Coupled Symmetry and Proportional Expansion of the Ribs Thorough Adolescence

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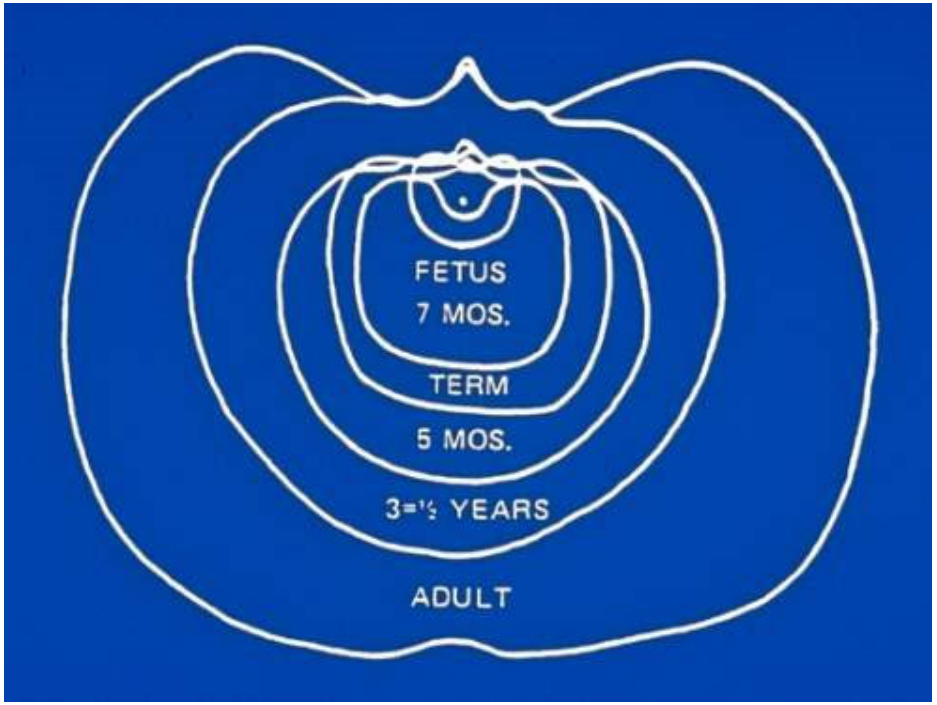
Disclosures

- POSNA Board of Directors
- AAP Chair Section on Orthopaedics
- No financial conflicts with this talk

Introduction

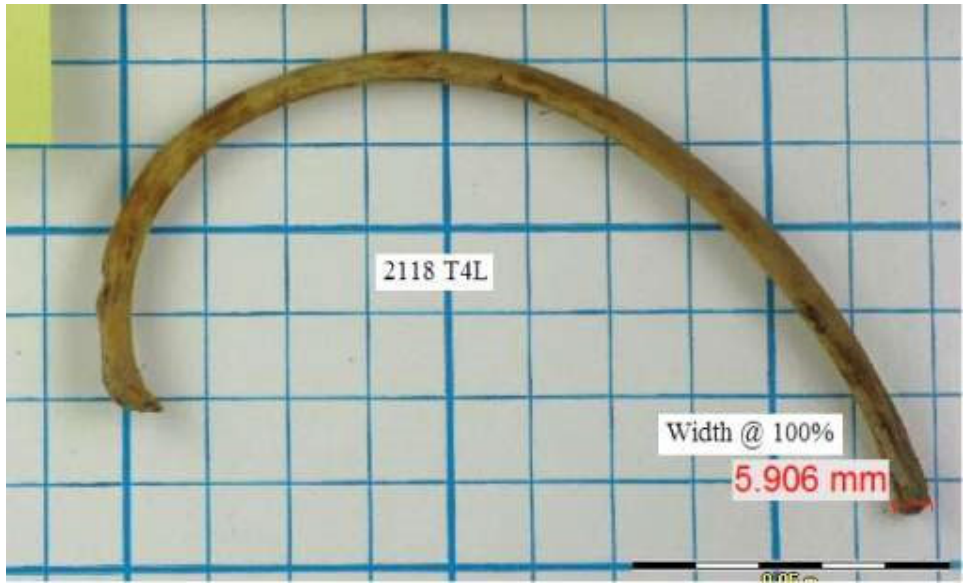
- Thoracic spine deformity is intimately involved with rib anatomy and growth



