MADRID

2007

THE GROWING SPINE

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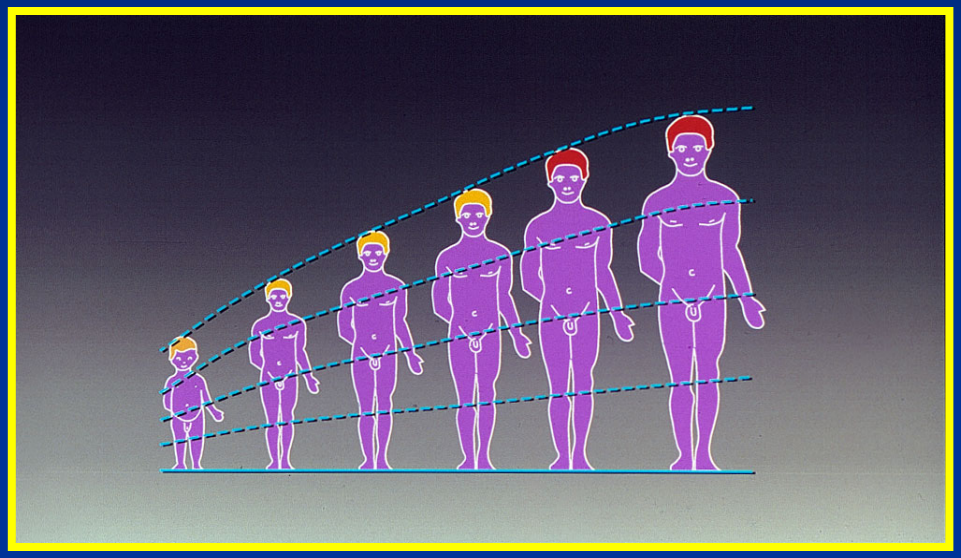
. Montpellier

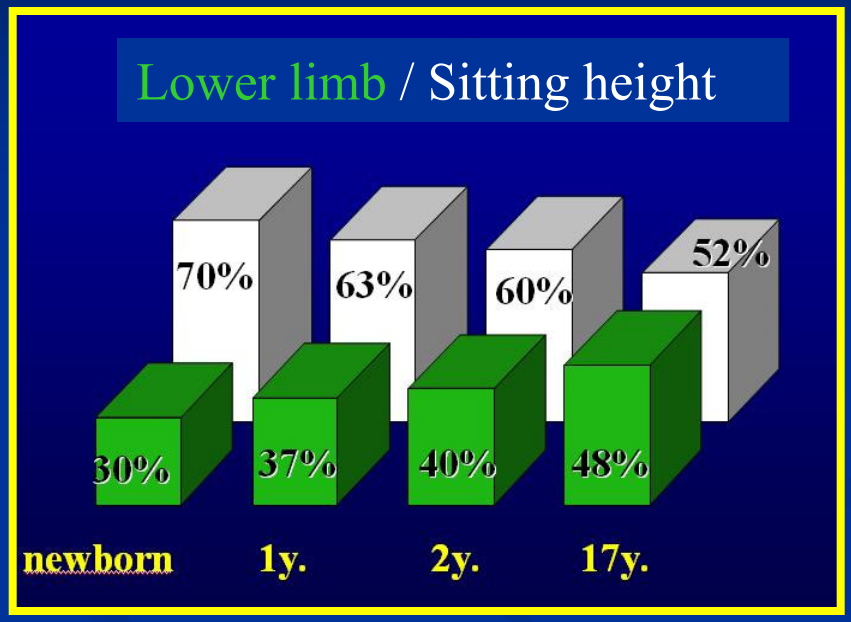
The growing spine

- Mosaic of growth plates
- Changes in rhythm
- All parameters do not progress at the same speed
- The thorax is the fourth dimension

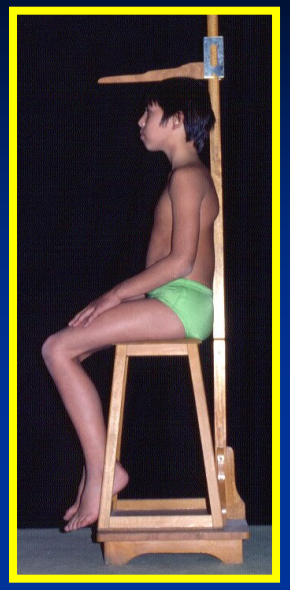
- Challenging the growing spine means how to maintain the spinal growth, the thoracic growth, the lung growth and keep the spine supple

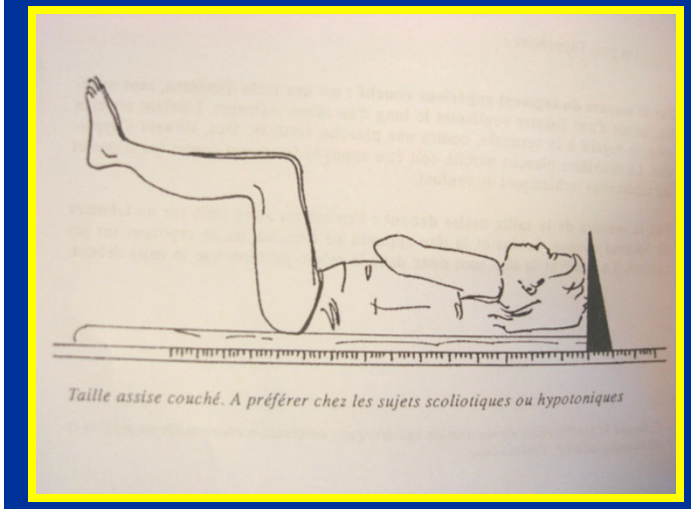
“Growth is a change in proportions”





	Sitting height	Subischial leg length
Birth	35 cm	18 cm
Skeletal maturity	93 cm	81 cm
Gain	58 cm	63 cm





