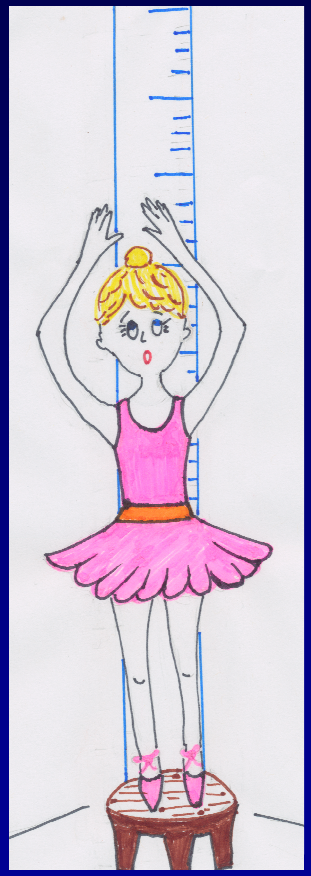
Measuring spinal growth in EOS:
What are the goals and what does it tell us



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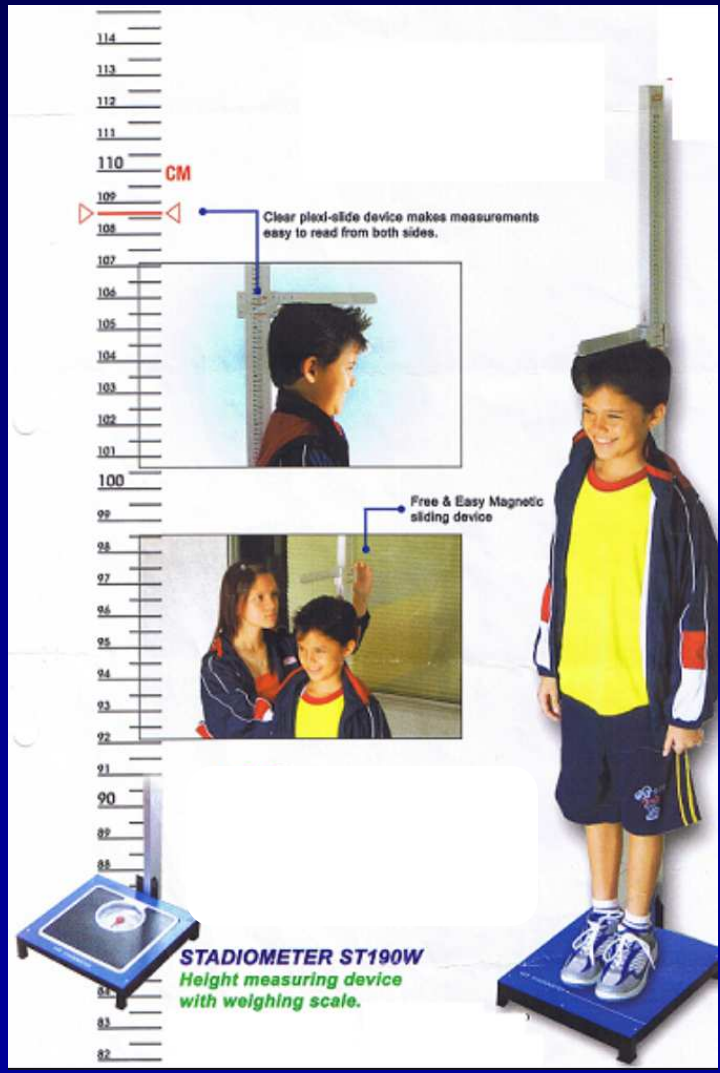
Three of the most important tools in measuring child health

- Stadiometer
- Scale
- Growth Charts



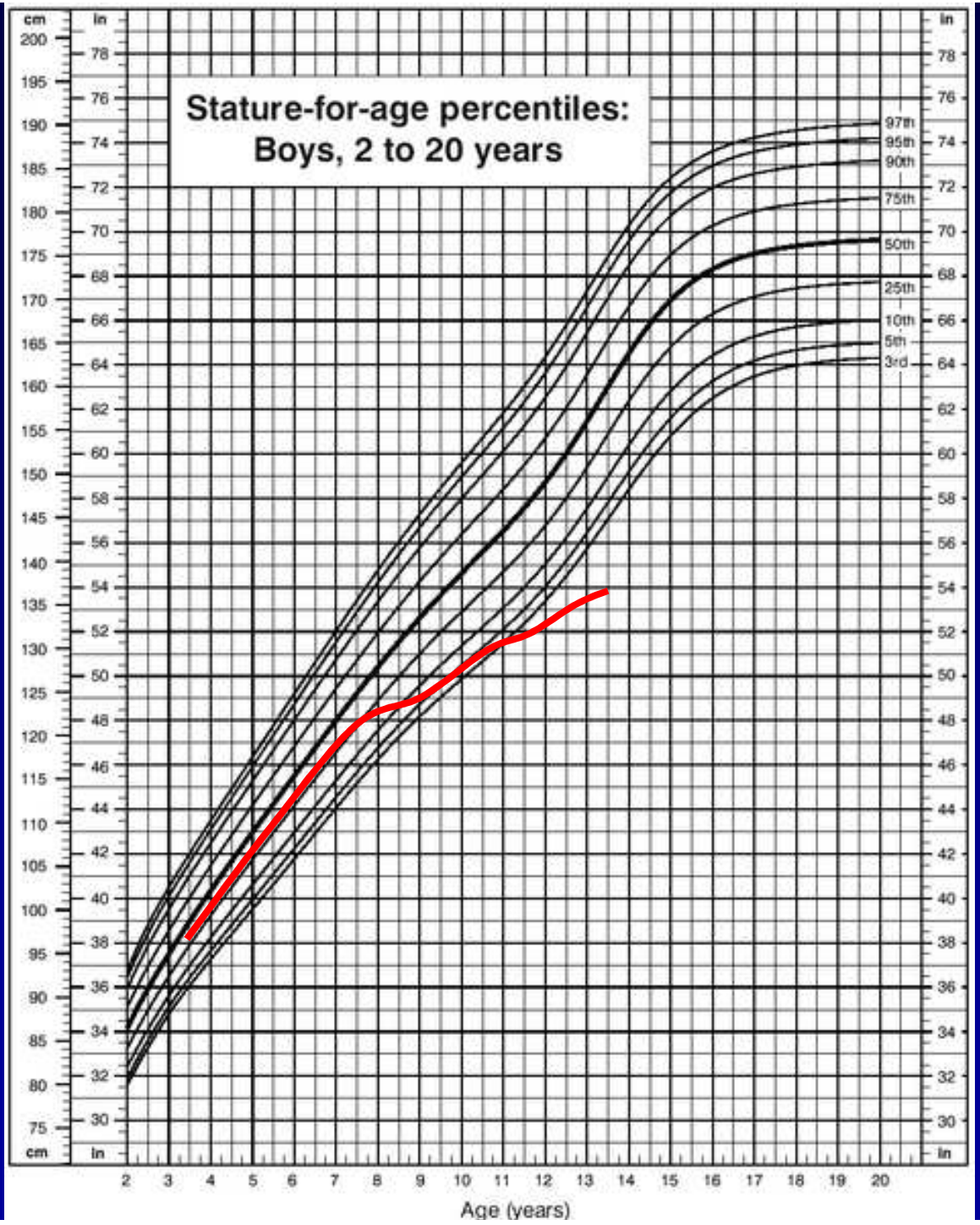
Height Measurements are Only as Accurate as the Technique

Technique for measuring erect height (Herpenden Stadiometer)

- Child should be fully erect.
- Head in the Frankfurt plane.
- Back of the head, thoracic spine, buttocks, heel should touch the vertical axis of the stadiometer.
- Should be measured in triplicate and the mean should be recorded.

Stunting

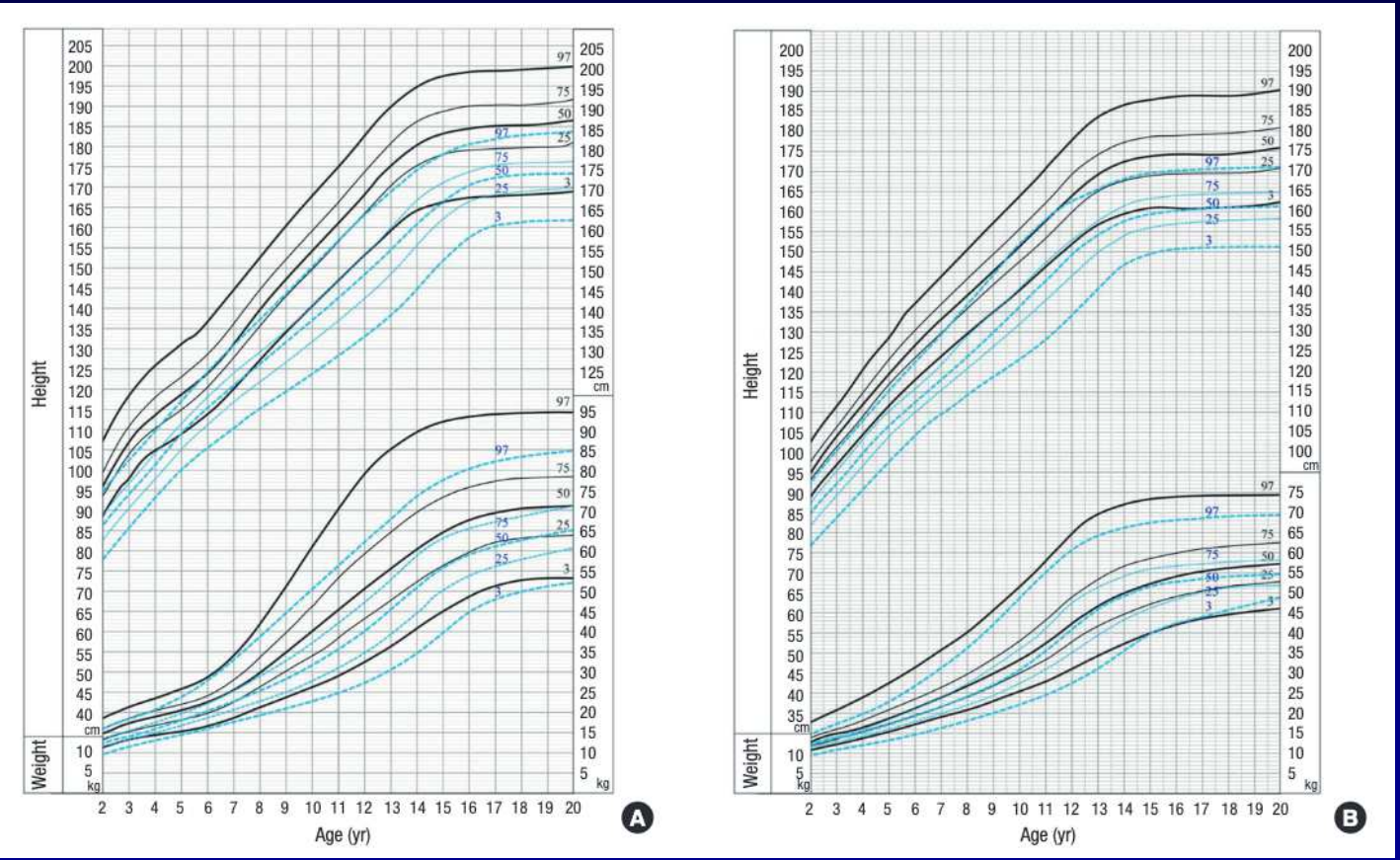
- Not etiology specific
- A generalized measure of health



