than average



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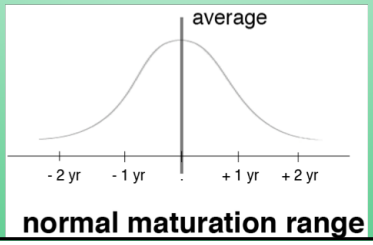


normal maturation range

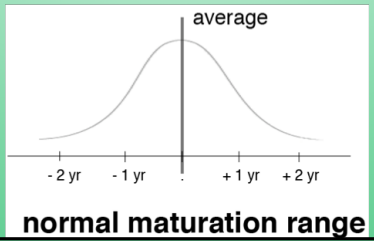
72

Late Maturing

is defined as **12 months later** than average

"Delayed maturation" is a POOR term as it implies **something causes delay**. Late maturing is **very natural and normal** (as is **early** maturing)

10 11 12



normal maturation range

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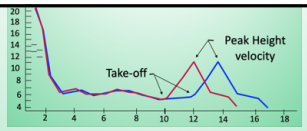
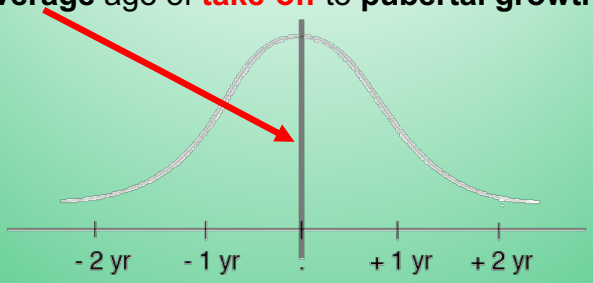


Average age of **take-off** to **pubertal growth**



2 years earlier or 2 years later

= "**NORMAL**"

74

Examples of gymnasts who are the same ages, but **very different in maturation**

75

Examples of gymnasts who are the same ages, but **very different in maturation**

It is obvious that gymnasts of **the same age** can be VERY DIFFERENT in **maturation**

- Thus their **adaptations to training** will also be **different** ...
- and will be **changing** **as they grow**
- This must be **understood** and **accounted for** in your planning

77

- **Early maturing** children are generally **taller** & **heavier** for their age than their late maturing peers

They will excel in sports where **larger size**, **greater speed** and **early strength....**

Give them an advantage (team sports, speed swimming, athletics, etc.)

- **Late maturing** children generally catch up to early maturers in height in late adolescence

But often **do not catch up in body weight**

78

Late Maturity typically features:

- **smaller stature** during growth years
- **low adiposity** during growth
- **narrower hips** during growth
- **higher strength** to weight ratios…

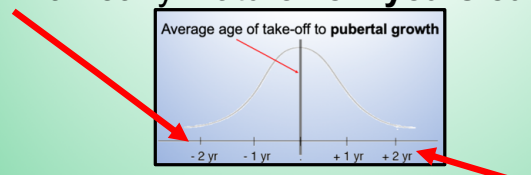
These are, of course, **highly desirable** traits in WAG.

thus **late maturing** children
gravitate to gymnastics
or, are **selected for** gymnastics
and are **successful in** gymnastics

- **Gymnastics does NOT cause short stature** and late maturation...
- Nor does **basketball cause tall stature** and early maturation
- But, late maturation does have **implications to growth plate injuries !**

80

- If an early maturer is **2 years early**



- and a late maturer is **2 years later** than average (these are both "normal")...

...the late maturing gymnast **will have growth plates 4 years after** the early maturing gymnast **has stopped growing**

- This has **profound implications** for coaches' planning and training designs

81

Can gymnastics delay or stunt Growth?

2 scientific papers argued this debate:

Pediatric Exercise Science 2003, vol 15

Human Kinetics Publishers. Inc.

Baxter-Jones et al. versus Caine et al.


Pediatric Exercise Science, 2003, 15, 360-372
© 2003 Human Kinetics Publishers, Inc.

Does Elite Competition Inhibit Growth and Delay Maturation in Some Gymnasts? Quite Possibly

Dennis Caine, Shona L. Bass, and Robin Daly

Pediatric Exercise Science, 2003, 15, 373-382
© 2003 Human Kinetics Publishers, Inc.

Does Elite Competition Inhibit Growth and Delay Maturation in Some Gymnasts? Pobably Not

Adam D.G. Baxter-Jones, Nicola Maffulli, and Robert L. Mirwald

FIG sponsored colloquium... 2011

Invited the authors of the papers cited on previous slide

plus the most eminent researchers in the world (4 from each side of the argument)

Published article in the journal *Sports Medicine*

Role of Intensive Training in the Growth and Maturation of Artistic Gymnasts: Sports Medicine

Sept. 2013 Vol 43 No. 9

R. Malina, A. Baxter-Jones, N. Armstrong, G. Beunen, D. Caine, R. Daly, R. Lewis, A. Rogol, K. Russell

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3751410/

http://link.springer.com/article/10.1007/s40279-013-0058-5

FIG sponsored colloquium ... Conclusions

1. **Final adult height** of both female and male gymnasts is **not compromised.**
2. There is **no credible evidence** that gymnastics training **alters growth** of upper body (sitting height) or lower body segments (legs).