MEASUREMENT EACH 6 MONTHS

ANNUAL GROWTH VELOCITY

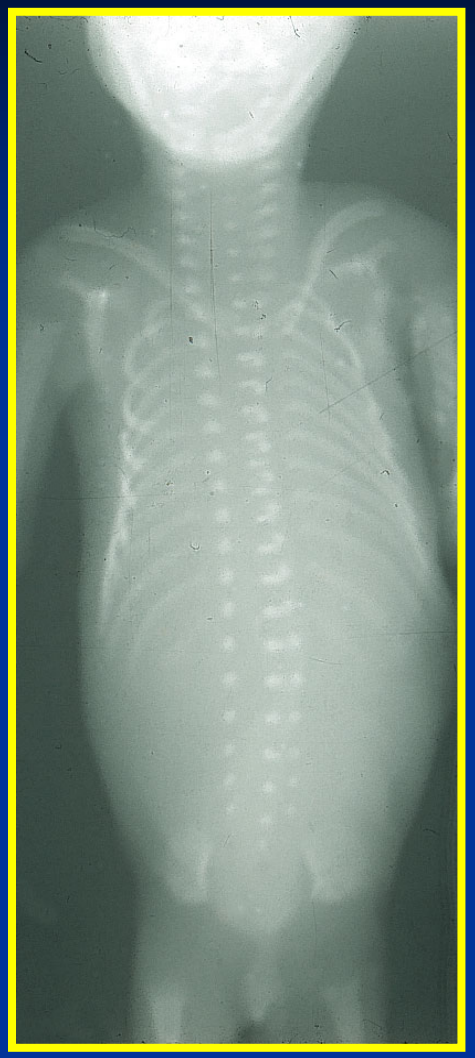
WEIGHT

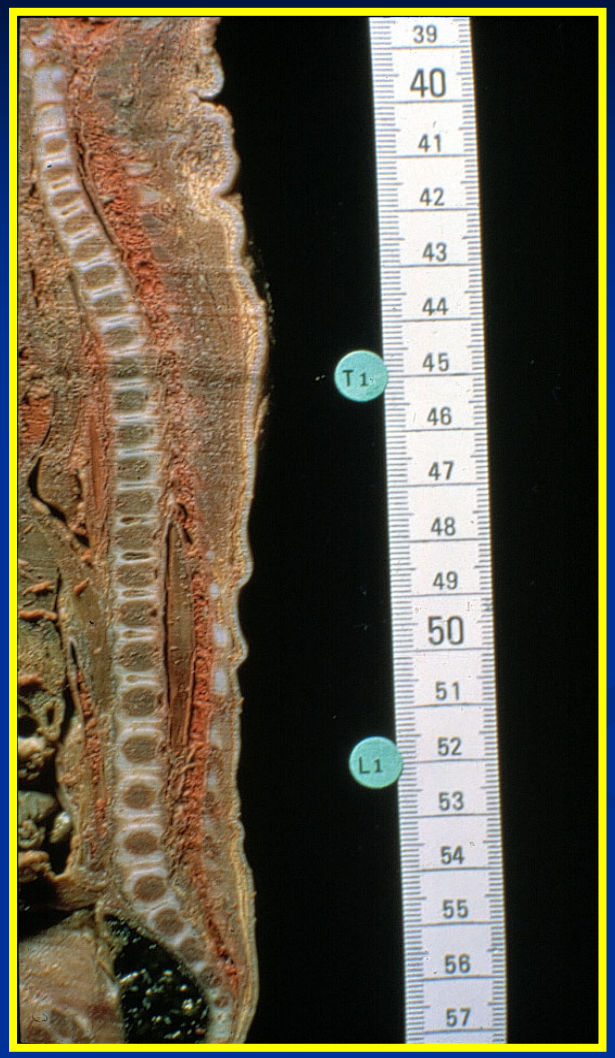
Birth: 3.5 Kg

5 y: 20 Kg

10 y: 30 Kg

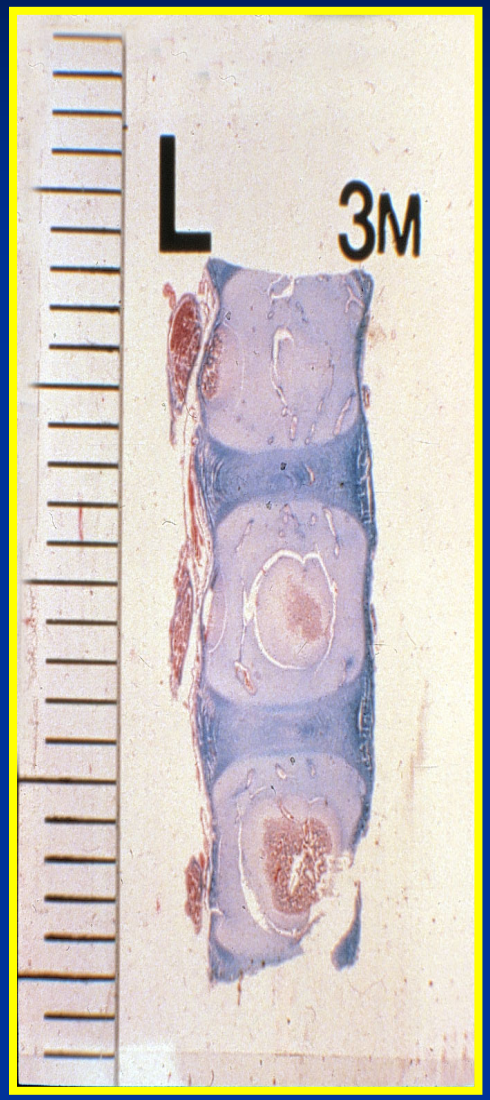
The weight doubles from 10 to skeletal maturity





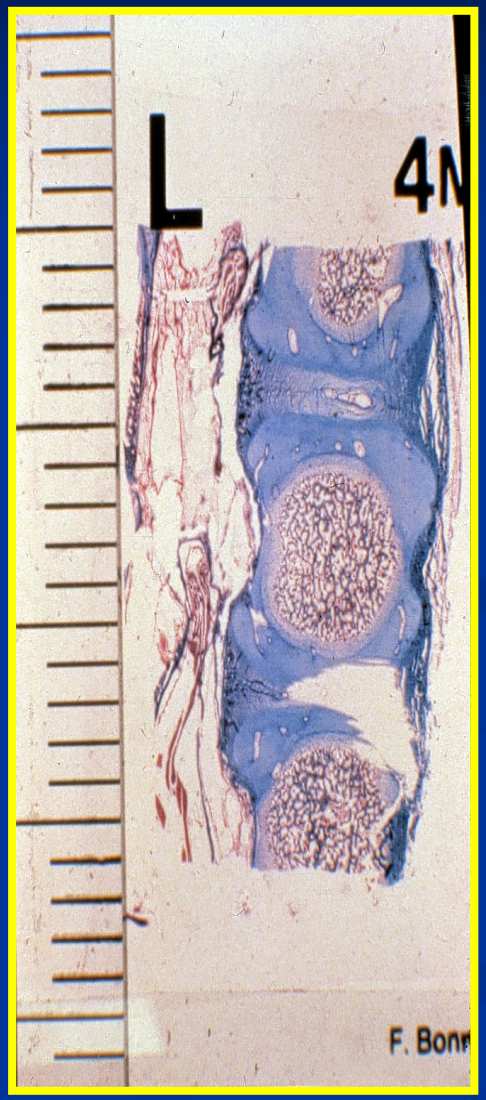
Ossification starts at the third month of intra-uterine life