There are Functional Alternatives to Height Measurement when Needed

- sitting height
- arm span
- upper arm length
- ulnar length

Disease Specific Growth Charts

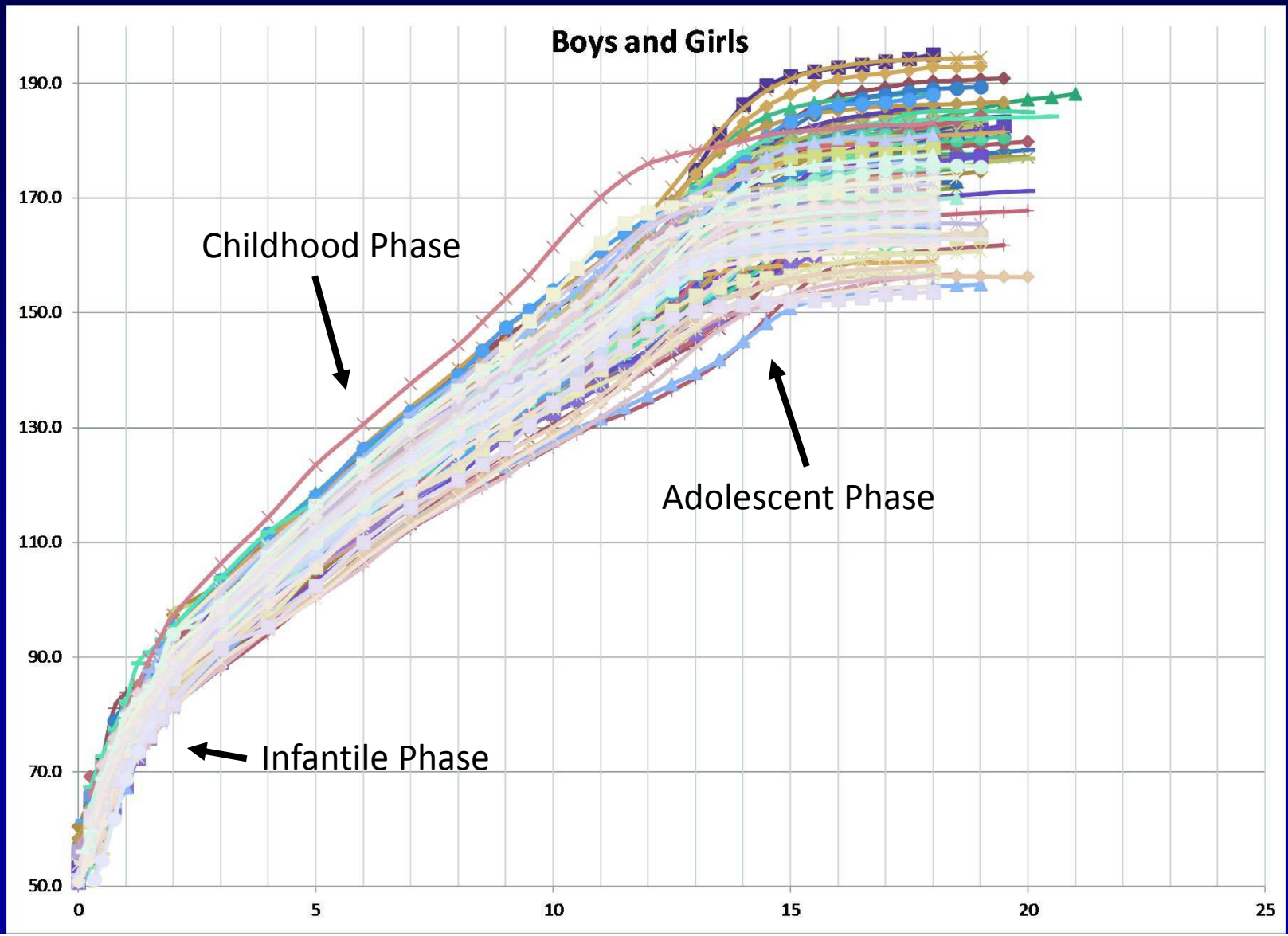


- Use with caution
  - Often small numbers, retrospective
  - Measurements not standardized
  - Unsure of nutritional or health status
  - No adjustment for racial or other characteristics

Disease Specific Growth Charts

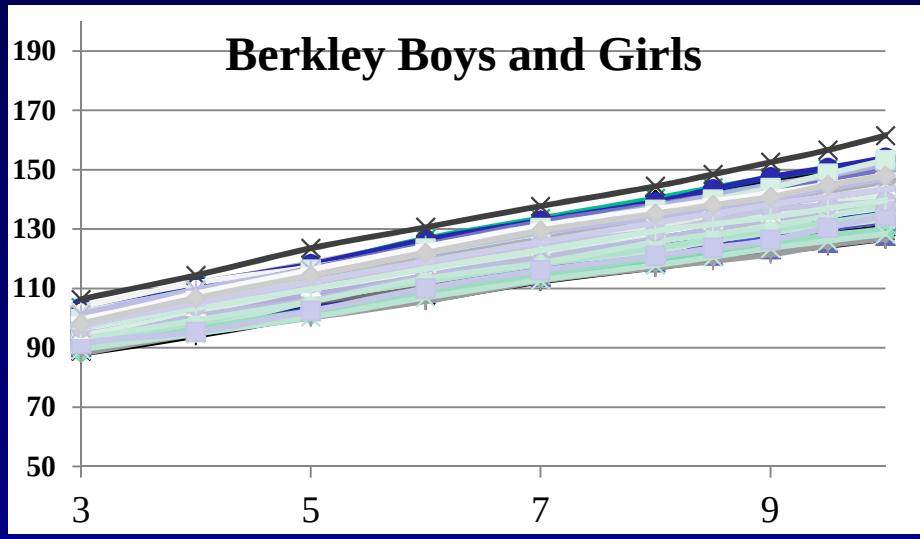
- Trisomy 21 (Down syndrome) (Cronk, 1988)
- Prader-Willi syndrome (Holm, 1995)
- Williams syndrome (Morris, 1988)
- Cornelia deLange syndrome (Kline, 1993)
- Turner syndrome (Ranke, 1983; Lyon, 1985)
- Rubinstein-Taybi syndrome (Reference)
- Marfan syndrome (Pyeritz, 1983; Pyertiz, 1985)
- Achondroplasia (Horton, 1978)