3. The majority of gymnasts are shown to be late maturers... but they have **the same pattern of growth** (timing and tempo) as late maturing non-gymnasts.
4. The **available data are inadequate** to address any effects of intensive gymnastics training on the endocrine system

Recall

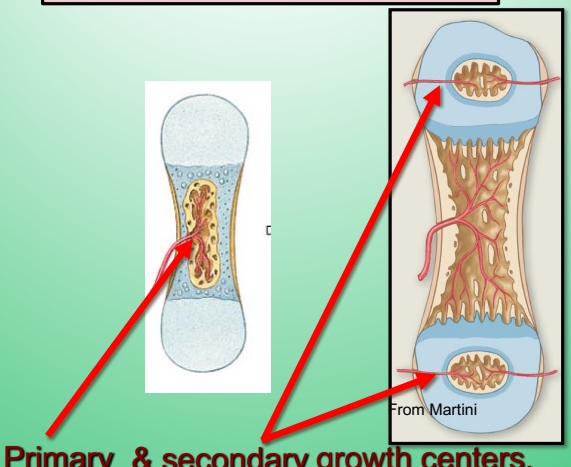
Late maturers...

Have growth plates longer (more years)

Therefore they have '**mechanical advantage**' of **being small** longer time

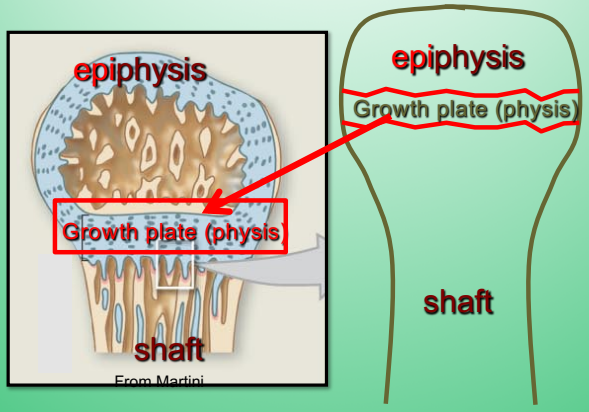
But, they are exposed to growth plate injuries longer time !

Bone Growth

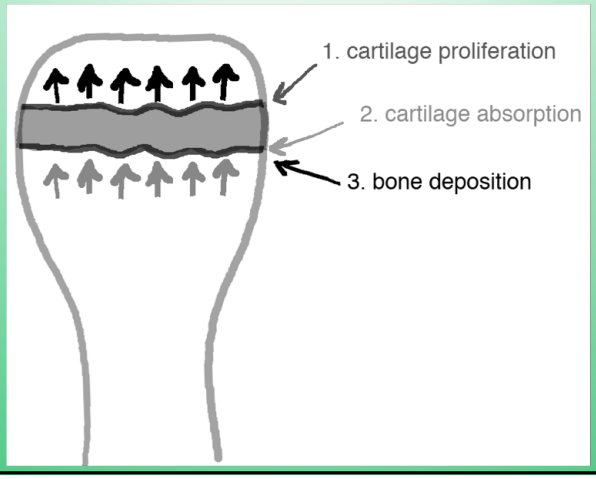


Primary & secondary growth centers.

Bone Growth



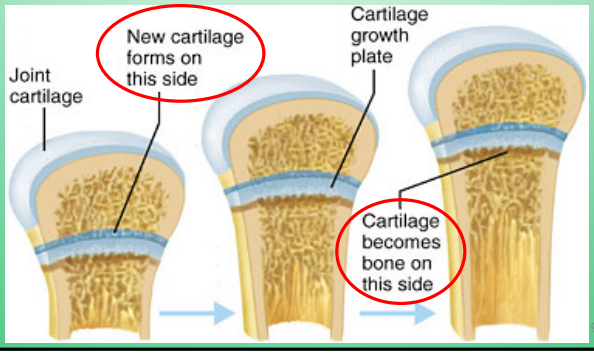
Bone Growth



Bone Growth

Growth Plates

Growth in height occurs at growth **plates on both ends of the long bones**



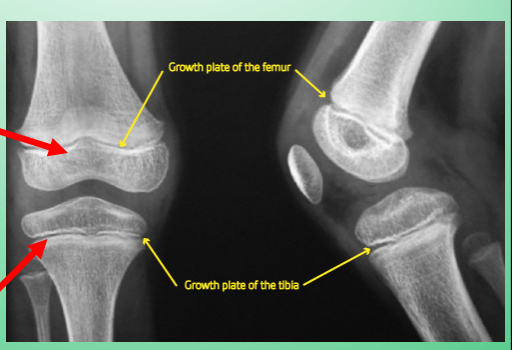
92

Bone Growth

Growth plates of the Knee

Bottom (distal) Growth plate of femur (upper leg)