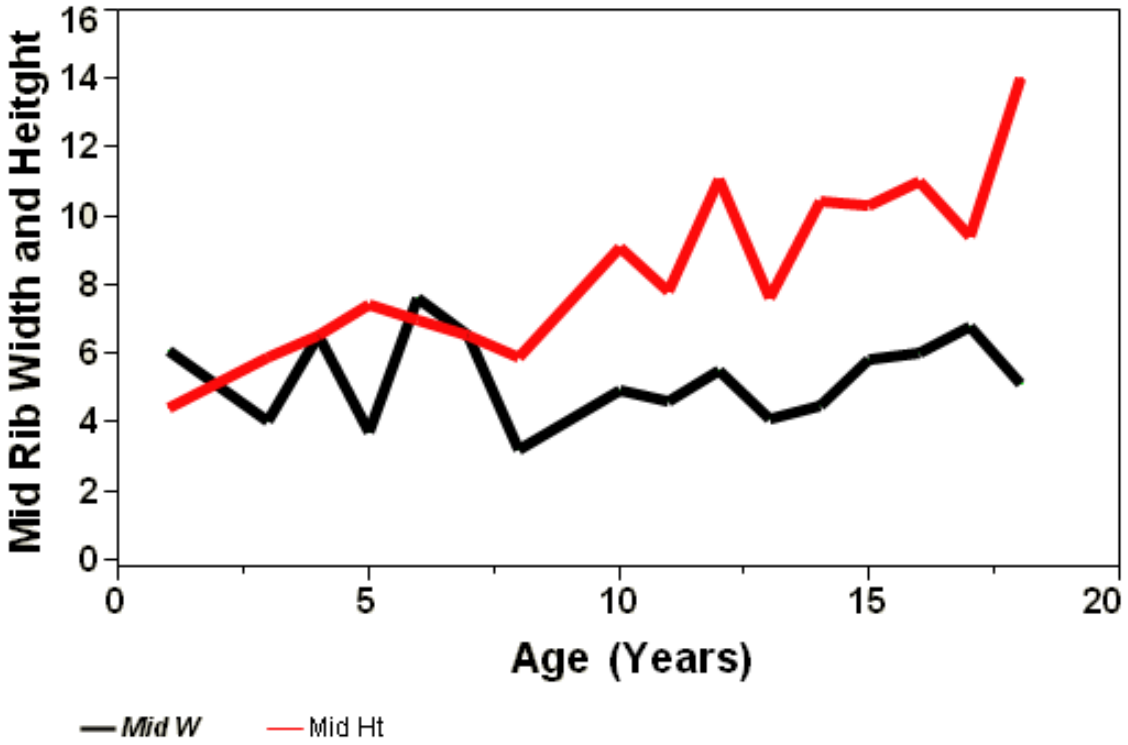
Thorsax volume doubles
age 10y to adult

Purpose: Describe the changing rib length and shape during childhood to gain insight into

- normal thoracic shape
- volume increase with age
- thoracic deformity



Growth of Rib- Height/Width



- **Rib height is approximately one half adult height by one year of age and increases more than width with age,**
- **Hamann Todd Osteology studies**

Methods

- 31 unaltered, normal specimens (722 ribs), ages 1-18 years.
- Hamann-Todd Human Osteology Collection, Cleveland
- Photographed in cranial view, calibrated, enhanced, measured for outer costal length and base diameter of each rib.
- Calculation rate of costal length growth and (2D) projected rib area.

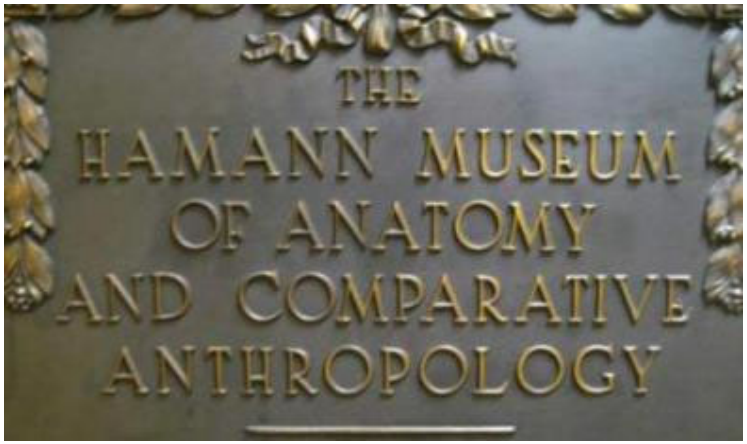
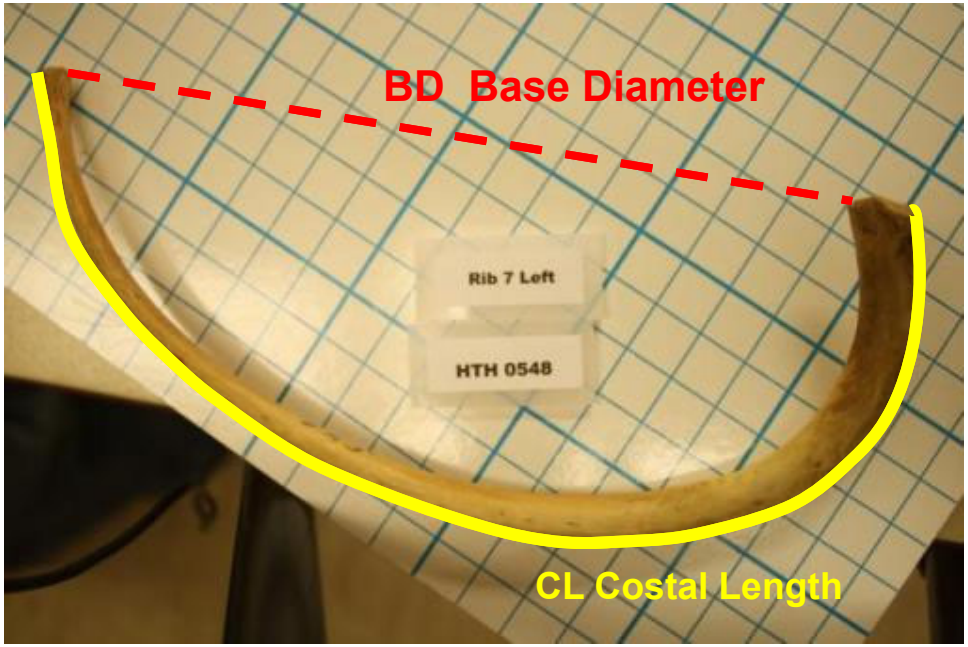