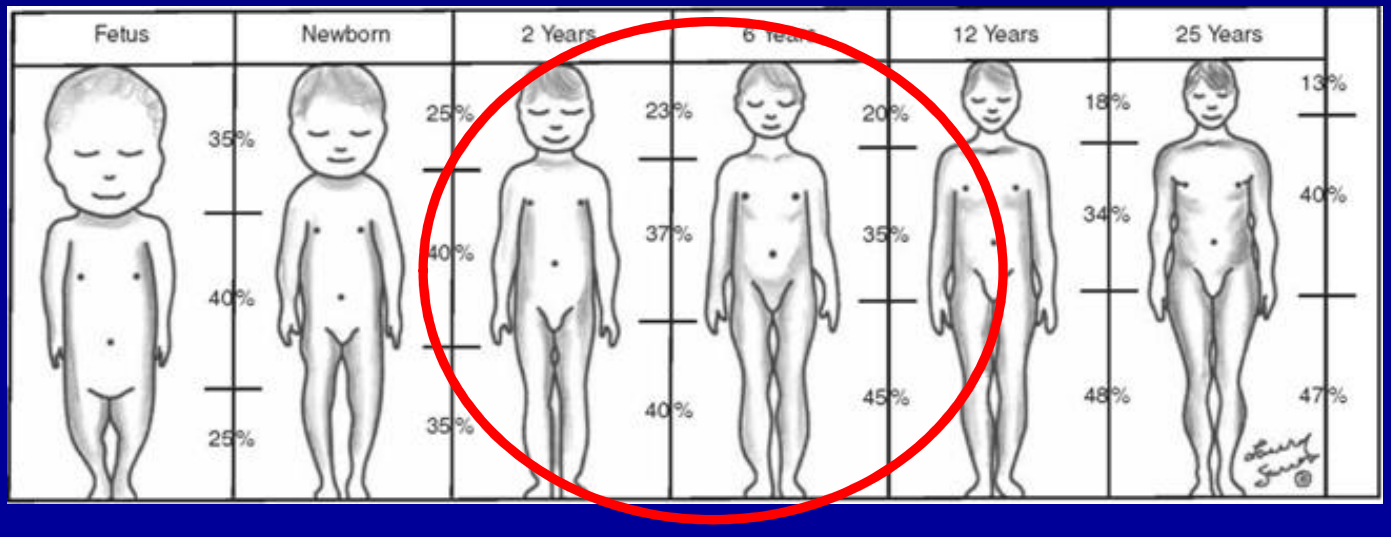
Actual Growth - Berkeley Series



Childhood Growth

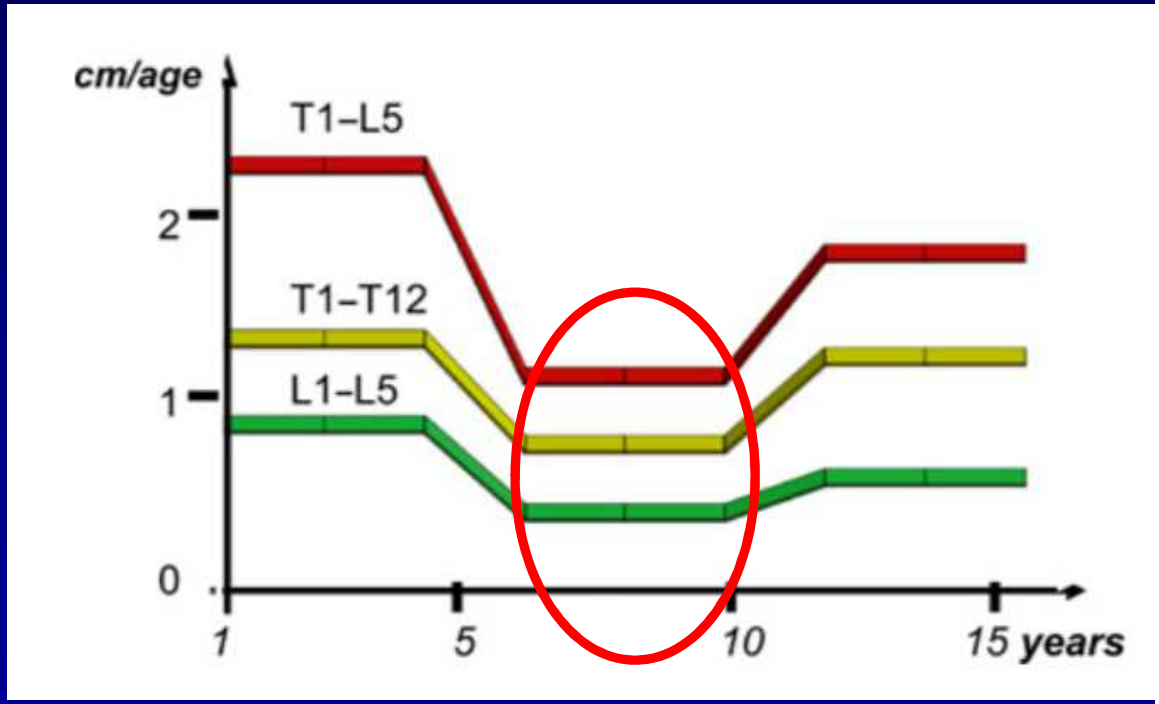
- Children tend to grow in a specific percentile (canalization).
- Growth is slower than infancy and relatively linear.



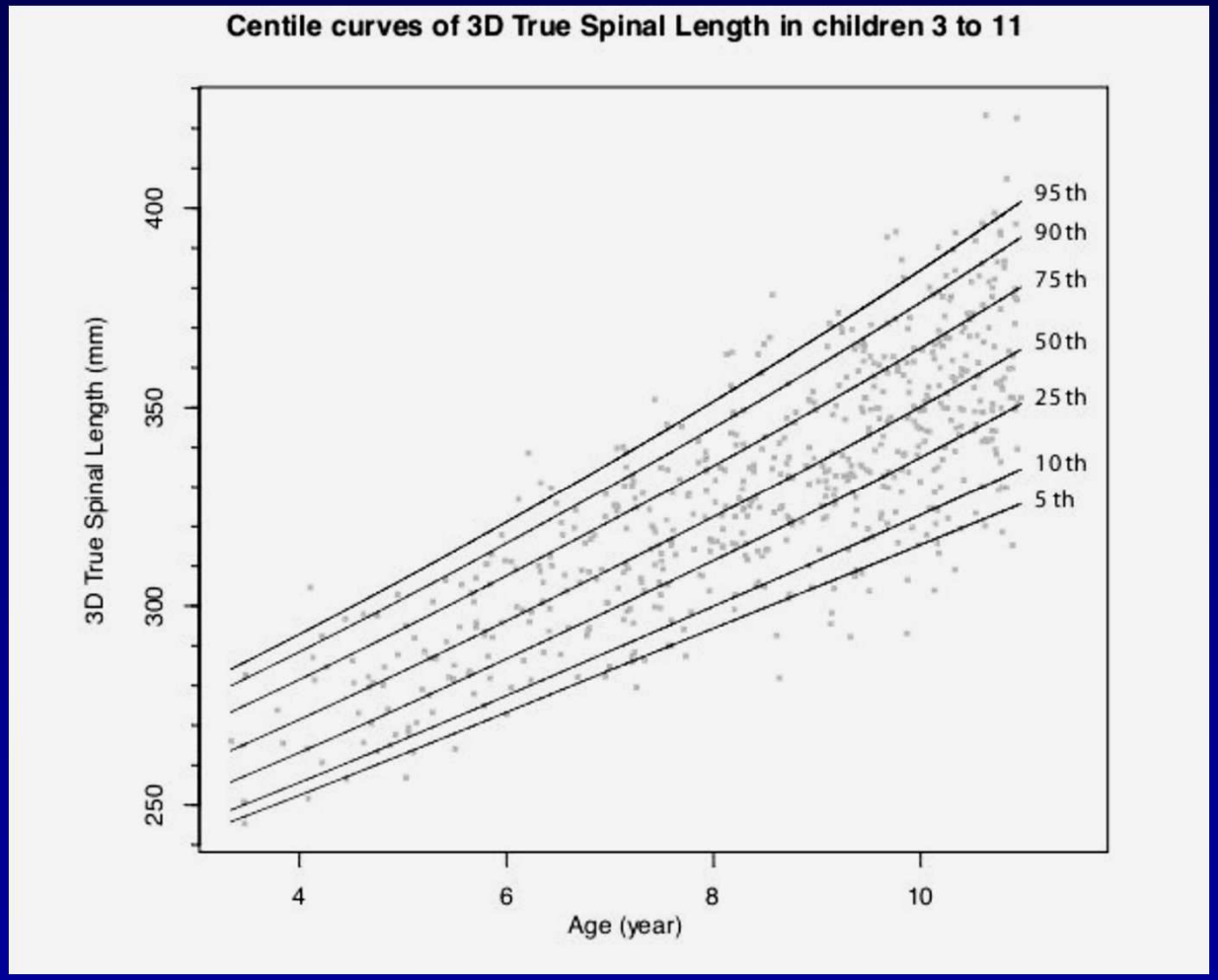


Spine Growth in Childhood

- Relatively linear and same for both sexes.
- T1-S1:
  - Our Data 1.5cm/year
  - DiMeglio 1.2cm/year