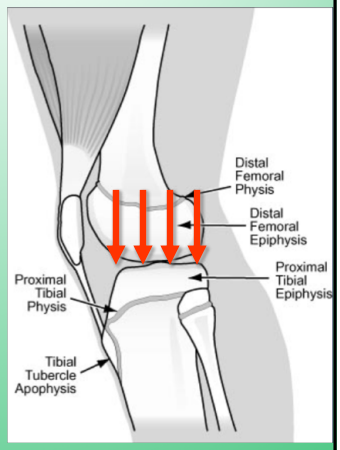
Top (proximal) growth plate of tibia (lower leg)



93

Bone Growth

- Growth plates (at the ends of long bones) are normally subjected to **compression loads** and are well designed for this



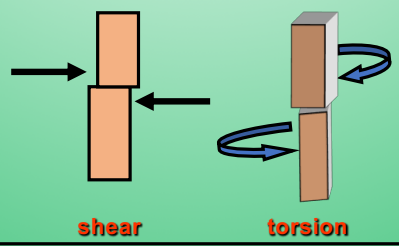
94

GROWING Tissue Response to Training

- **Excessive loading** can, however, damage them and even result in compression fracture

GROWING Tissue Response to Training

- Since growth plates are an **interruption in structural rigidity of bone...**
- They are **weaker** than the rest of the bone
- This **weakness** is **particularly vulnerable** in **shear** forces and **torsion** forces



GROWING Tissue Response to Training

Thus coaches MUST take steps to **reduce shear and torsion forces at this time** by REDUCING:

- Landing **under** or **over rotated saltos**
- Landing **under** or **over rotated twists**

Particularly on hard landing surfaces

This should mean

- **Reducing the level of skills** the gymnast **trains** if those skills can result in **large shear or torsion forces**
- **Reducing hard take-offs and Landings**

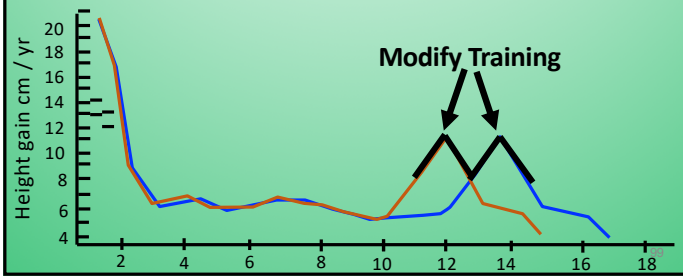
GROWING Tissue Response to Training

Instead, coaches should devote **more time** to training that **does NOT** result in large shear and torsion forces such as:

- **Physical Preparation** training
- **Mental skills** training
- **Artistry** training
- **Perfection** of technique
- **Consistency** of performance
- etc.

GROWING Tissue Response to Training

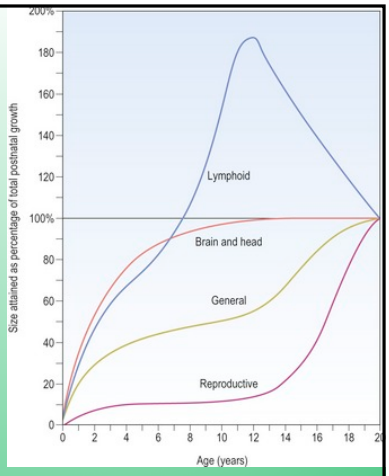
Modification in training, and extra protection of **landings and take-offs** should continue **AT LEAST 6 months either side of PHV**



Another Complication

Growth is NOT linear

- **Body systems** grow at very **different rates...**



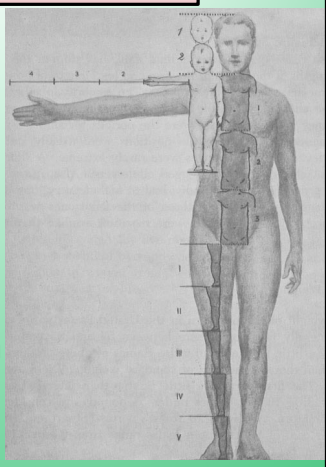
Bone Growth

Even **specific body systems** do NOT grow at a uniform rate.

The Skeletal System

From birth to adulthood:

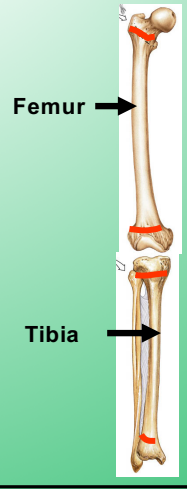
- **Head** grows **2x** in length
- **Trunk** grows **3x** in length
- **Arm** grows **4x** in length
- **Leg** grows **5x** in length



Bone Growth

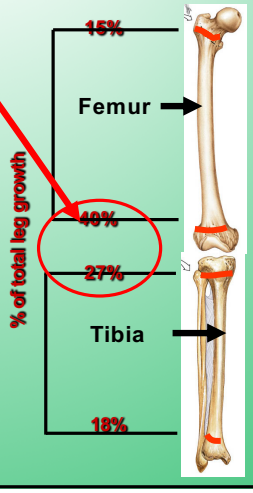
...And more surprisingly, **even in each limb** there is **uneven growth**