3 months
intra-uterine life



Lentil

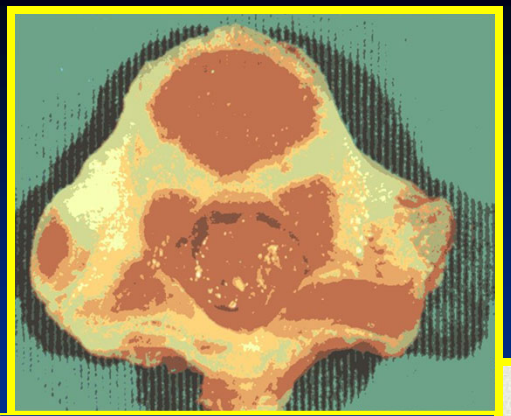
4 months
intra-uterine life



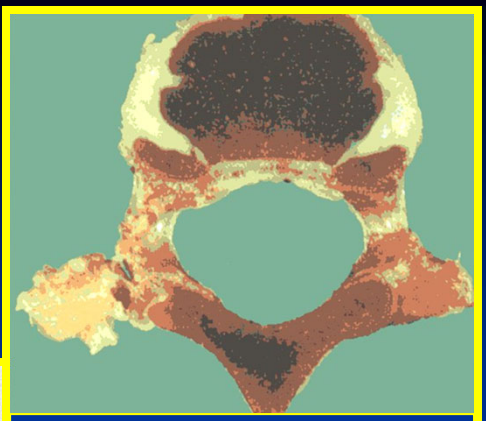
Ovoid

8 years

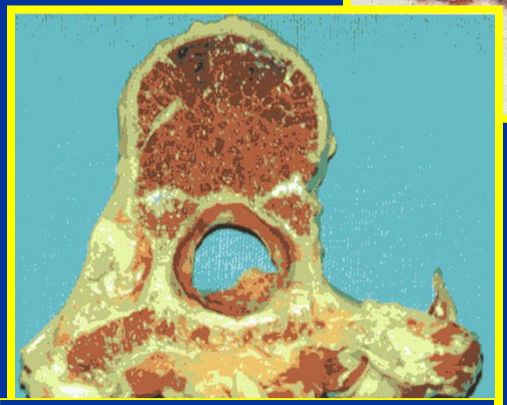
Rectangular



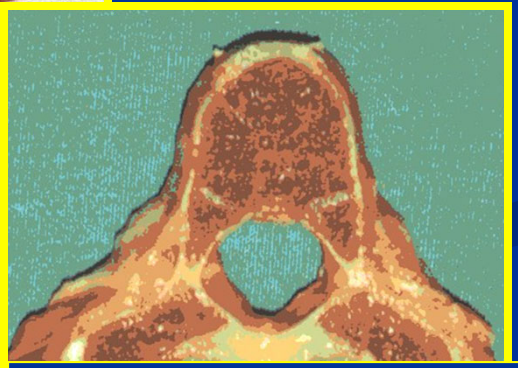
3 Months