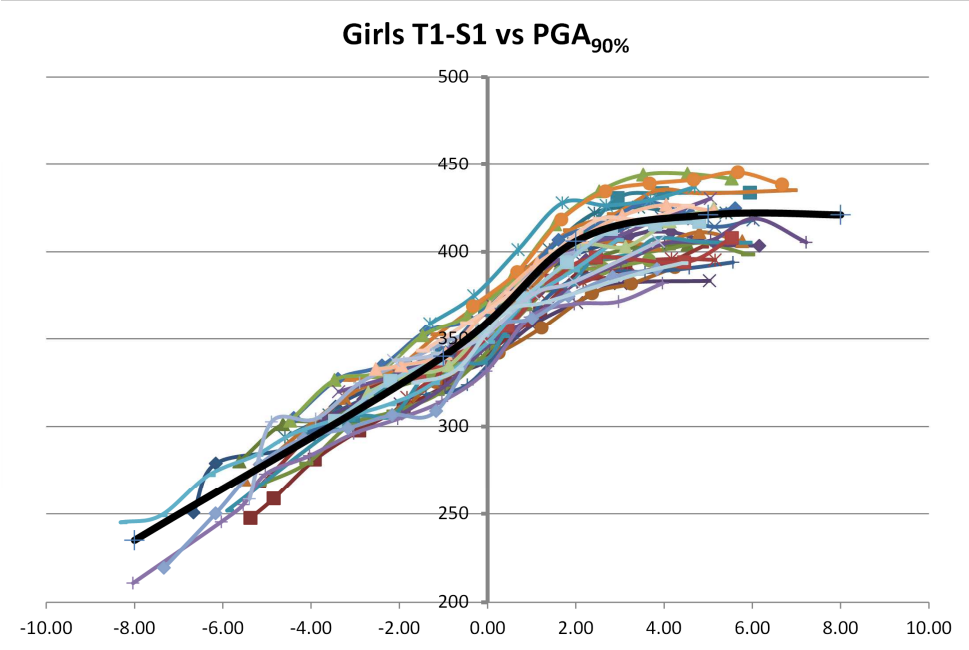


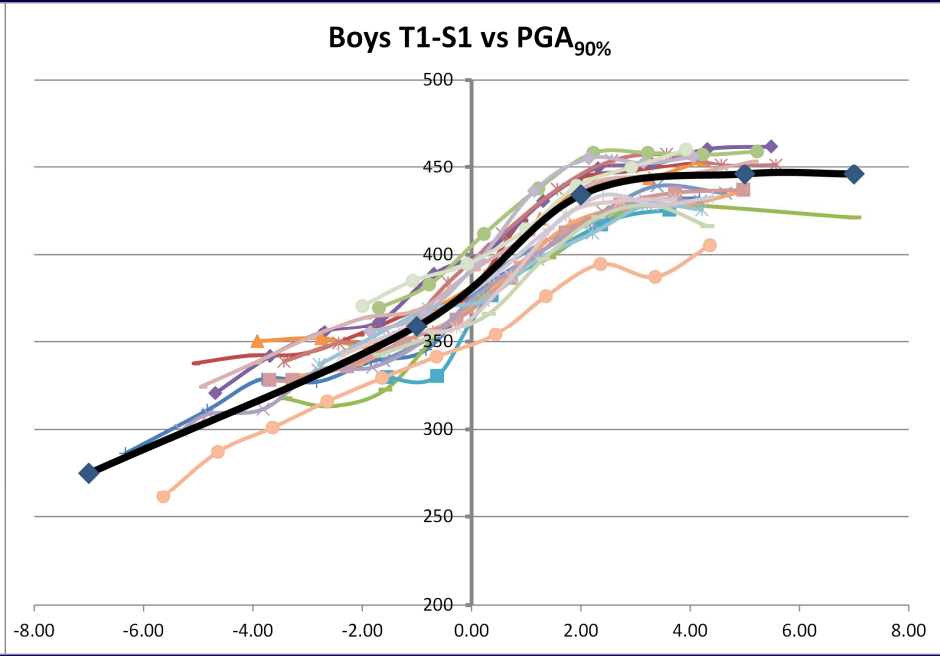
Parent, Beauséjour ,El-Hawary Sanders, Yaszay, Akbarnia



True spine 3D length = T1-S1 height x 1.026

Spinal growth (T1-S1) is very rapid during the growth spurt.

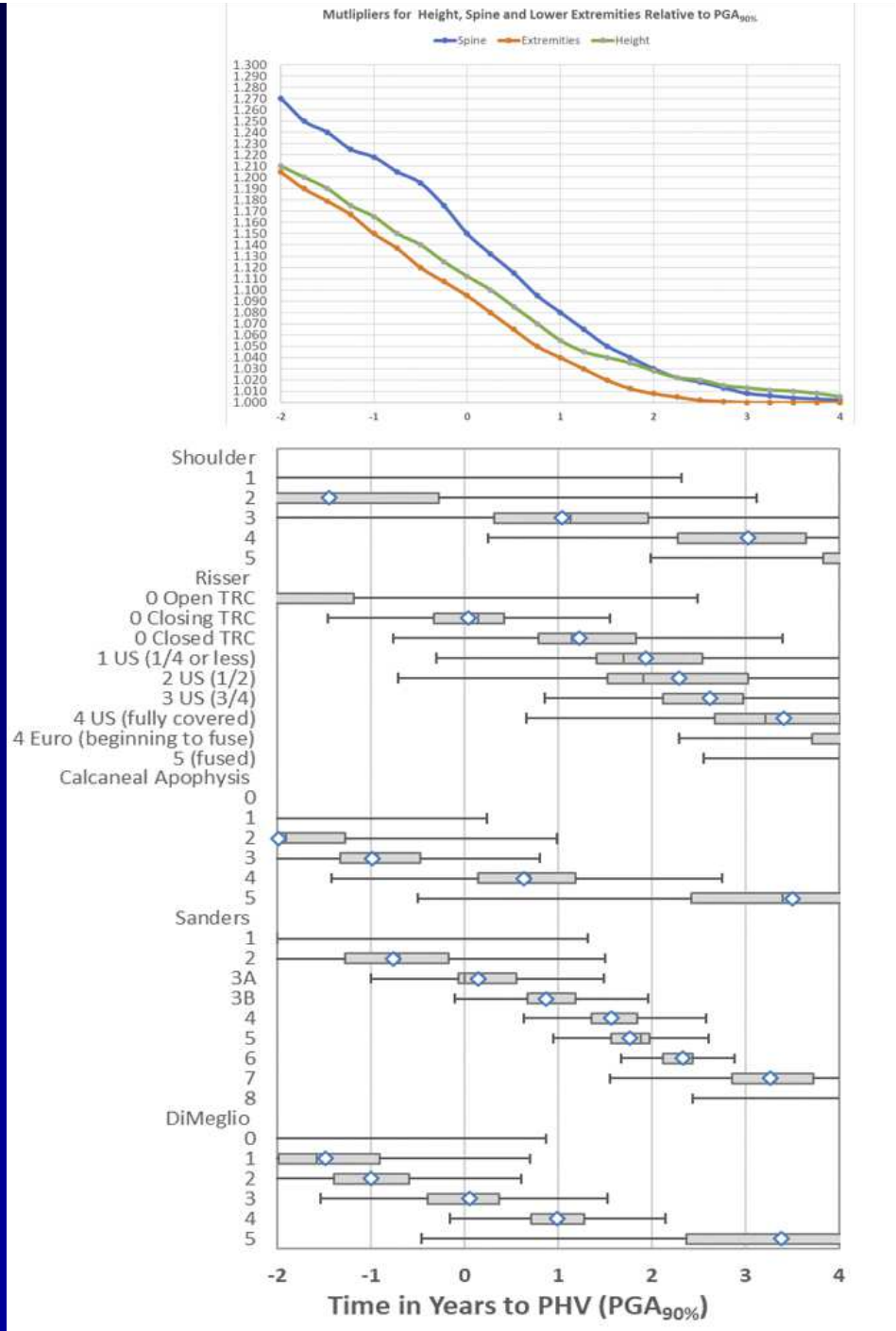




	Girls	Boys
Childhood	1.5cm/year	1.5cm/year
Growth Spurt	2.5cm/year	2.5cm/year
Terminal Growth	0.4cm/year	0.4cm/year

Growth Remaining (Multipliers) to Skeletal Maturity

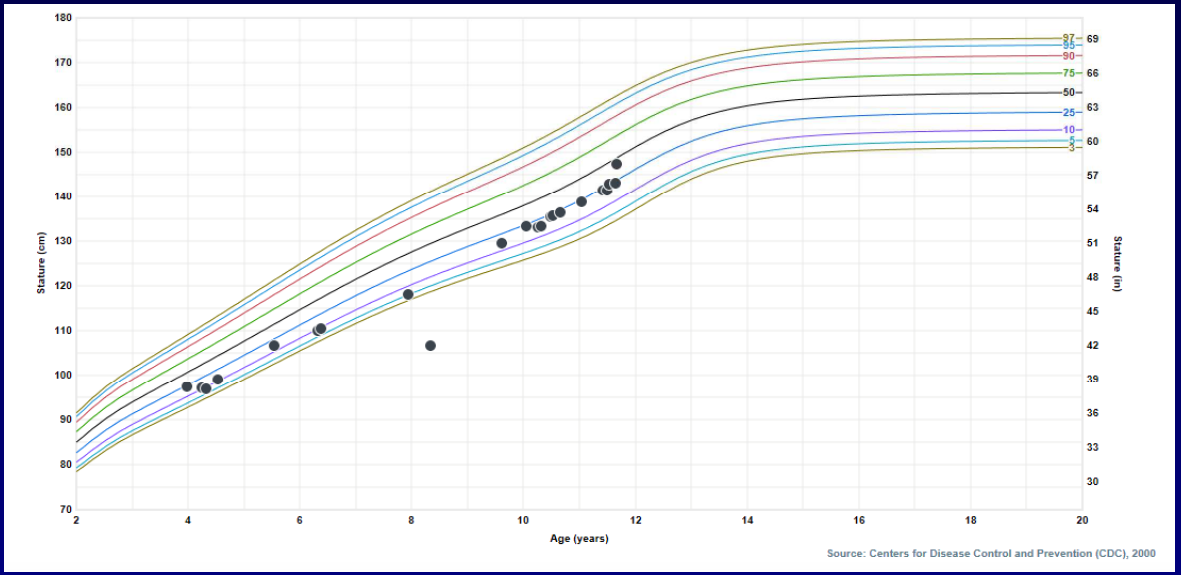
- The relationship between growth remaining and skeletal maturity is tight during the growth spurt



Early onset scoliosis can create:

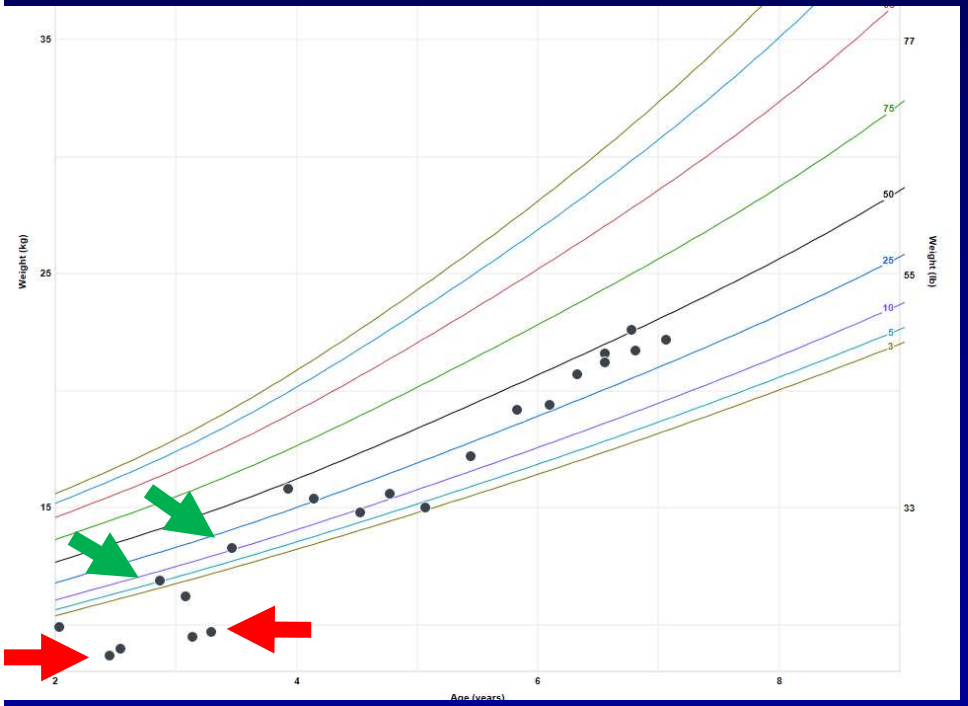
- A deformed breathing apparatus
  - Short
  - Twisted
  - Mechanically constricted
- A mismatch between respiratory ability and physiological demand.
- Poor health

What should we follow?