- The leg bones **do not all** grow at the same rate
- Even **within individual bones**, there is **not the same growth at each end !**



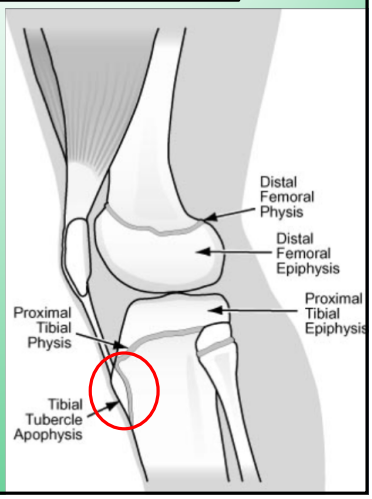
Bone Growth

- 2/3 of total growth of the leg **occurs at the knee!**
- Thus these growth plates are growing more rapidly, and are **very vulnerable to injury during rapid pubertal growth**
- Hence, the **need for modified training** to decrease shear and torsion forces



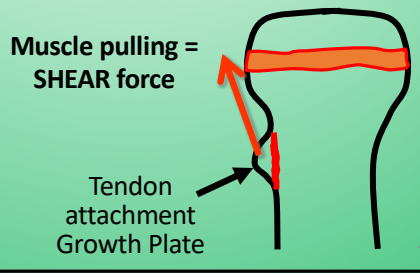
Bone Growth

- There is **another category of growth plates** .... **injured more frequently**
- These, more numerous, growth plates are located between **tendon attachments** and the main bone shafts



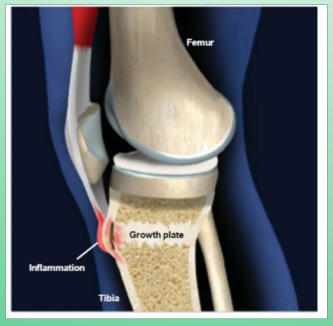
Bone Growth

- Between this bony bump (apophysis) and the main shaft, is a **growth plate** structurally the same as epiphyseal growth plates
- **BUT**, The **forces apophyseal growth plates** are subjected to **are always SHEAR**



Bone Growth

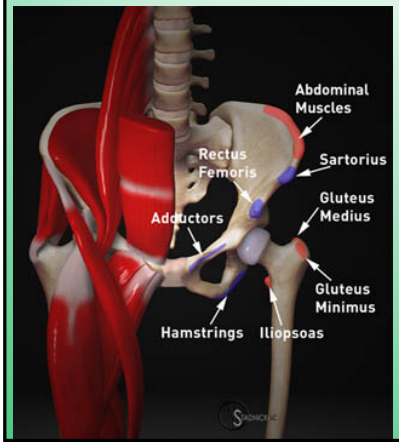
These 'tendon attachment' growth plates are usually injured from **overuse** and they become **inflamed and tender** (apophysitis)

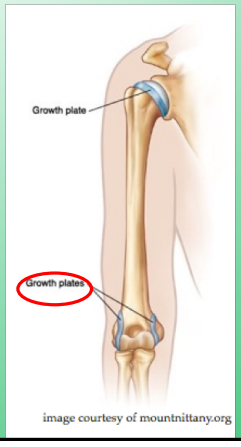


Osgood-Schlatter's disease

Bone Growth

Tendon attachments (Apophyseal growth plates)





Bone Growth

- Injury can be from **excessive concentric contractions** (swimmer's shoulder, little leaguer's elbow, Osgood Schlatters, Sever's)
- Or from **eccentric contractions** (all landings in gymnastics = shear force on tibial tuberosity by quadriceps)
- Occasionally a contraction can **break off (avulse) the apophysis**