Image Analysis Definitions



CL: Costal Length = the total curved length of the rib

BD: Base Diameter = linear distance to rib ends

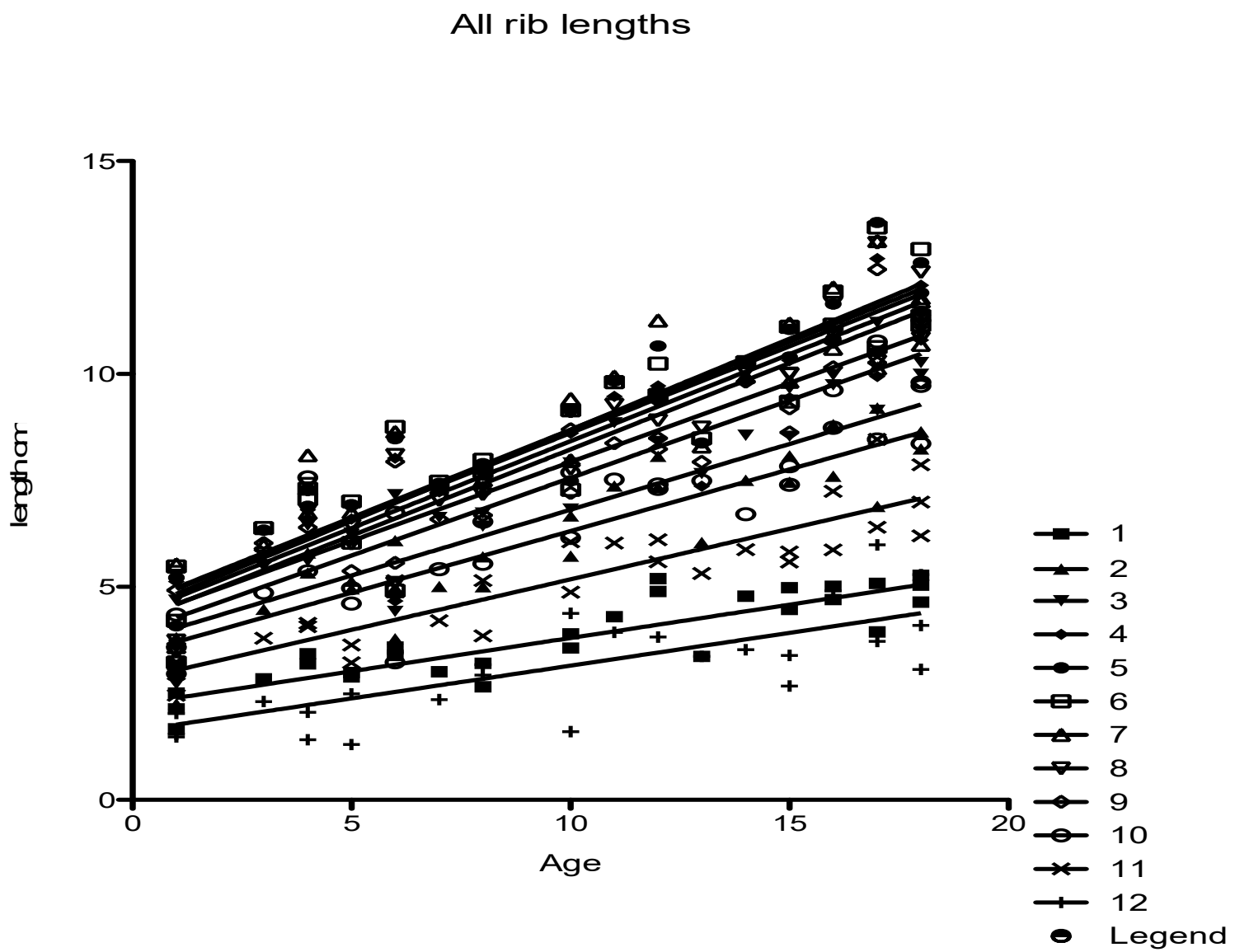
CL X BD = projected surface area of the rib

The scale in the background is used to calibrate each image

Results- Linear Growth

- Linear regressions showed that the thorax can be divided into three sections based on rib growth, measured as the slope of the lines.
- All ribs showed linear growth rates of the costal length.
- The costal length of ribs 4-8 grow the fastest, at the same rate of 0.4 cm/year - 2.6-2.7 times faster than rib 1.