- Height - readily available.
- Effected by:
  - spinal deformity
  - underlying disorder
- Does provide an overall metric:
  - vs. age in preadolescent children
  - vs. PGA in adolescence

Courtesy Brandon Ramos



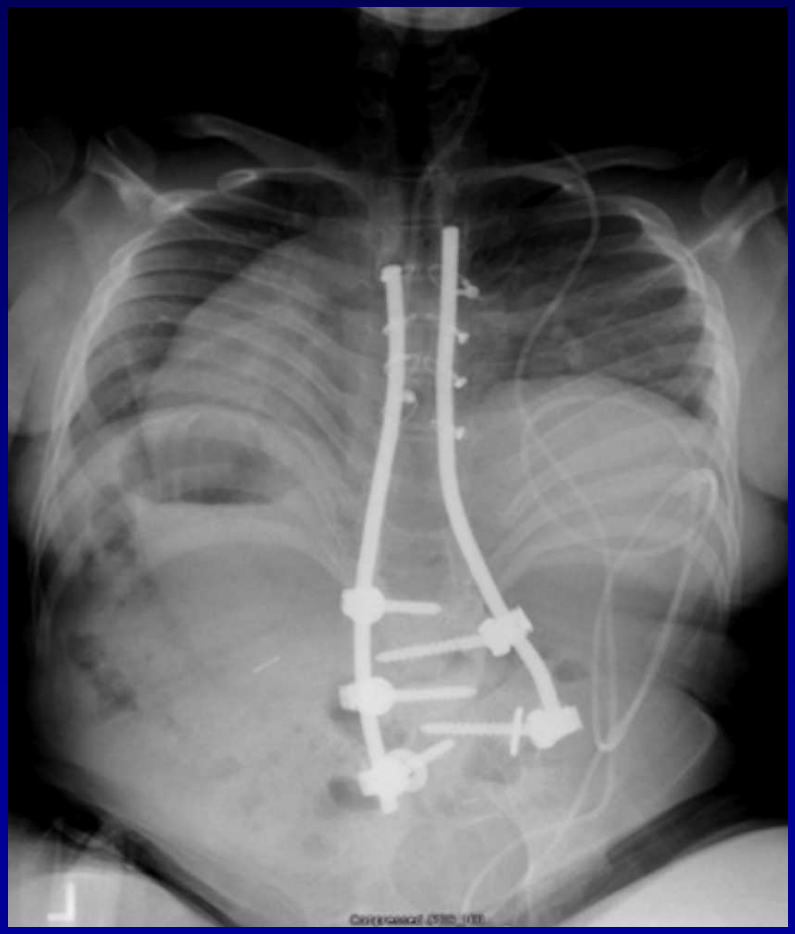
Spine Specific Measures

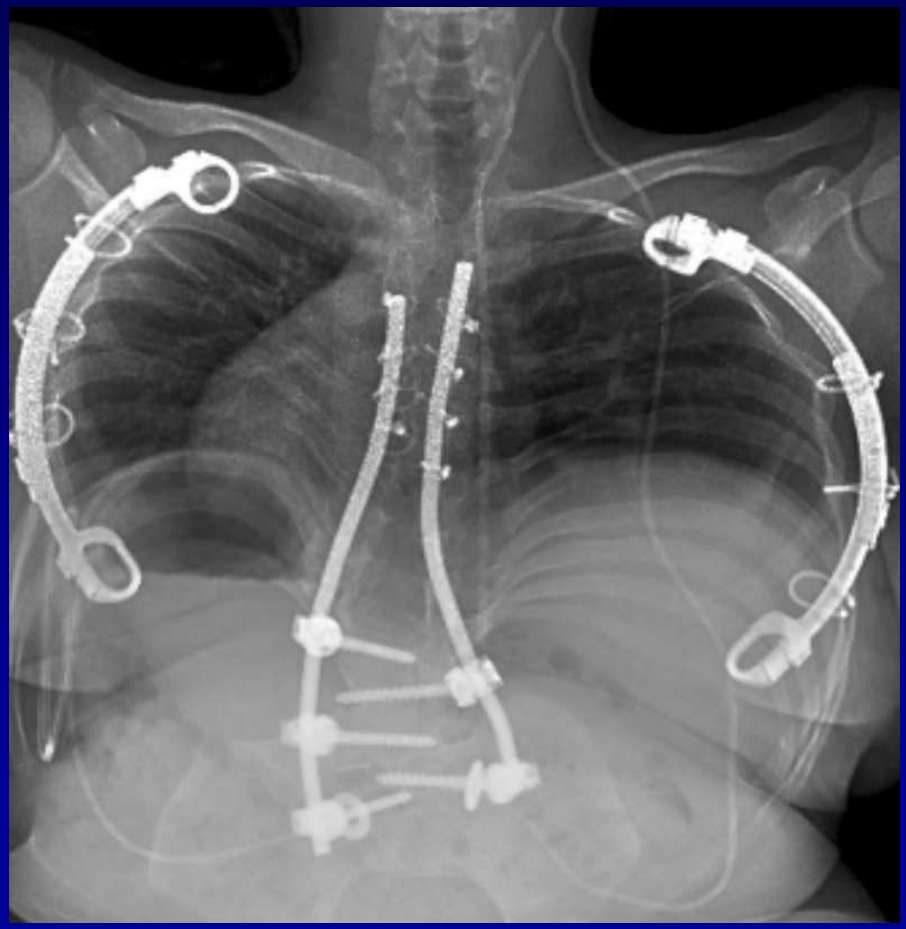
- T1-S1
- T1-T12
- Ratios

T1-S1

- Most curves effect both thoracic and lumbar spine
- T1-S1 is a global measure
- How much do we really care about the lumbar spine?