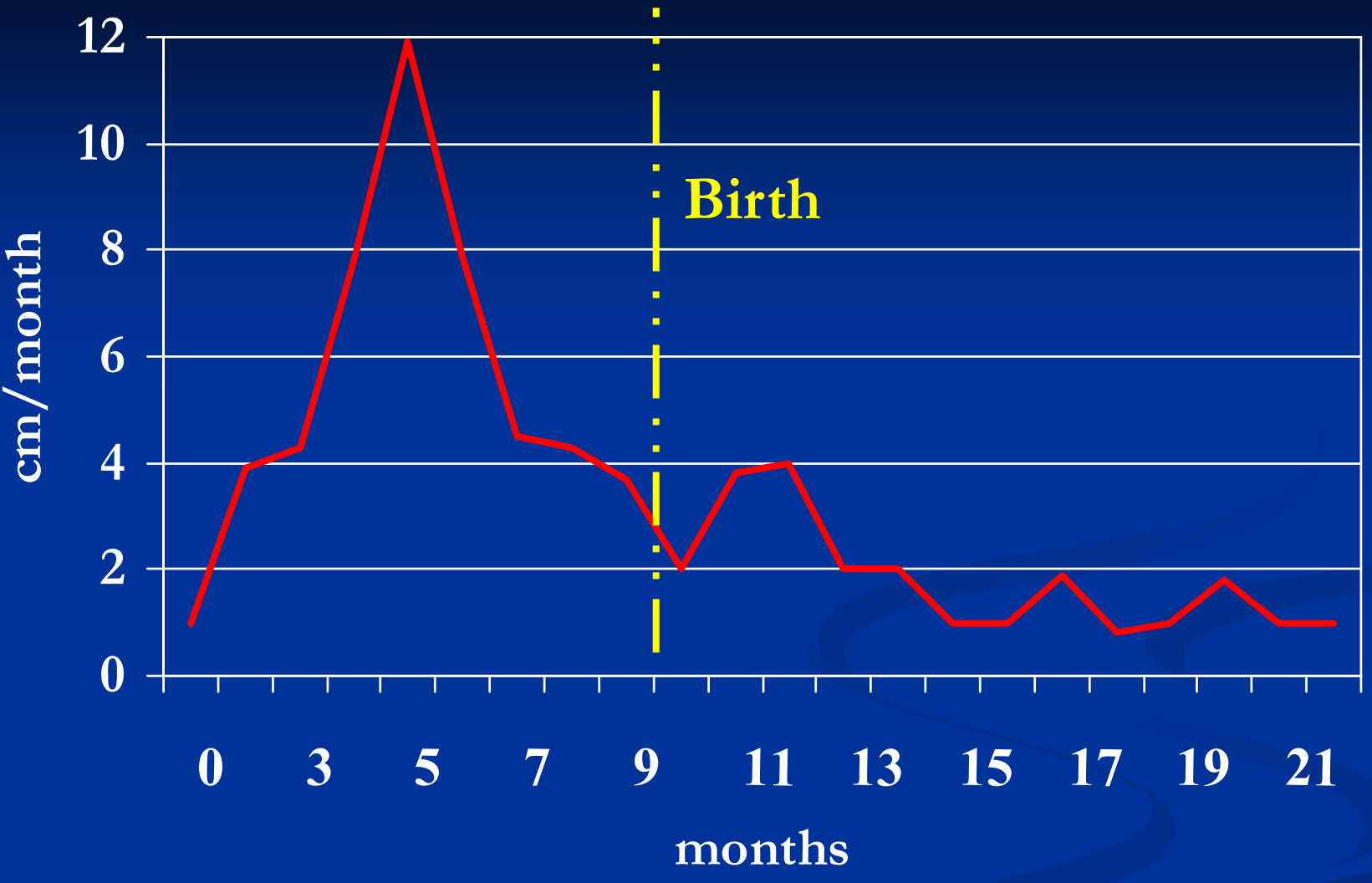
2 Years



9 Years

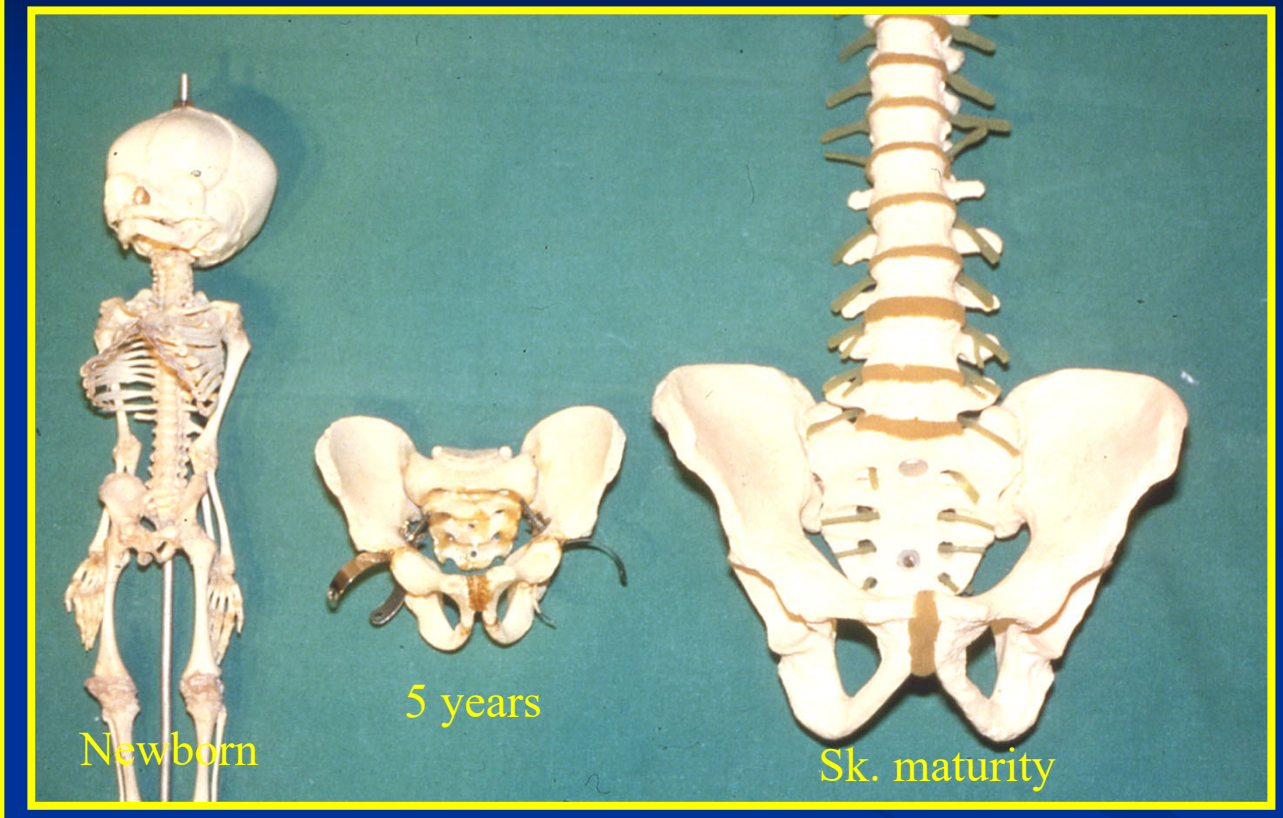


11 Years

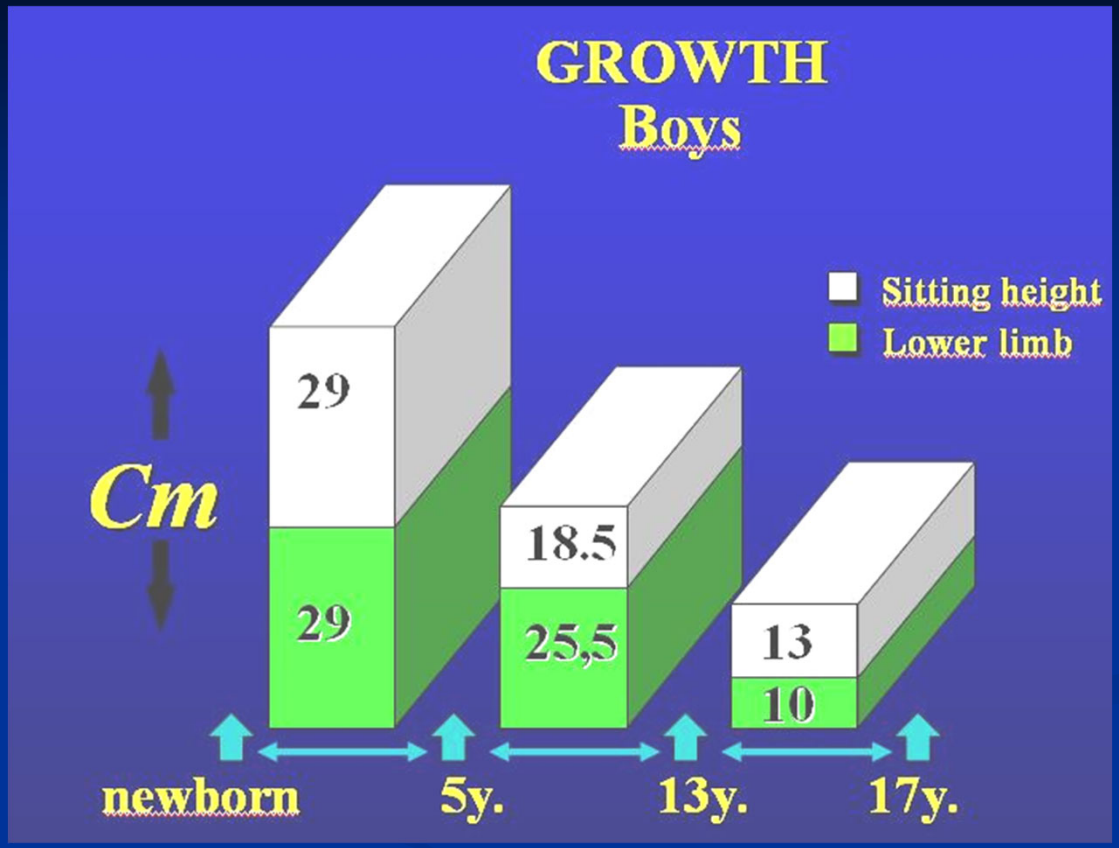


The fastest growth occurs during the intra-uterine period.
As early as birth growth already begins to slow.