111

Bone Growth

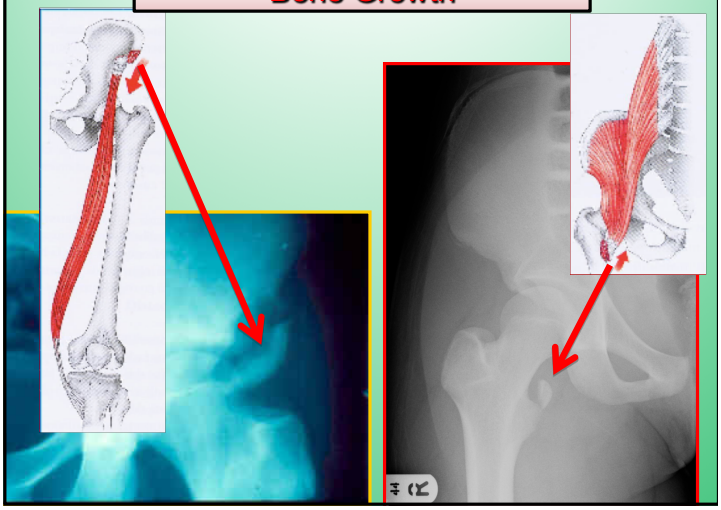
AVULSION FRACTURES

Bone Growth

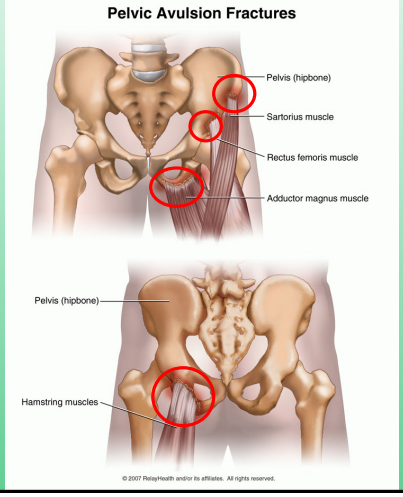
AVULSION FRACTURES

113

Bone Growth



Bone Growth



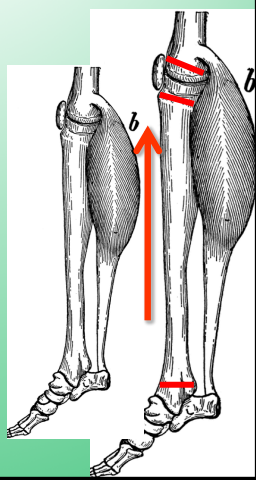
115

Bone Growth

Another complication

Bones grow...

- And consequently, the attaching muscles are STRETCHED (tractioned)
- This stretching of muscles is the stimulus for muscle to grow longer (as also happens during flexibility stretching)

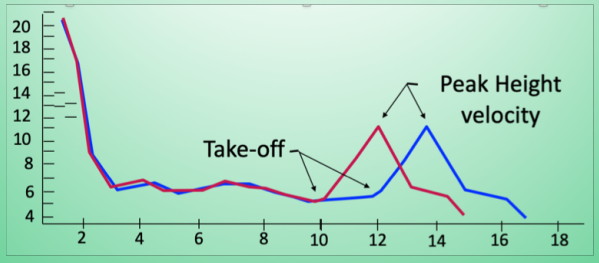


Bone Growth

- When athletes are growing rapidly, the muscles are catching up to bone growth an are tractioned (tight).
- This tractioning, in turn, increases the problem of avulsion fractures (adults often tear tendons, children avulse bone)

Bone Growth

- This tightness **is greatest at PHV** and it increases the forces on the tendon attachment



- This exacerbates the **overuse problem** and increases injuries to these growth plates

118

Bone Growth

In summary
There are **two types of growth plates**:
1) At end of long bones, 2) At tendon attachments

- Growth plates are **widest at PHV** and most **vulnerable** to injury around PHV
- 1) **Epiphyseal** growth plates are usually injured by **shear or torsion forces** on take off and landing but can be damaged with **excessive compressions** (gymnast's wrist)
- 2) **Apophyseal** growth plates are usually injured by **overuse** but can be **avulsed** by forceful contractions on take-off or landing

120

GROWING Tissue Response to Training

We should **modify training** in pubertal growth by:

- **Decreasing** plyometrics
- **Decreasing** number of repetitions
- **Decreasing** shear & torsion forces (no under rotated saltos or twists onto hard surfaces)
- Doing **less unilateral** training
- **Increasing** % of other types of training

Very **early detection** and **modified training** can **prevent** most serious injuries

- Closely monitor tenderness near growth plates

121

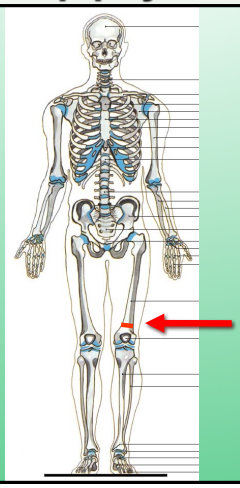
GROWING Tissue Response to Training

Know the **growth milestones:**

Take-off & Peak Height Velocity

- Measure the gymnast's height monthly
- Measure the gymnast's foot every three months starting at age 10 (or earlier if rapid growth is detected)

Important Epiphyseal Growth Plates



Distal femoral physis

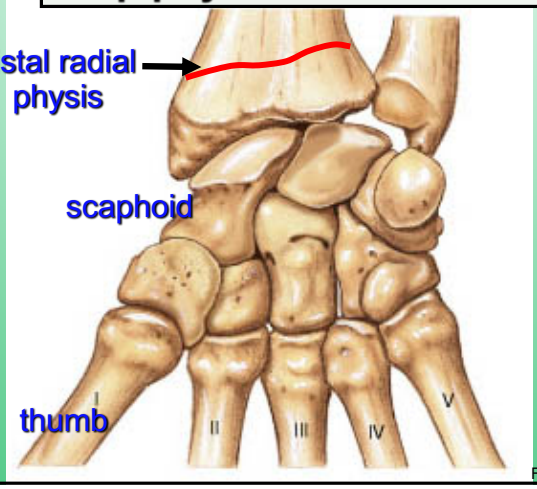
Epiphyseal Growth Plates

1. **Distal femur** (just above knee)
   By far the greatest amount of growth in leg length occurs at this growth plate
- Potential fracture when under-rotating vaults & dismounts
- This could lead to premature fusion of growth plate thus shorter leg