Outer Costal Rib Length With Age

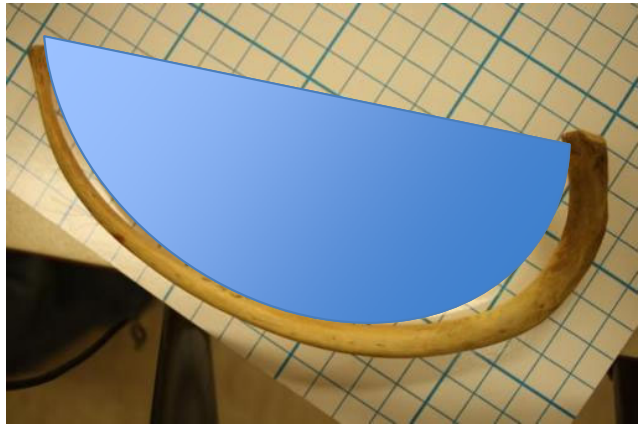


Paired Symmetry of Linear Growth

- There is paired symmetry, with ribs 1 and 12, 2 and 11, 3 and 10 showing nearly identical growth rates.
- There was no acceleration of costal length growth rate during adolescence.
- Left and right linear growth is symmetric

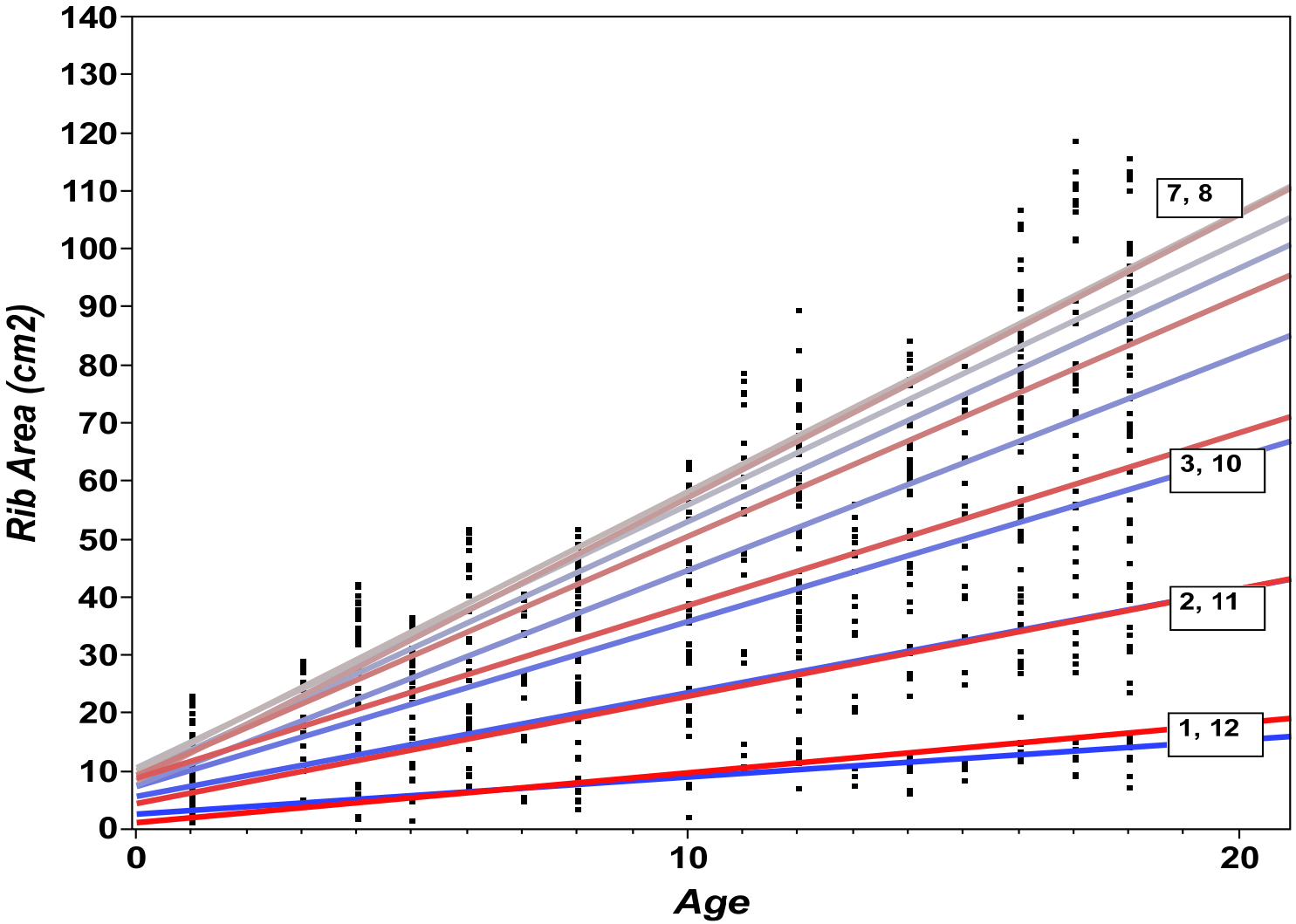
Results Projected Rib Area Growth

- The projected rib area growth rate of ribs 4-8 have an increasing growth rate…
- Rib 4 5.8x
  Rib 5 6.8
  Rib 6 7.1
  Rib 7 7.5
  Rib 8 7.6