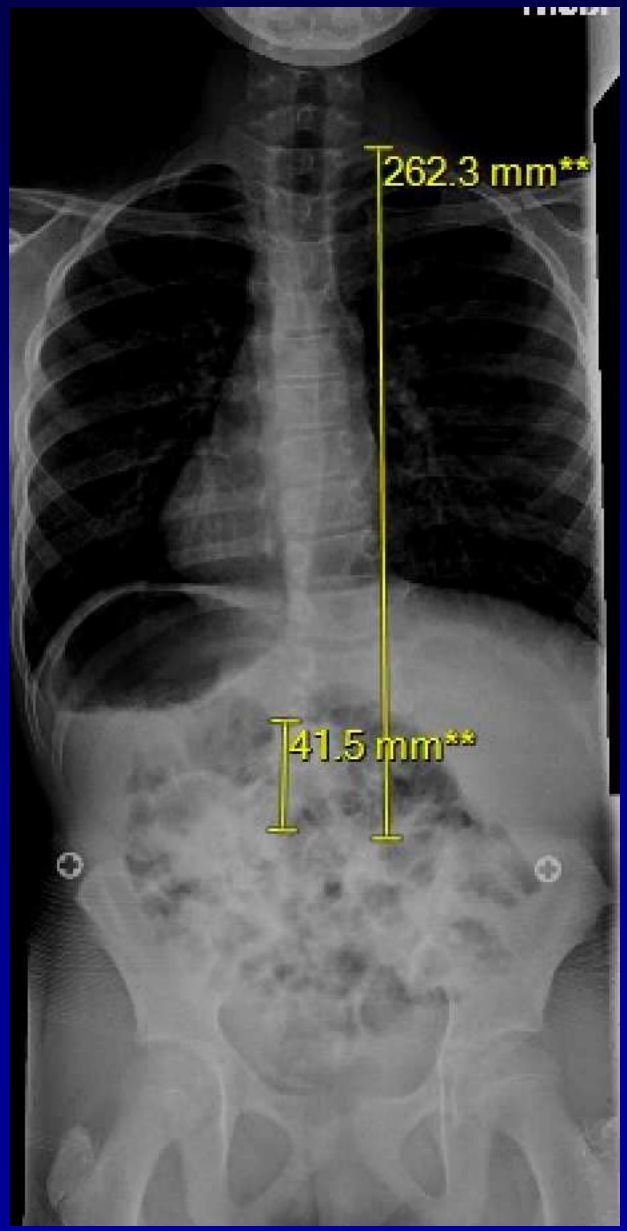
Crowding from Lumbar Spine
McCarthy



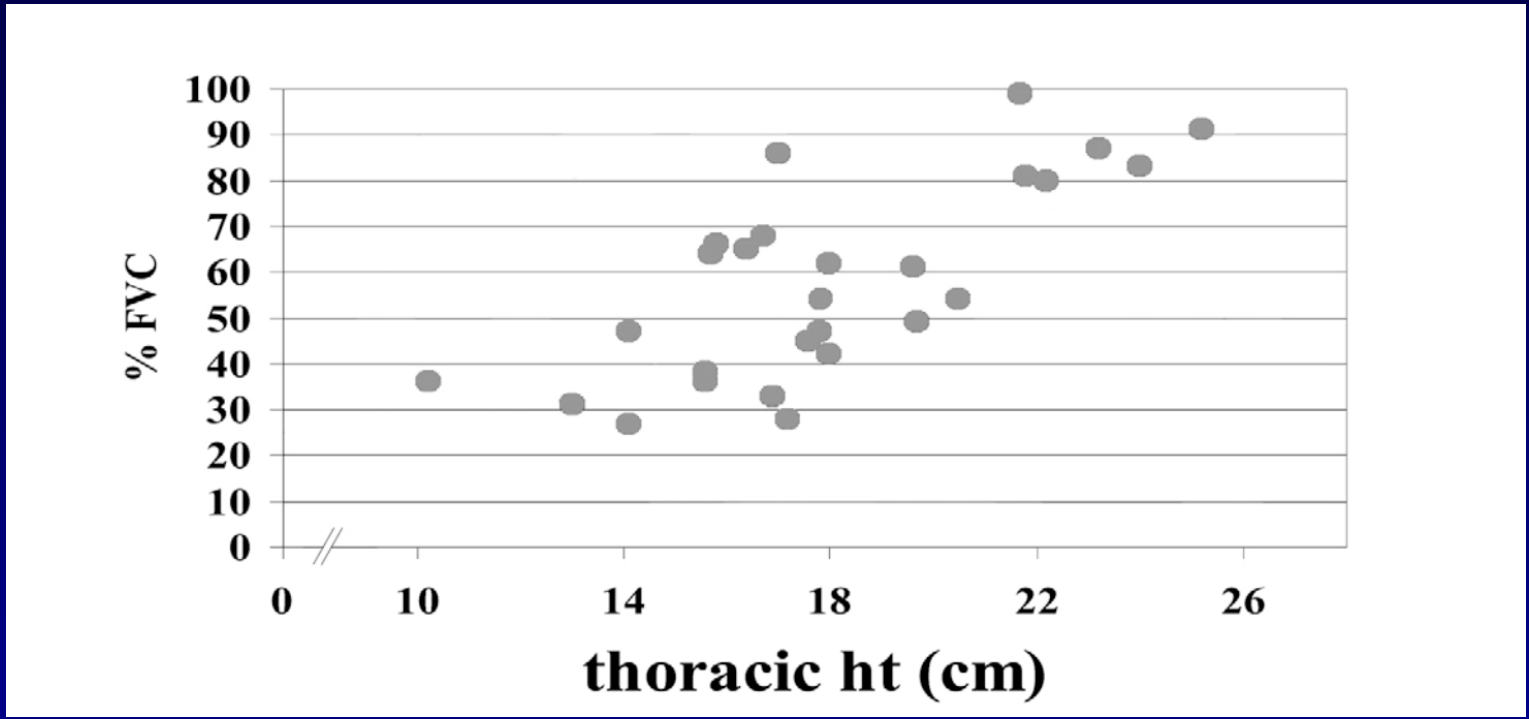


T-S1 and Lumbar Spine Length

- It takes very severe lumbar spine shortening to cause thoracic crowding and pulmonary dysfunction.
- In general, it is the thoracic dimension (excluding crowding) that matters.

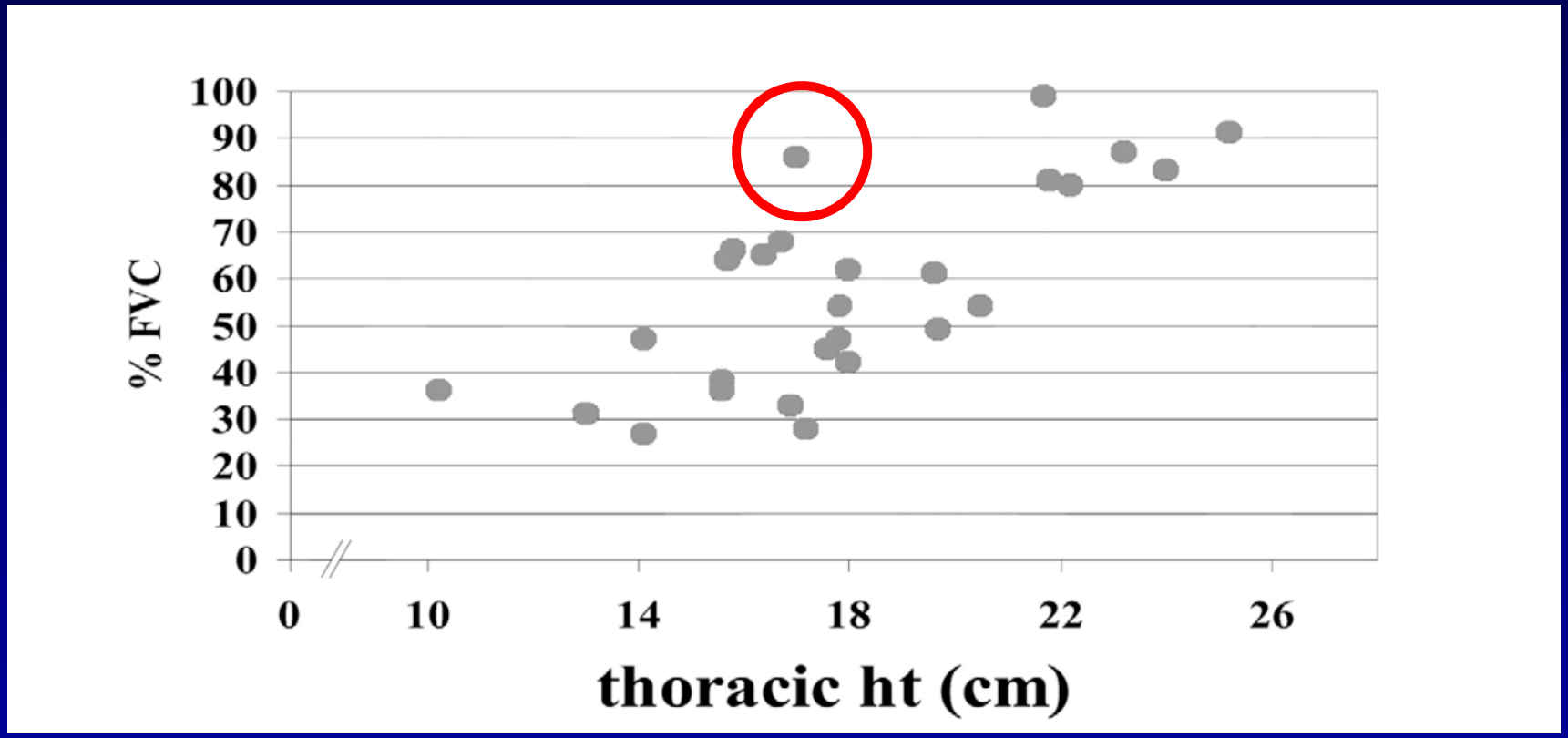


T1-T12



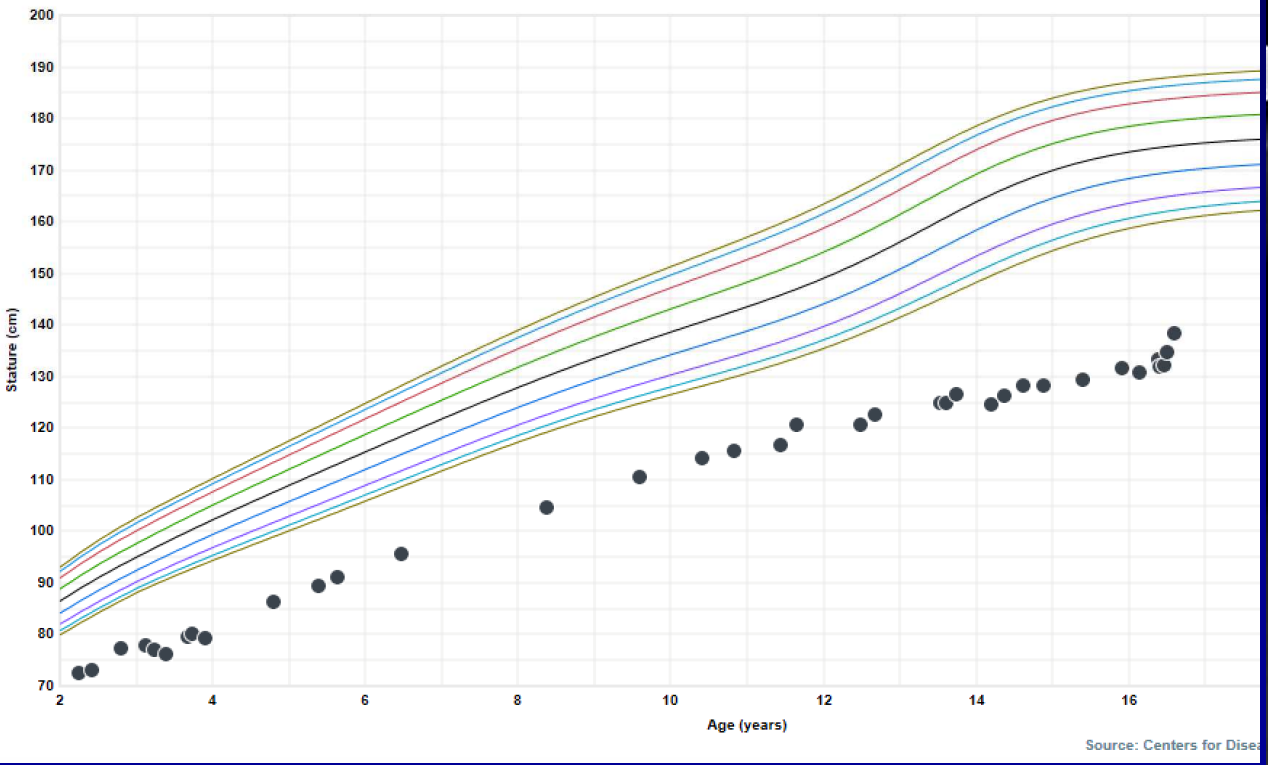
- May be reflective of pulmonary volume
- Correlates with FVC in a cohort with largely congenital scoliosis (20/28)
- All severe curves fused *in situ*