Epiphyseal Growth Plates

2. Distal radius (wrist)
compression injury known as "Gymnast's wrist"

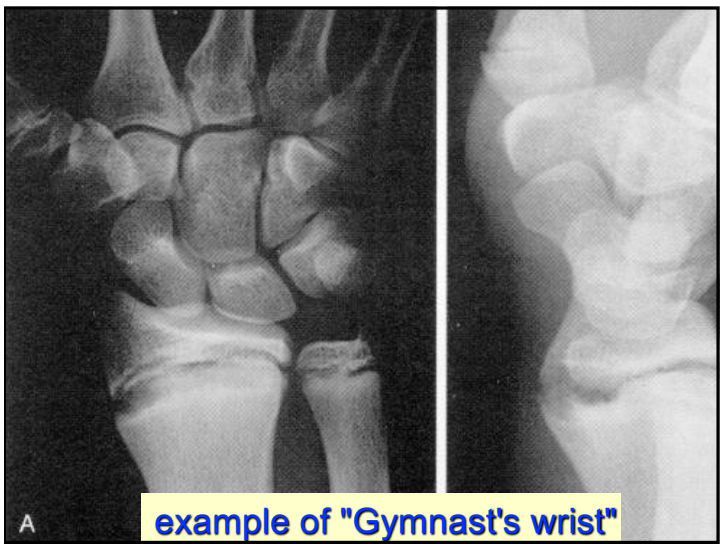
Epiphyseal Growth Plates



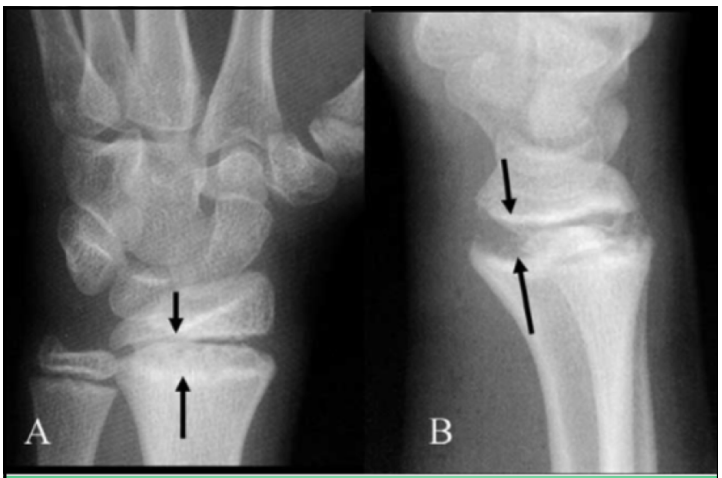
From Martini

Epiphyseal Growth Plates

Healthy epiphyseal growth plates (radius & ulna)



example of "Gymnast's wrist"



example of "Gymnast's wrist"

igure 53 "Gymnast's wrist"—SH II injury of radius and ulna. (A) A PA view shows mild widening of the physes of the ulna and radius arrows) with possible minimal metaphyseal sclerosis. (B) The cor-

Epiphyseal Growth Plates

A complication of 'gymnast's wrist" is the possibility of **premature fusion of radius**

If this happens, the ulna can continue to grow (positive ulnar variance) resulting in wrist pain and necessity of surgery to shorten the ulna

To detect POSITIVE ULNAR VARIANCE it is very important that the x-rays are taken using the "Anterior Posterior" (AP) protocol shown on this slide !

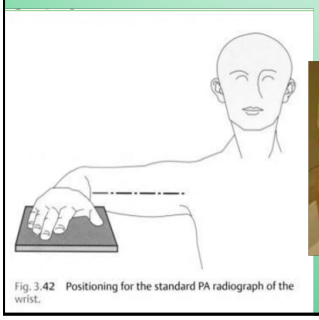


Fig. 3.42 Positioning for the standard PA radiograph of the wrist.

Epiphyseal Growth Plates

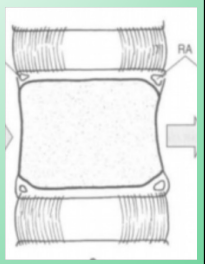
3. Vertebral epiphyseal growth plates

Important Apophyseal Growth Plates

Bumps where muscles attach

Apophyseal Growth Plates

1. Vertebral Ring Apophysis
   This is where muscles attach and is damaged and the cause of pain in gymnasts, especially RG



The physes may be vulnerable during development. Fusion between ring apophysis and the adjacent vertebral body does not complete fully prior to the age of 25 years. This increases risk of apophyseal ring fractures in adolescents [8].