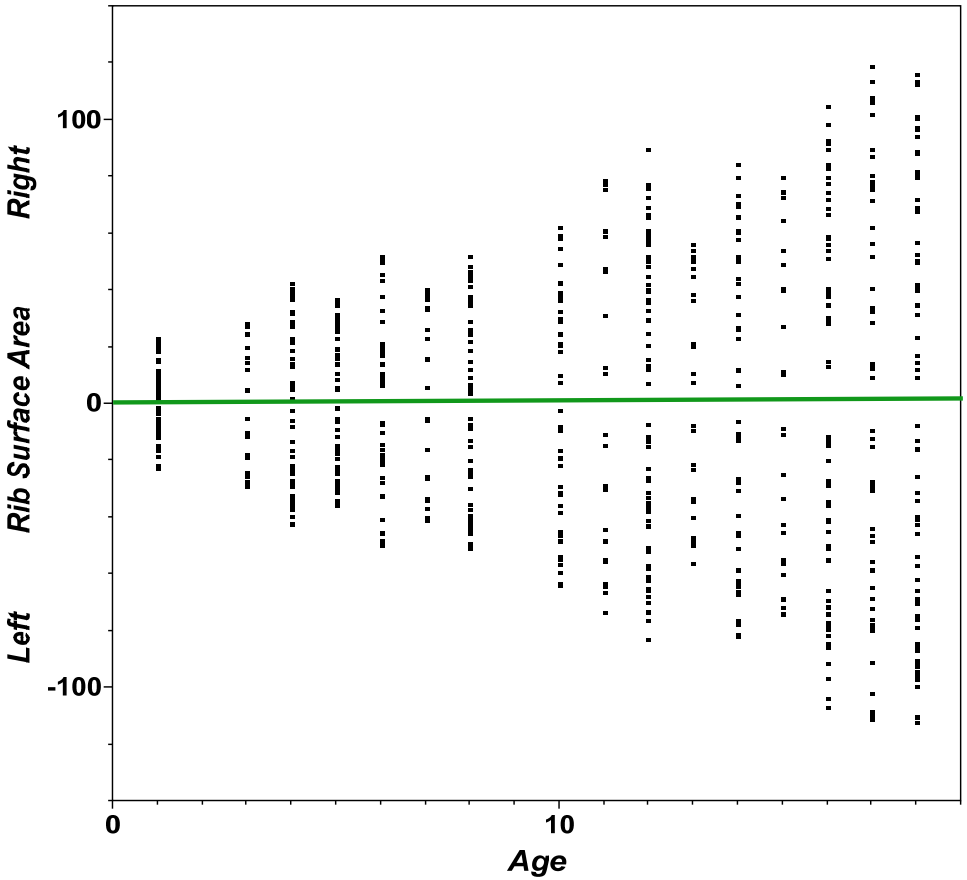


times faster growth rate than rib 1.

Projected Rib Area (cm2) with age



Rib Symmetry Right-Left



Left and right sides have symmetric growth.

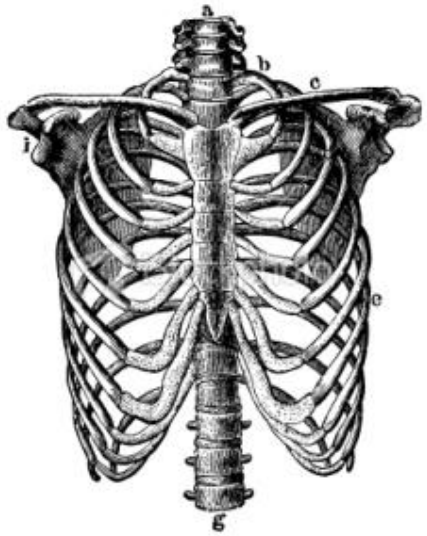
The symmetrical growth is demonstrated by looking at the projected area of each rib, each patient, at each age.