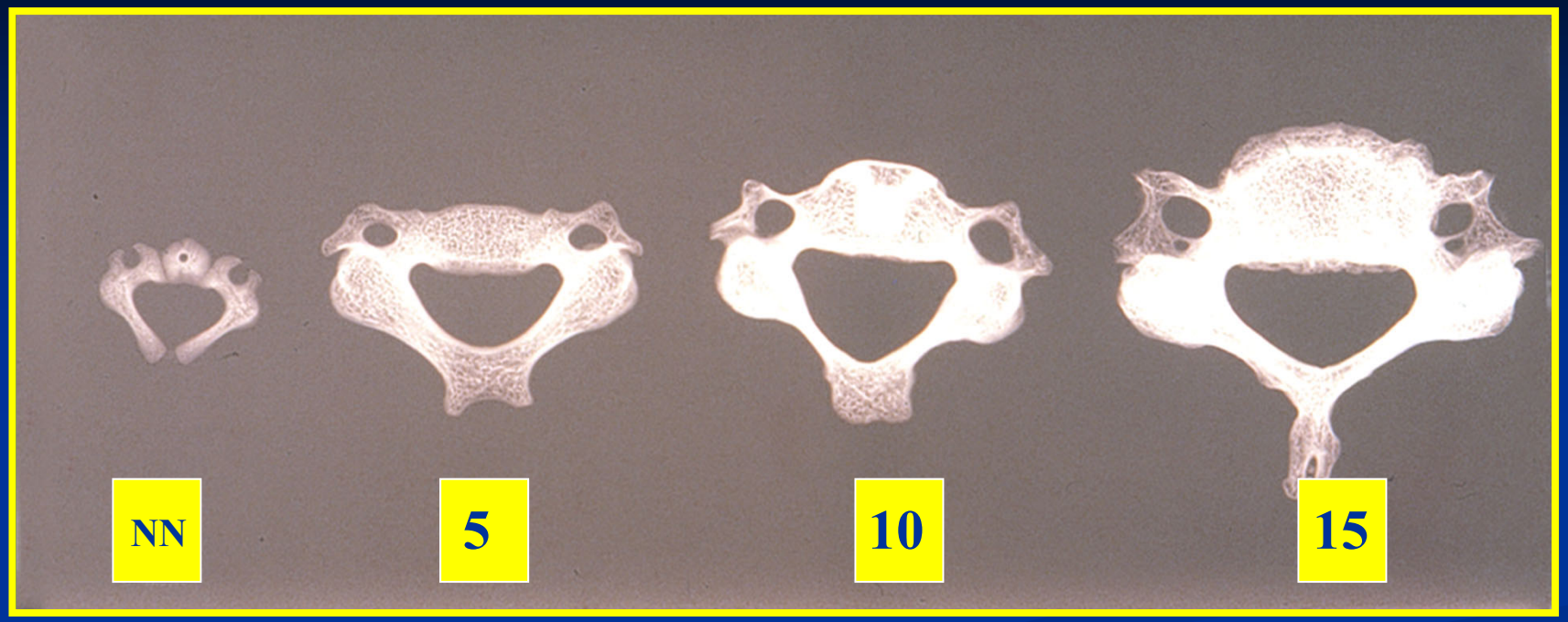
GROWTH IS A VOLUMETRIC REVOLUTION



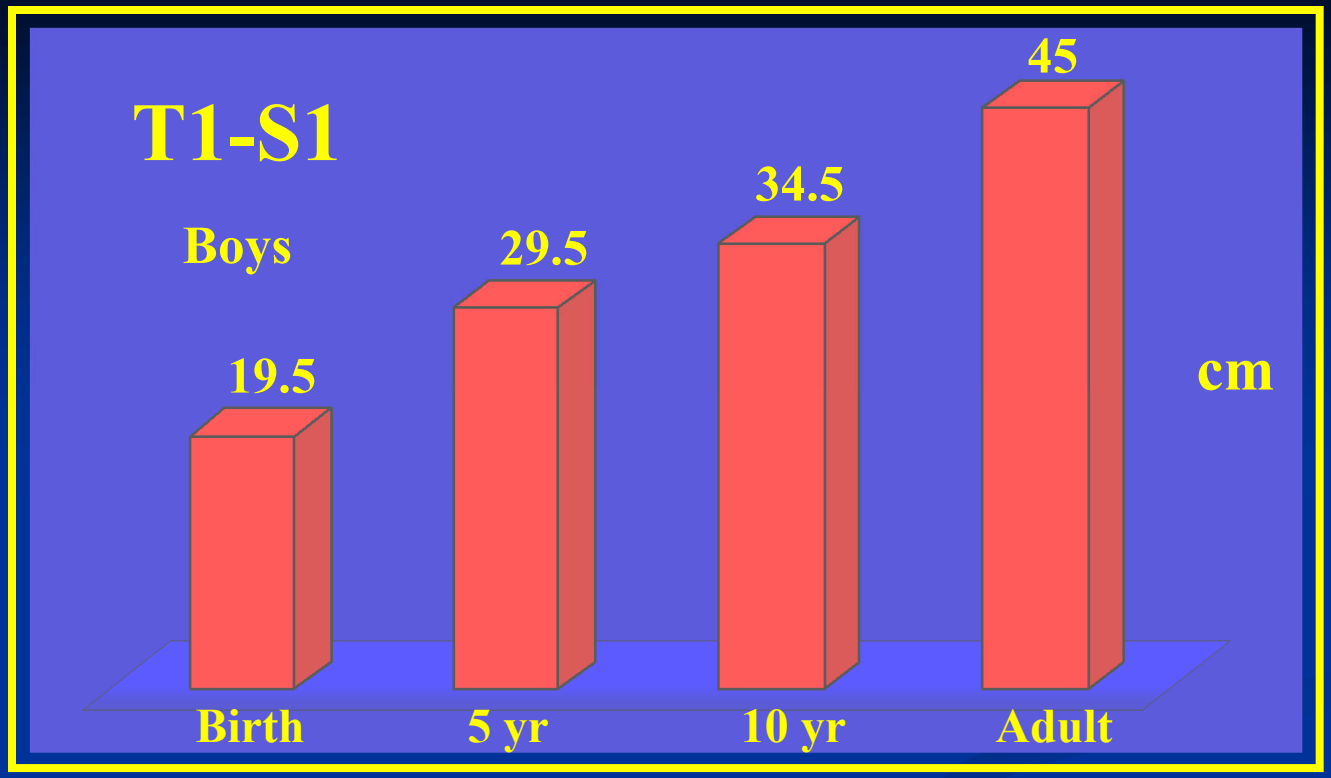
AT BIRTH 30% OF THE SPINE IS OSSIFIED



SITTING HEIGHT INCREASES BY 29 CM IN BOYS AND 28 CM IN GIRLS FROM BIRTH TO AGE OF 5 YEARS



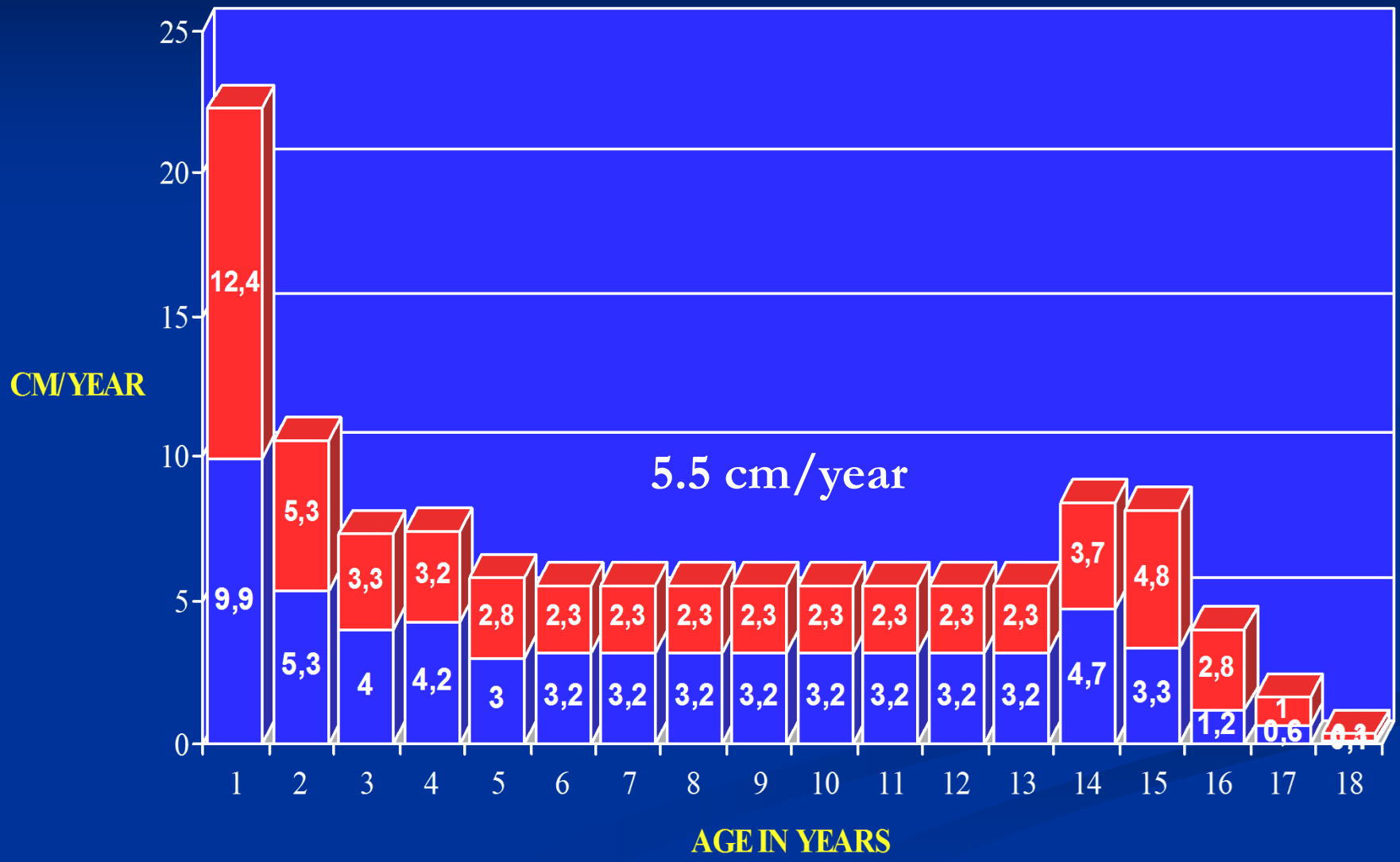
At age 5 years, the spinal canal has grown to 95 % of its definitive size.