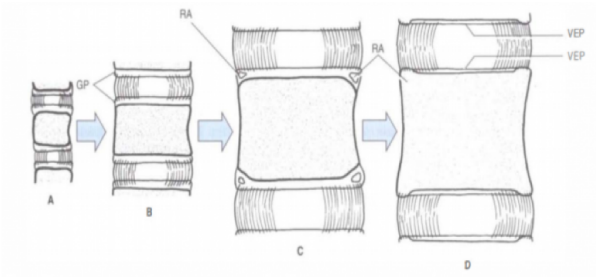


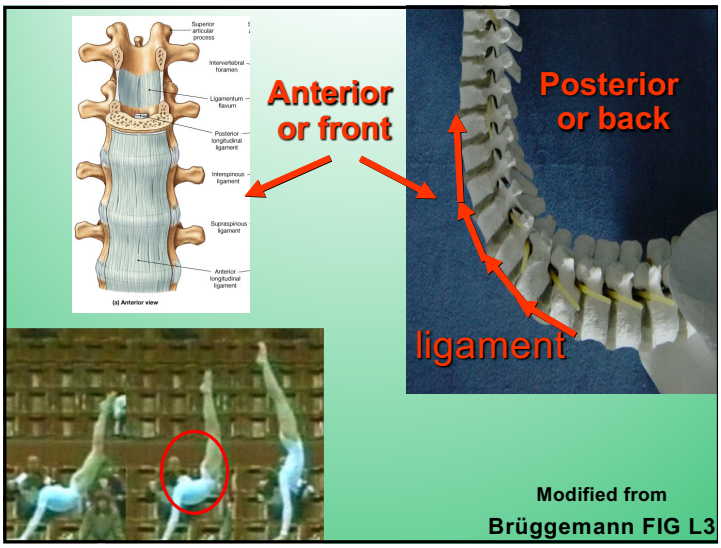
Figure - Stages of the grwoth of the vertebral bodies[15]

A. The vertebral bodies, discs and growth plates (GP) of a 1-year old infant.

B. The same structures in a pre-pubertal child.

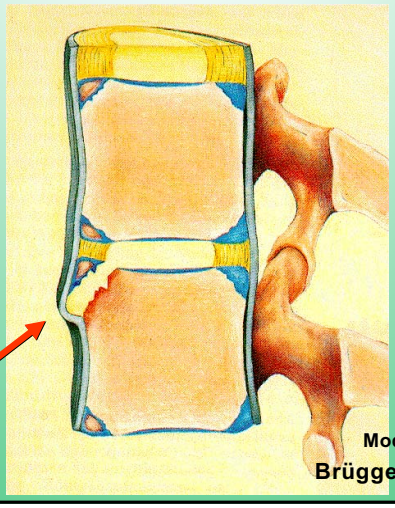
C. The appearance of the ring apophyses (RA) in adolescence.

D. Ossification of the ring apophyses and the formation of the vertebral endplates (VEP) in adulthood.



Excessive loading can fracture pieces of bone off vertebrae

ligament

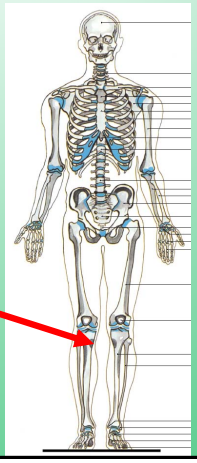


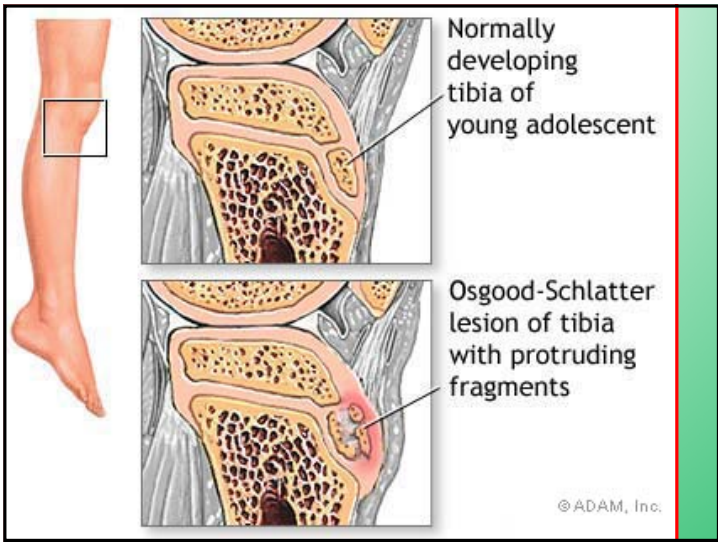
Modified from Brüggemann FIG L3

1. Vertebral Ring Apophysis fracture

Apophyseal Growth Plates

2. Tibial tuberosity





Apophyseal Growth Plates

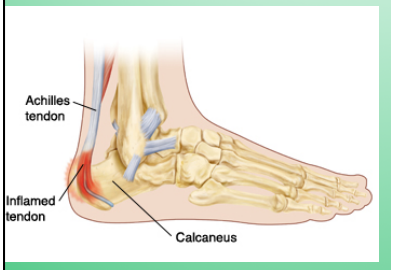
3. Calcaneal tuberosity

inflammation of calcaneal tuberosity (apophysitis)