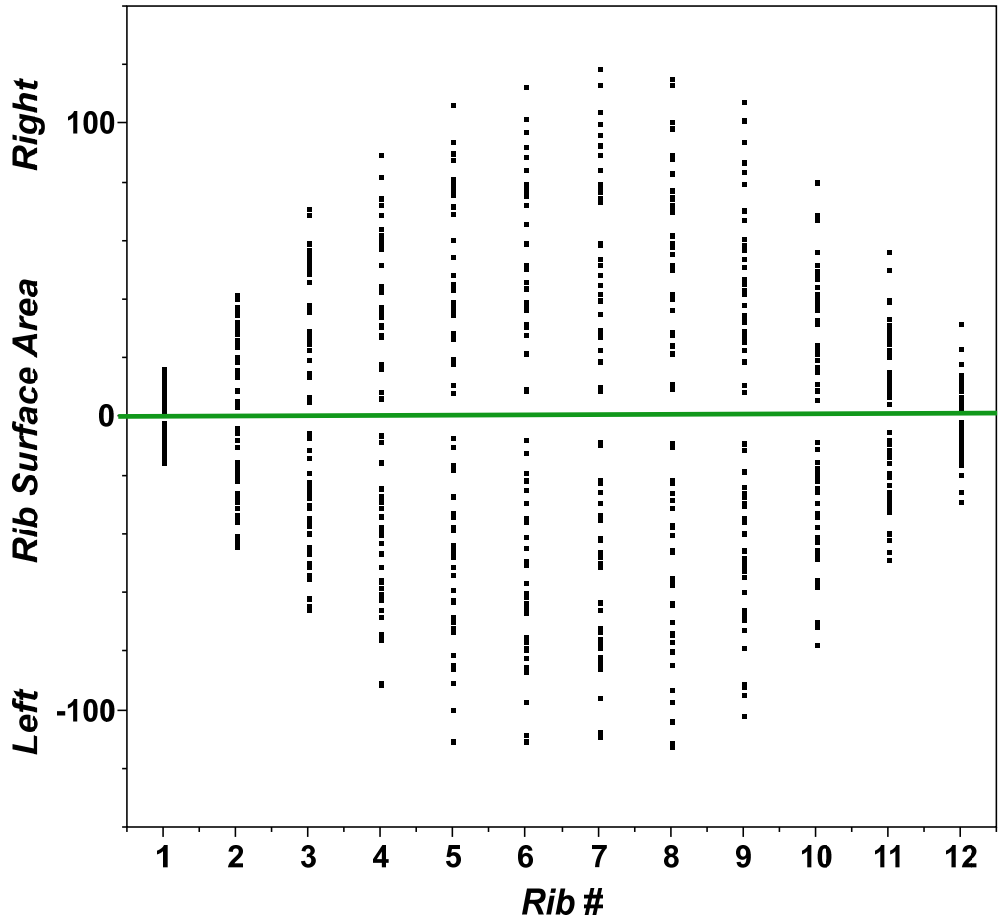
Symmetry on either side of the green line.

Rib Symmetry Proximal/Distal

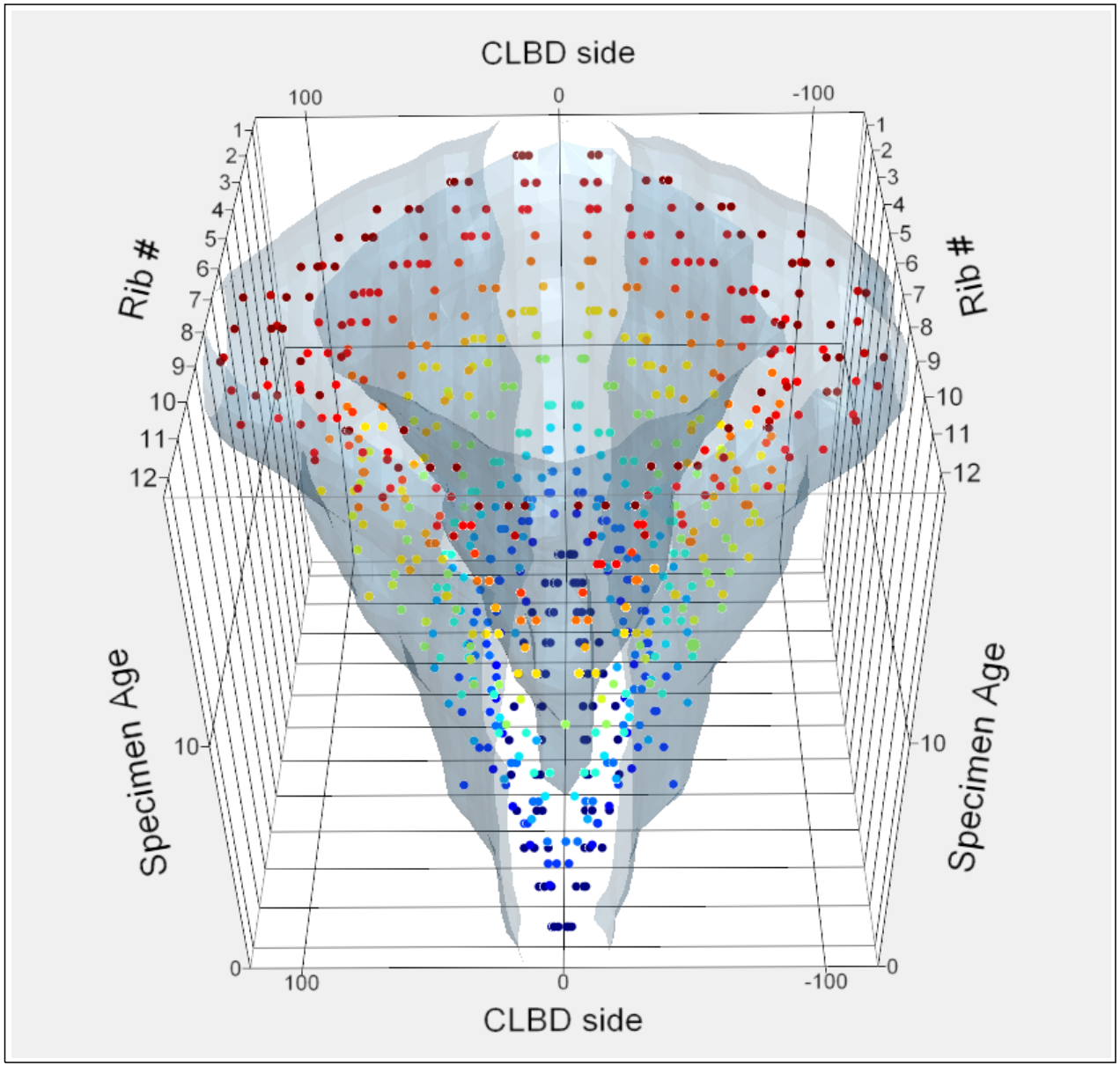
Symmetry of the thorax (barrel chested nature of humans) .