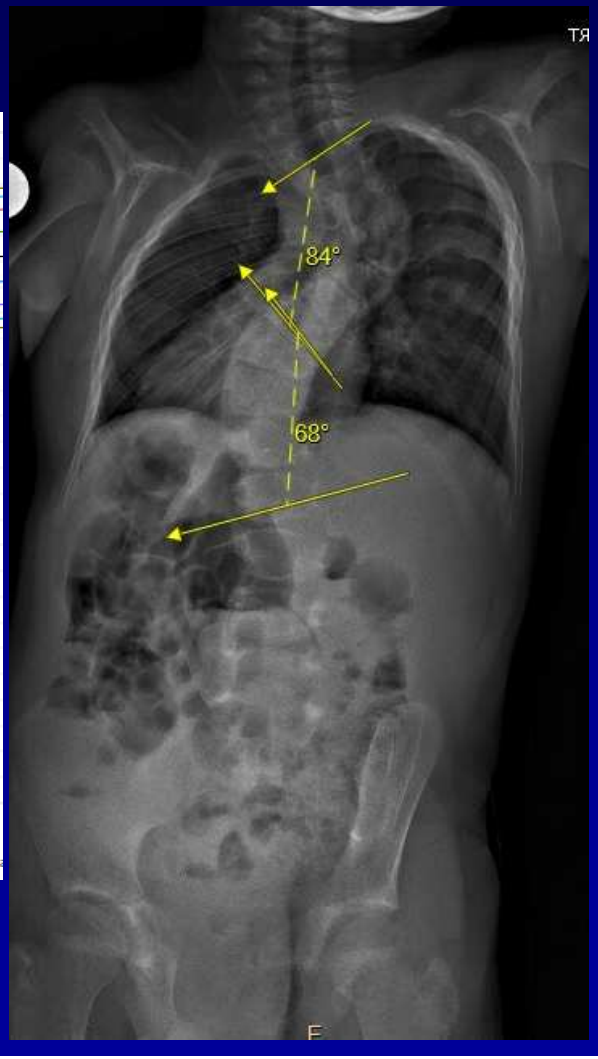
As noted by CJ



- Not all patients with short chests do poorly

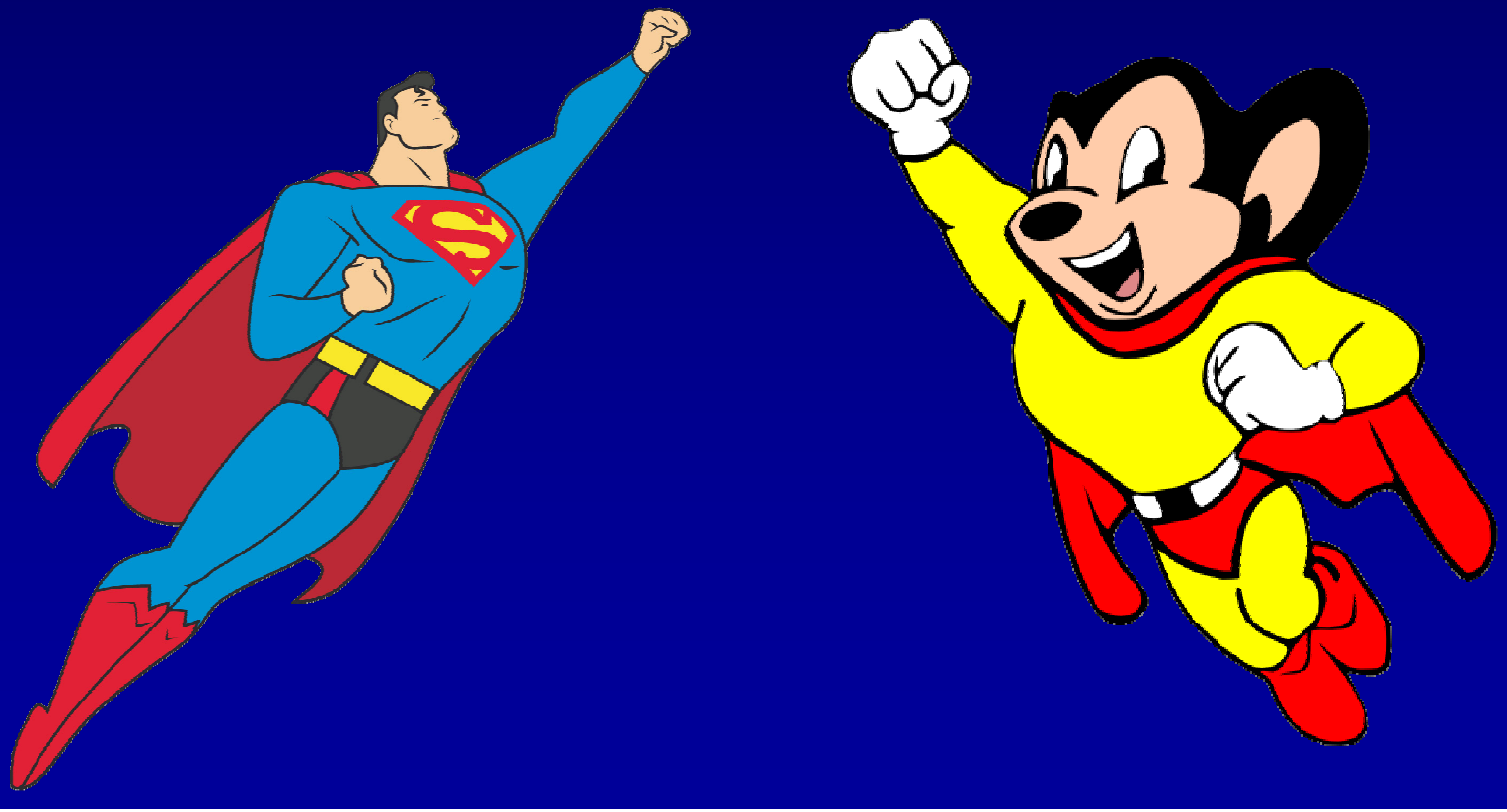
Does this boy with cleidocranial dysostosis need T1-12 of 22cm to function well?



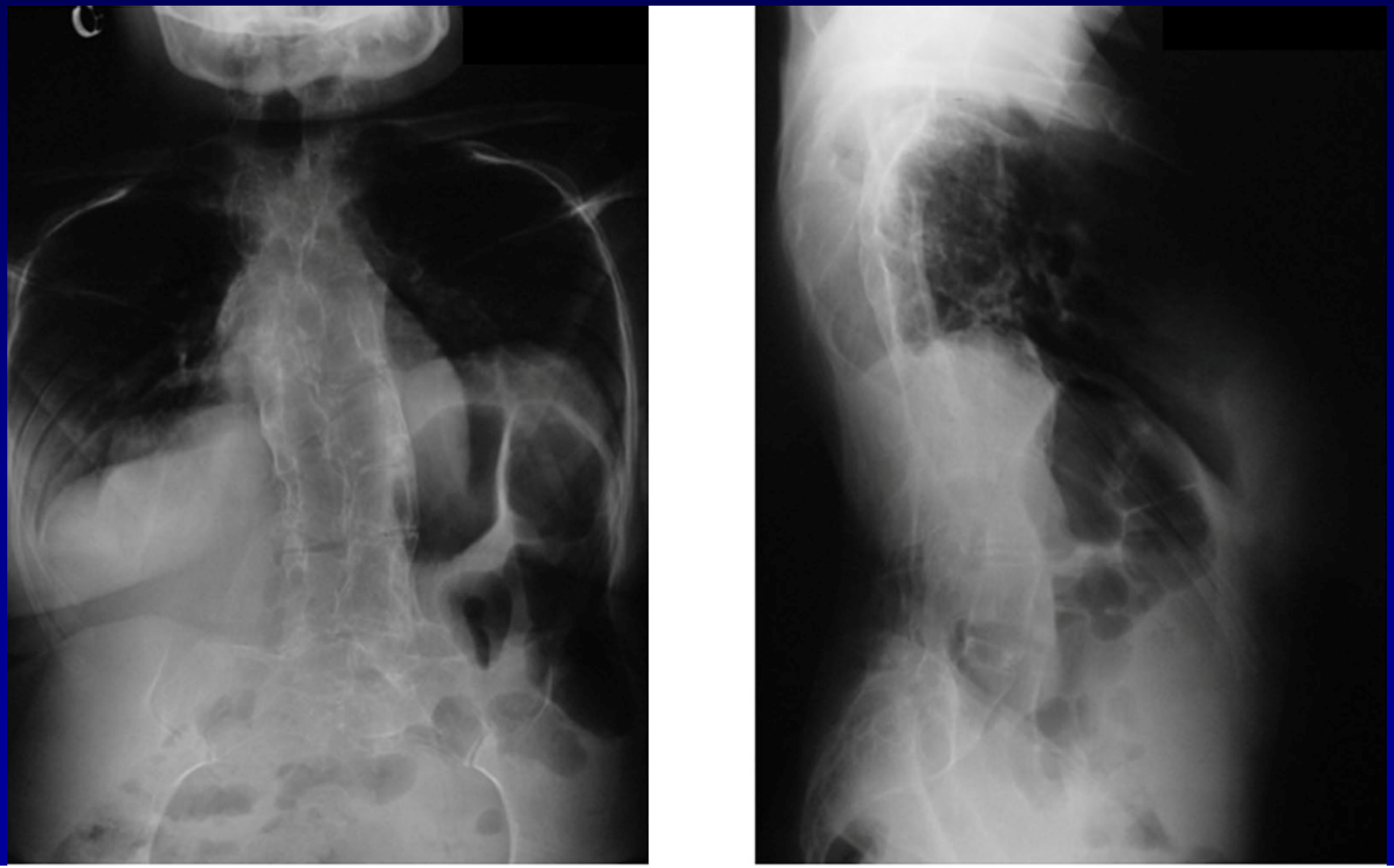


Ultimately, chest growth should match the remainder of the body

A mouse does not need a human sized chest



Spondylothoracic Dysplasia (Ramirez)