Gain		
	Birth to 5	10 cm
	5 to 10	5 cm
	10 to 15	10 cm

A peri-vertebral arthrodesis in the T1-S1 segment at 5 years of age causes a sitting height deficit of 15 cm
(T1 – T12 =10 cm; L1 – L5= 5 cm)

GROWTH VELOCITY IN BOYS

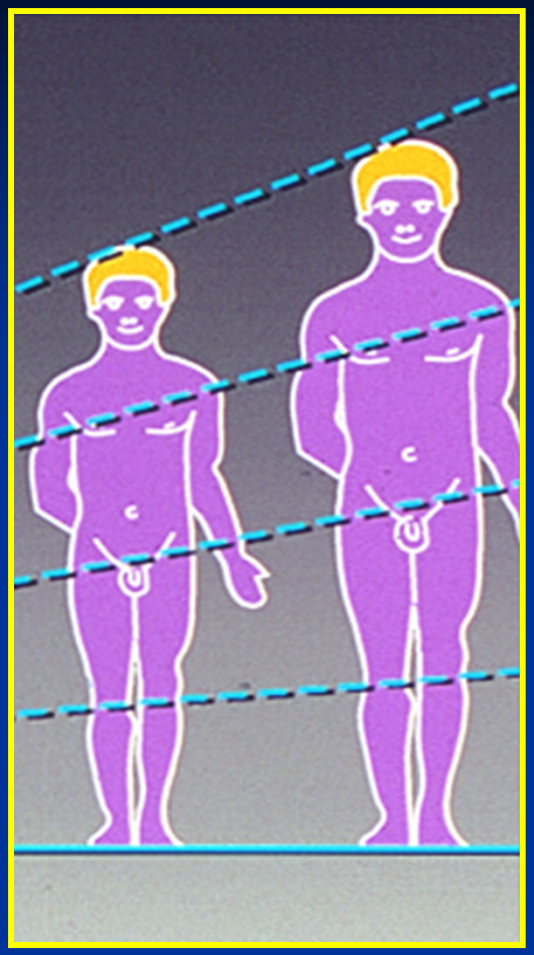


AT AGE OF 5 YEARS

Remaining standing growth 65 cm

Remaining sitting growth 32 cm

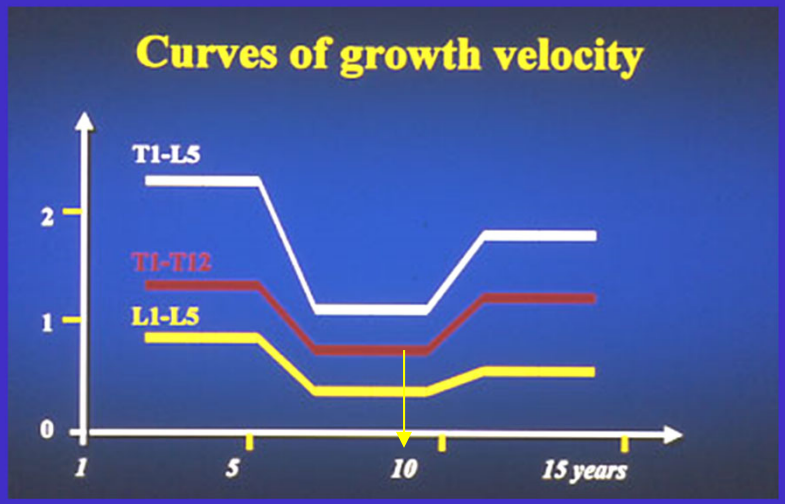
Girls: remaining sitting height is 27 cm (30%), MF=1.4
Boys: remaining sitting height is 32 cm (35%), MF=1.5