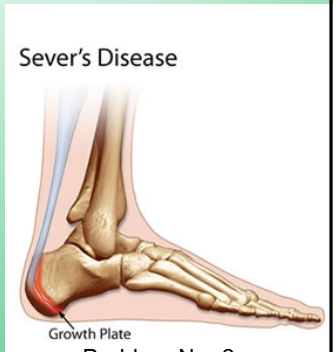
Sever's disease

Apophyseal Growth Plates

3. Calcaneal tuberosity



Problem No. 1:
Achilles Tendon



Problem No. 2:
Growth Plate

Apophyseal Growth Plates

Apophyseal Growth Plates

Modified from
Brüggemann FIG L3

Apophyseal Growth Plates

What are injury statistics ?

A research study of one country in top 6 in the world that looked at elite & sub-elite female gymnasts for **18 months** found:

- elite gymnasts (n=24)
  - 2.6 injuries per 1000 hours
  - 6.3 injuries per gymnast
- sub-elite gymnasts (n=40)
  - 4.1 injuries per 1000 hours
  - 5.0 injuries per gymnasts

Kolt & Kirby, 1999 *Br J Sports Med* 1999;33:312–318

What are injury statistics ?

Of the 162 girls who began the study, 88 retired from the sport before the end of the study.

The 64 girls who completed this study had 349 injuries including:

- 29 fractures
- 43 growth plate injuries

(38 in elite group of 24 gymnasts)

What are injury statistics ?

The injuries were distributed:

• head	4
• spine & trunk	60
• upper limb	74
• lower limb	205
• other	6

The injuries were classified as:
fracture, dislocation, sprain, strain, tendinitis, inflammation, contusion, growth plate, other.

What are injury statistics ?

The most common injury type in the elite group was GROWTH PLATE!

- Growth plate injuries were much more common than previously reported.

What are injury statistics ?

The 64 girls who completed this study had 349 injuries including:

- elite :
  - acute (sudden onset) 50 %
  - chronic (slow onset) 50 %
- sub-elite
  - acute (sudden onset) 75 %
  - chronic (slow onset) 25 %

What are injury statistics ?

Because of injuries, the gymnasts trained at reduced capacity:

- 21 % of the time for elites
- 16.5 % of the time for sub-elites

Only 1 other study reported this kind of data & it found that the gymnasts spent 29% of season at less than full training capacity.

Conclusions about injuries

- Elite WAG Gymnastics has a fairly high injury incidence.
- Injuries are most common in ankle & foot.
- Backs, knees and wrists are also common injury sites.
- Much training time is lost or modified due to injury.
- Insufficient recovery time appears to be common in the elite Artistic gymnasts

Reasons for high injury rates

- Excessive training volume (> 30 hrs/wk)
- Early onset of intensive training (< 10 yrs)
- High mechanical loading

(> 20 x BodyWeight spinal compression load)

- High loading frequency

(20,000+ high impact loadings per year)

Bruggemann

Gymnastics CAN BE VERY HEALTHY

- Bone density in competitive gymnasts is the highest of all athletes measured

Gymnastics CAN BE VERY HEALTHY

- Benefits to bone are still present 10 years after retirement (WAG)

ORIGINAL ARTICLE

JBMR

Former Premenarcheal Gymnasts Exhibit Site-Specific Skeletal Benefits in Adulthood After Long-Term Retirement

Marta C Erlandson,[1,2] Saija A Kontulainen,[1] Phil D Chilibeck,[1] Cathy M Arnold,[3] Robert A Faulkner,[1] and Adam DG Baxter-Jones[1]

[1]College of Kinesiology, University of Saskatchewan, Saskatoon, SK, Canada
[2]Osteoporosis and Women's Health Program, University Health Network, University of Toronto, Toronto, ON, Canada
[3]School of Physical Therapy, University of Saskatchewan, Saskatoon, SK, Canada

Gymnastics CAN BE VERY HEALTHY

In summary, 10 years after retirement female gymnasts had significant site-specific bone geometric, densitometric, and estimated strength benefits at the radius and tibia compared to females who had not participated in gymnastics during the premenarcheal period. Skeletal adaptations were geometric in nature at the radius, resulting in 22% to 32% greater estimated bone strength in retired gymnasts compared to non-gymnasts. At the distal tibia greater vBMD was observed without a change

Gymnastics CAN BE VERY HEALTHY

- Even recreational gymnasts have higher bone density than controls

Gymnastics CAN BE VERY HEALTHY

Precompetitive and recreational gymnasts have greater bone density, mass, and estimated strength at the distal radius in young childhood

M. C. Erlandson · S. A. Kontulainen · A. D. G. Baxter-Jones

Received: 2 November 2009 / Accepted: 9 March 2010

Gymnastics CAN BE VERY HEALTHY

...If we keep the training loads at safe levels