Projected area of the ribs plotted by rib number. Younger patients (age 1) are close to the green line while the 18 yo are the farthest away.



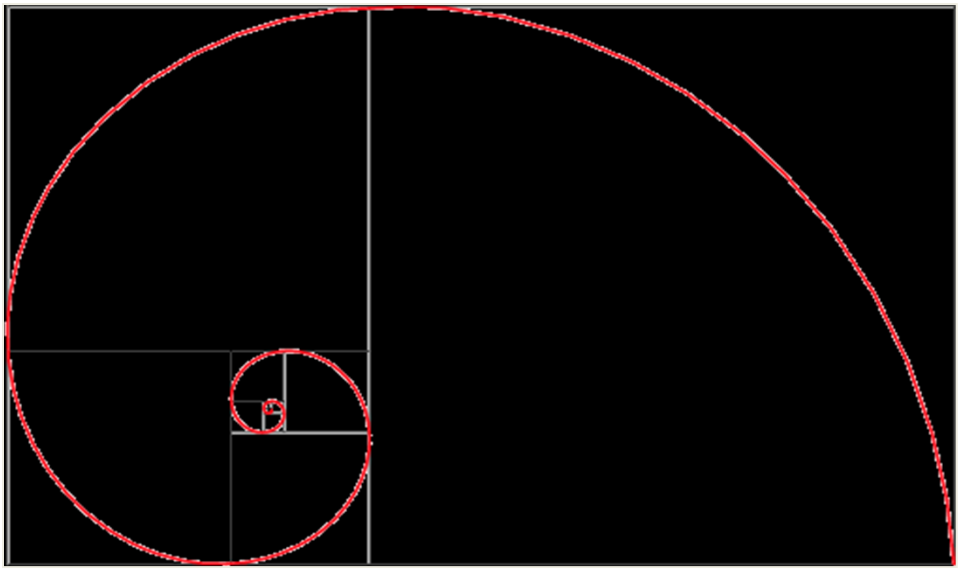


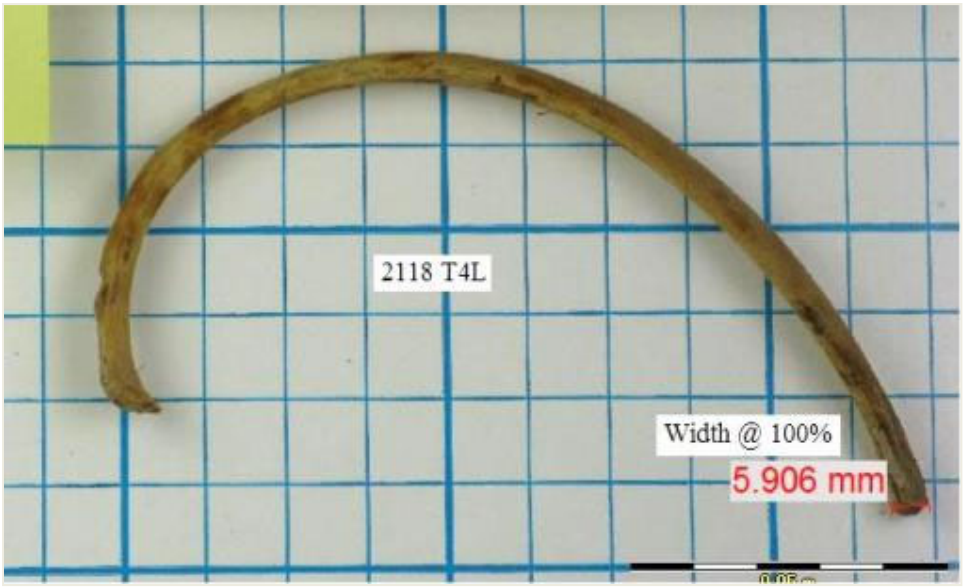
Proportional Expansion

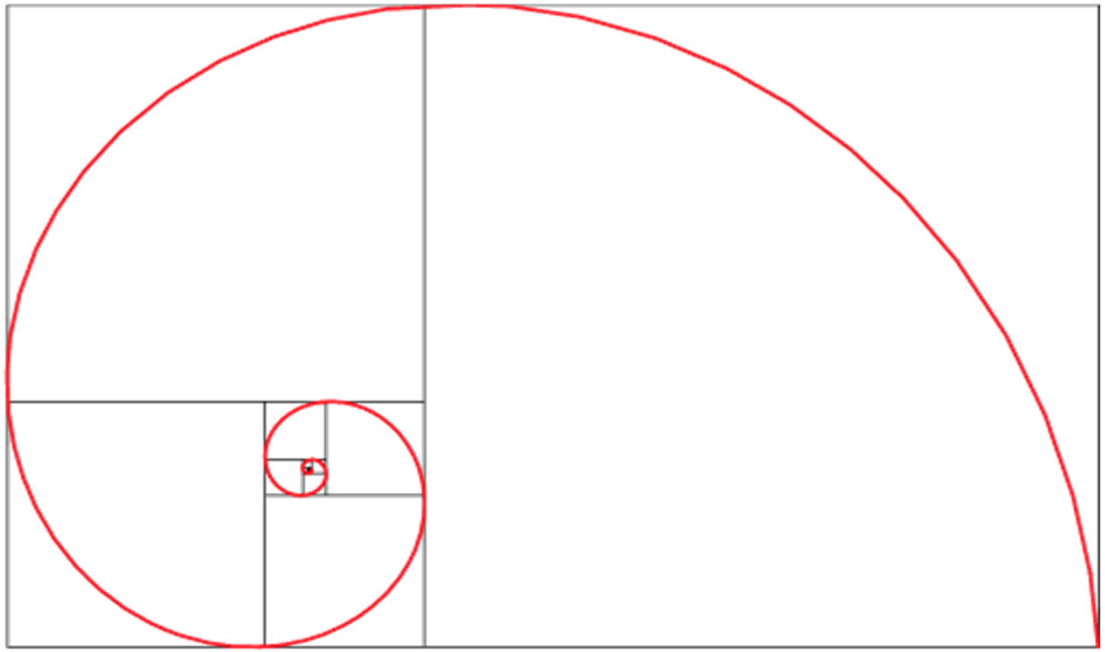


Results: Ribs Golden Spiral

- **Ratio of 1.618: 1**
- **Found throughout nature**
- **Ribs follow it (<10% error)**



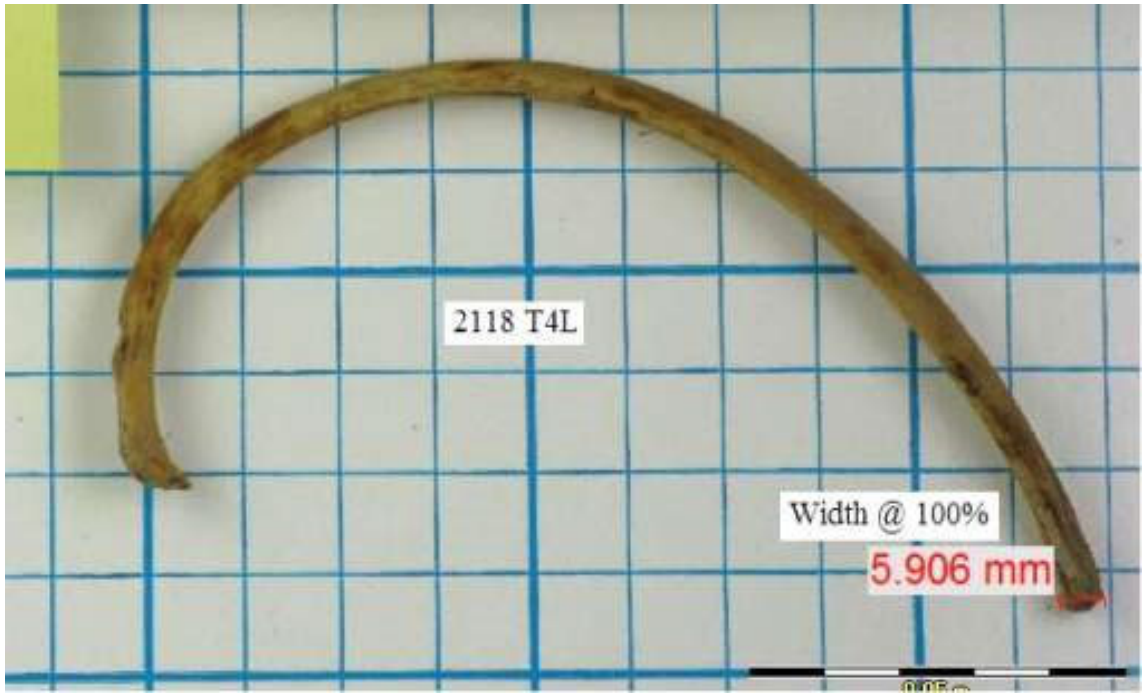




How does Lung volume doubles age 10 years to adulthood?

Rib grows more at its sternal end.

Similar to a nautilus shell.



Summary: Coupled Symmetry and Proportional Expansion of Ribs through Adolescence

- Thorax follows symmetric coupling r/l and proximal/distal.
- Constant rib linear growth rates throughout childhood with the middle ribs growing the fastest,about 2.6 times that of rib #1.
- The projected area of ribs likewise had constant growth rates- middle ribs- greatest rates of growth, about 7.5x that of rib #1.
- The faster growth the middle ribs and golden spiral growth pattern of all ribs results in the barrel chest of an older human.