Growth velocity

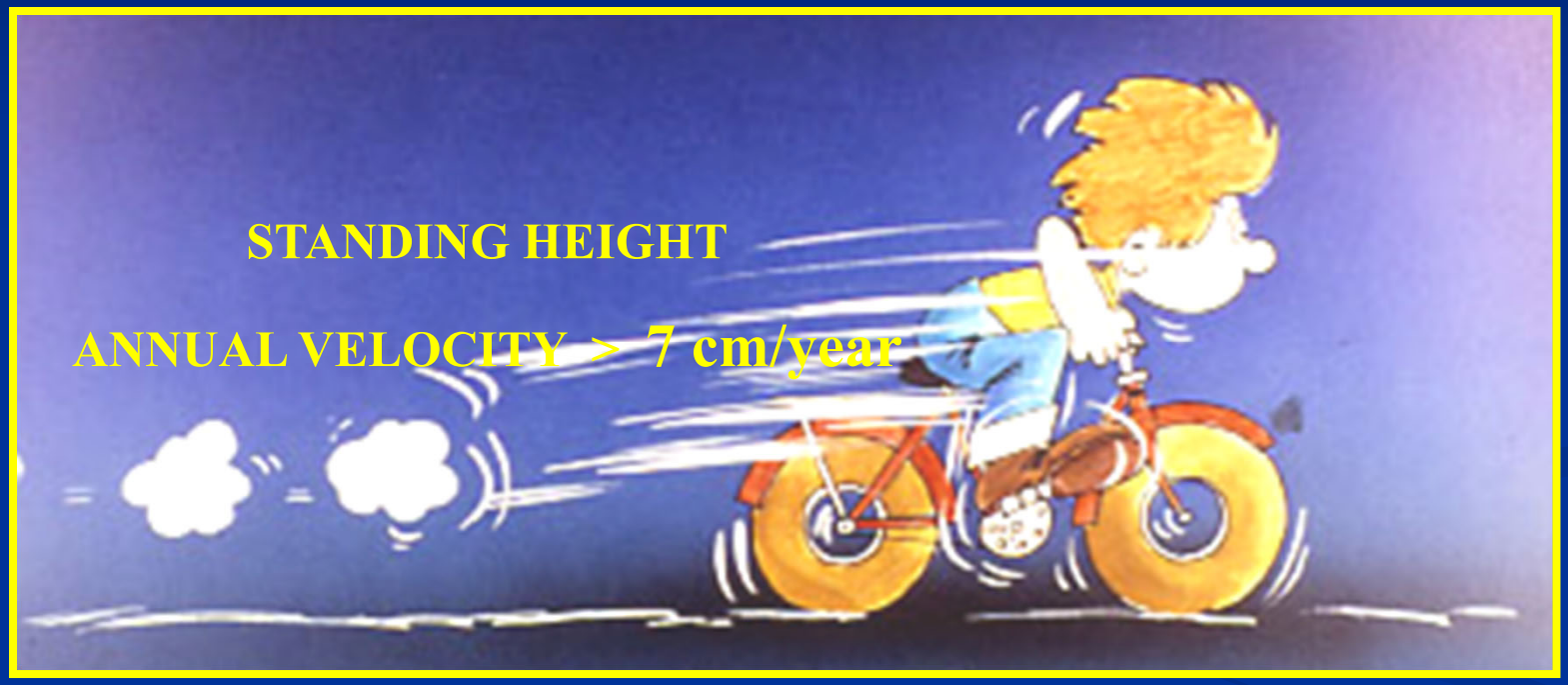
5.5 cm/year

AFTER 5 YEARS GROWTH SPINE VELOCITY DECREASES STRONGLY



After five T1-S1 increases by 1.1 cm / year

PUBERTY IS A TURNING POINT

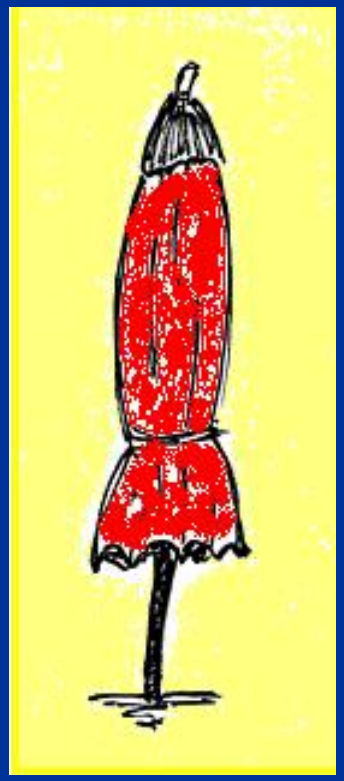


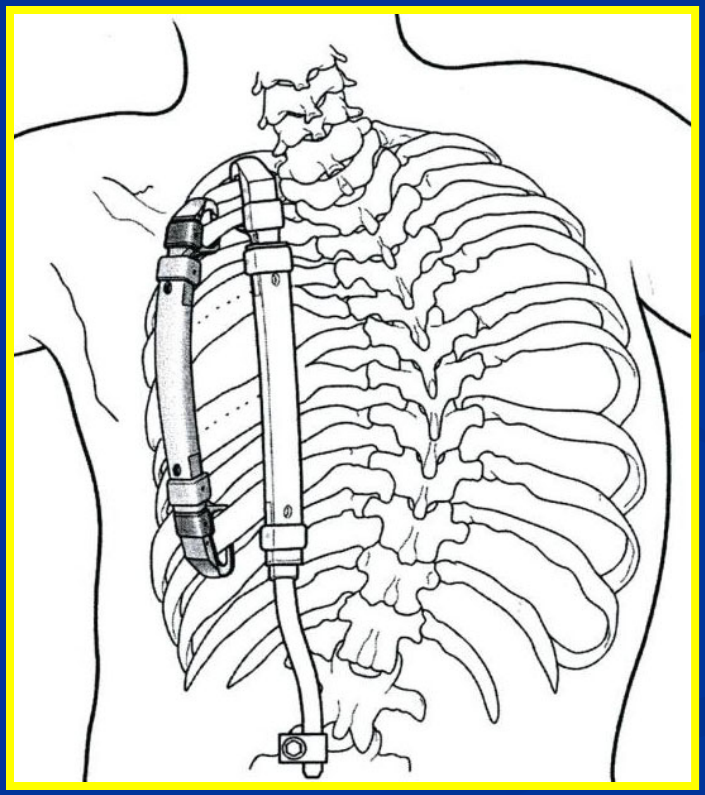
Girls: remaining sitting height is 12 cm (14%), MF=1.16
Boys: remaining sitting height is 13 cm (15%), MF=1.17

Infantile scoliosis, 16 Years
Deficit on the sitting height 25 cm
Weight 22 kgs
Normal Length of the lower limbs


ing No cut
Mar 2
13.5mm/rot
1.2sp

Influence of idiopathic scoliosis on volumetric thoracic growth and proportions?