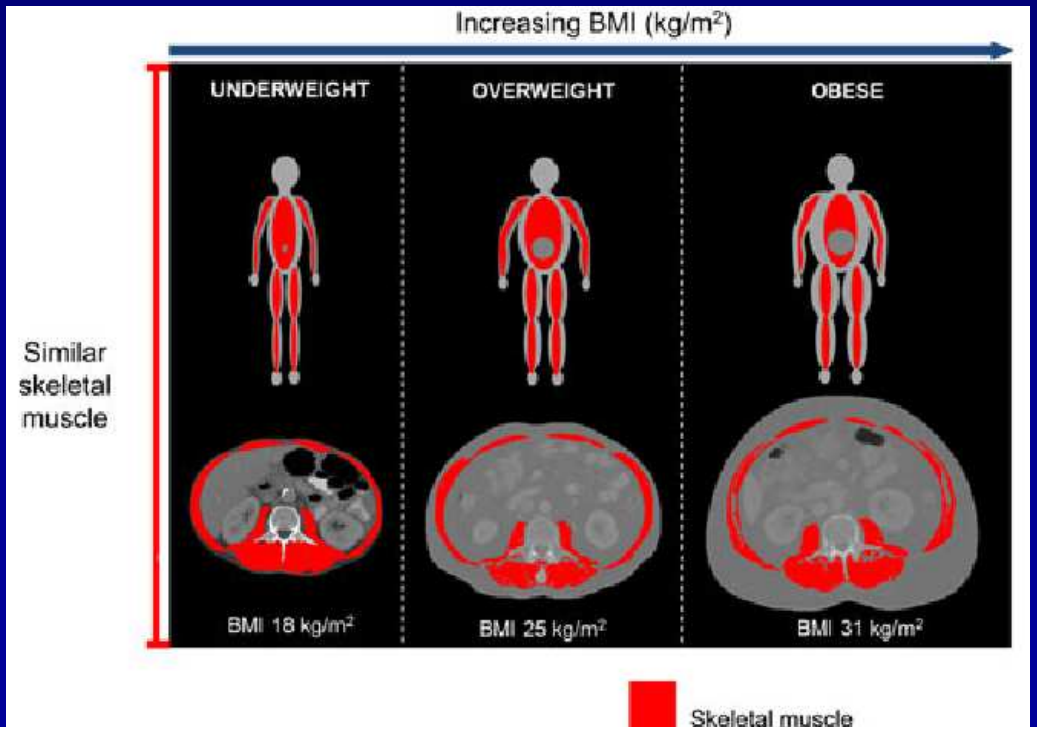


Severe Restrictive Respiratory Pattern

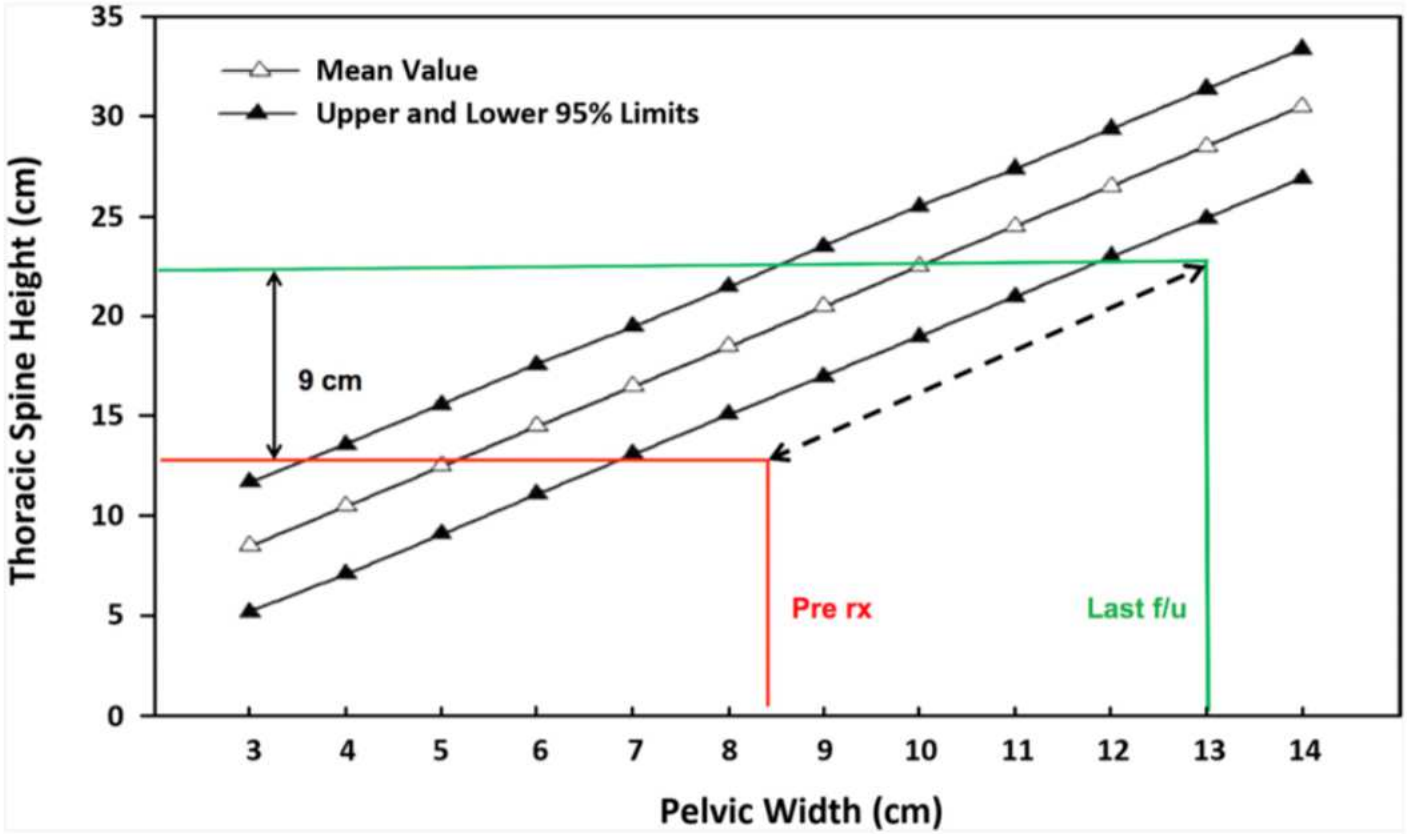
- Average spirometric values 27.9% FVC
- 29.5% predicted FEV1
- 0.92 FEV1/ FVC ratio
- clinically stable restrictive disease with an adequate quality of life not requiring supplemental oxygen in adults
- “It is surprising how well our older patients have done clinically with severe restrictive lung disease secondary to a decreased thoracic height.”

Ratios

- Ratios may be more reflective of patient size and pulmonary need than absolute measurements.
- Much like BMI is a better measure of cachexia or obesity than weight alone.

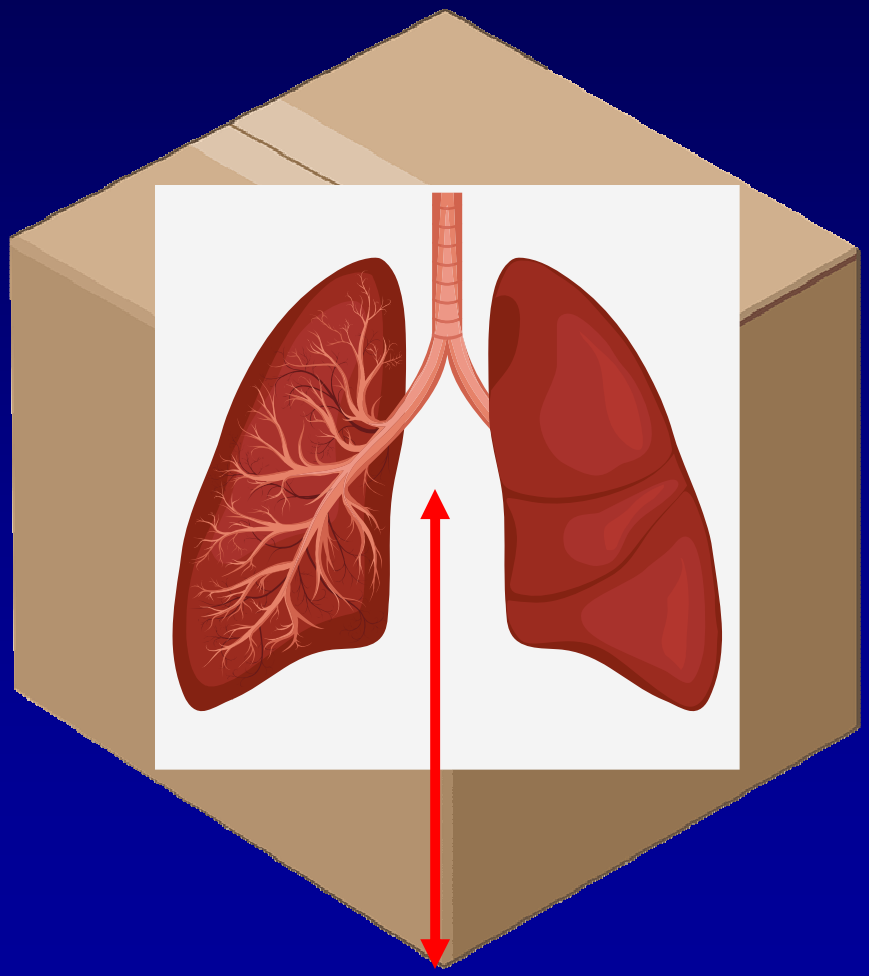


Pelvic Width to Height (Emans, Johnston):



The Orthopedic Concept

- The chest is a box with the spine creating the vertical component
- All current EOS devices work to make a static box bigger.
- Does not account for the dynamic nature of breathing



We need a paradigm change for EOS

- It’s not just a bigger box.
- It’s dynamic expansion and contraction with a bigger box –a larger, more effect bellows.

How do we get there?

- T1-S1
  - Relate to age in childhood
  - Relate to PHV during adolescence
  - Not as important as chest growth for lung function
- Use PSSG data to correlate mature PFT with T1-T12 ratios to:
  - BMI
  - Height
  - Pelvic width
- Think more about chest dynamics rather than purely a bigger box.