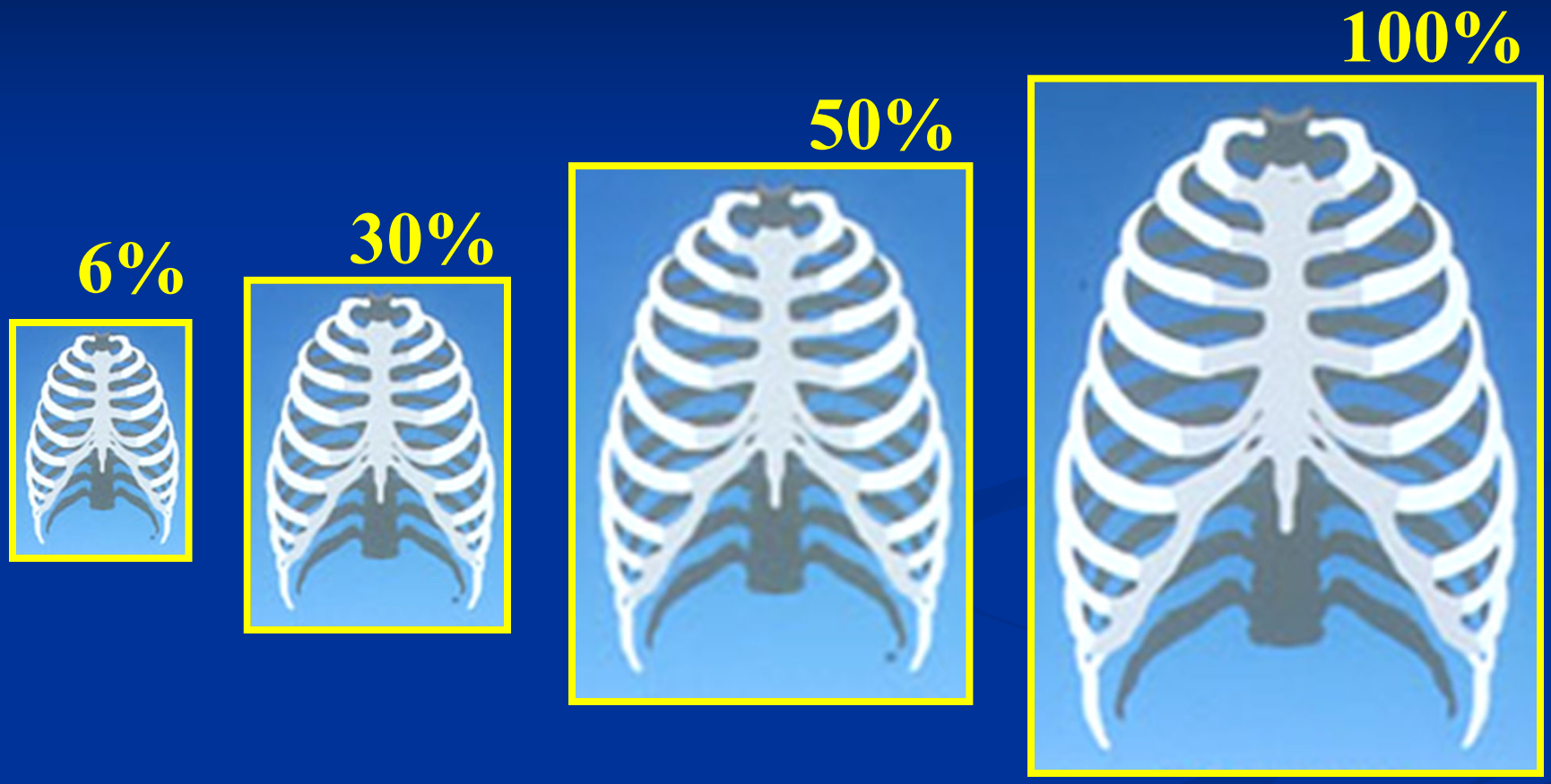




Campbell et al. J Bone Joint Surg (Am) 2003

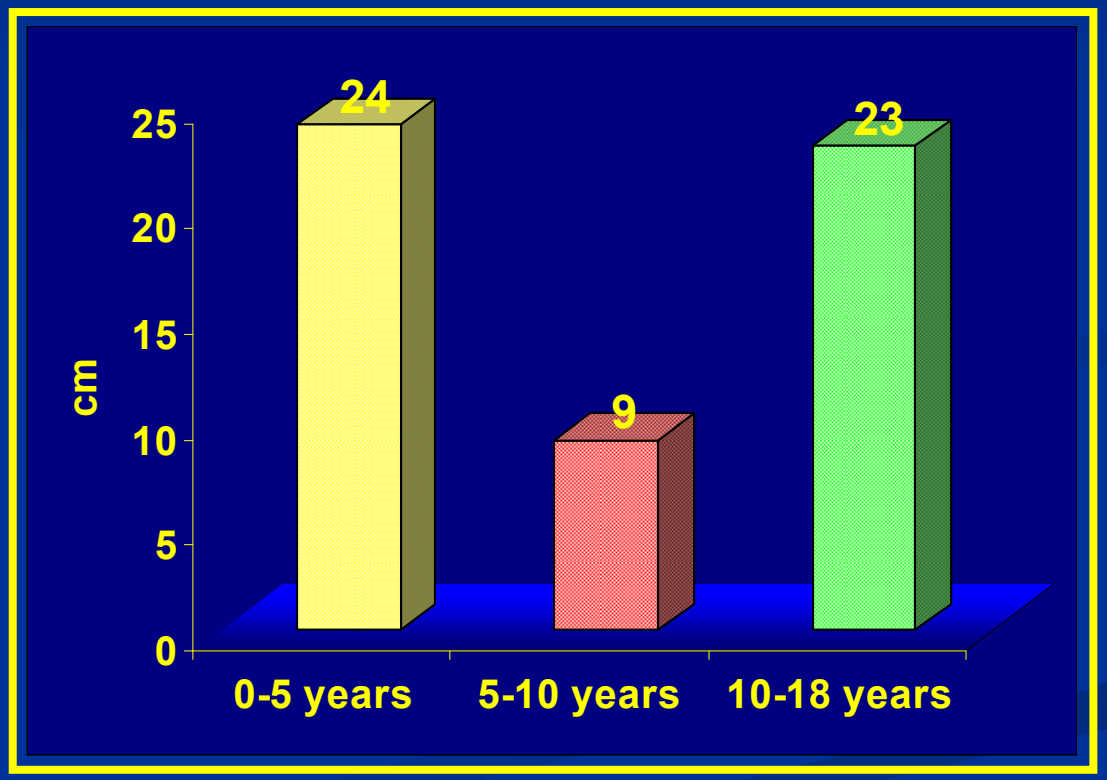
VOLUMETRIC GROWTH

The thorax: the fourth dimension of the spine



The growing spine, springer Velarg 1990

THORACIC PERIMETER GROWTH



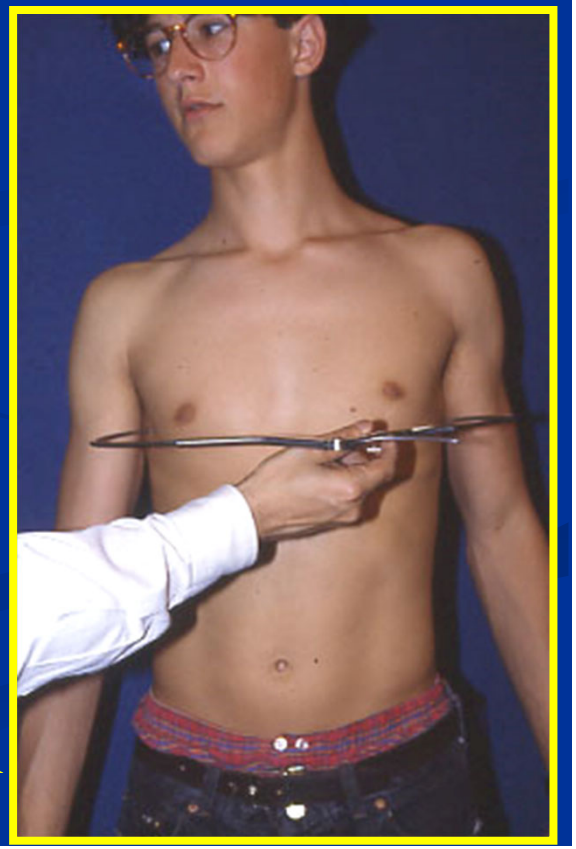
The gain is particularly important the first 5 years (24 cm) with a slow down after 5 years and a new peak at puberty.

Optical data acquisition,

Clinical measurement

NORMAL THORACIC GROWTH
ANT. – POST. DIAMETER
21 % SITTING HEIGHT

NORMAL THORACIC GROWTH
TRANSVERSAL DIAMETER
30 % SITTING HEIGHT

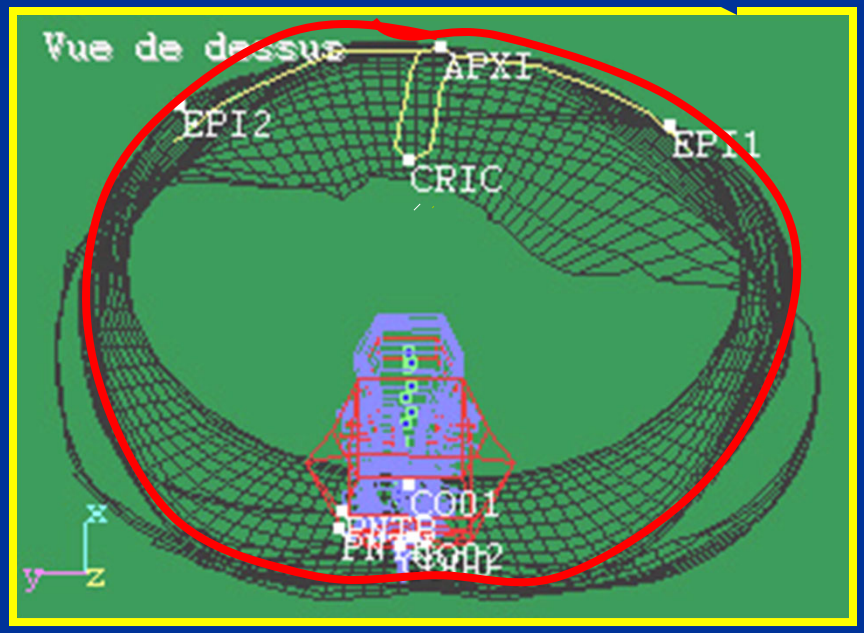


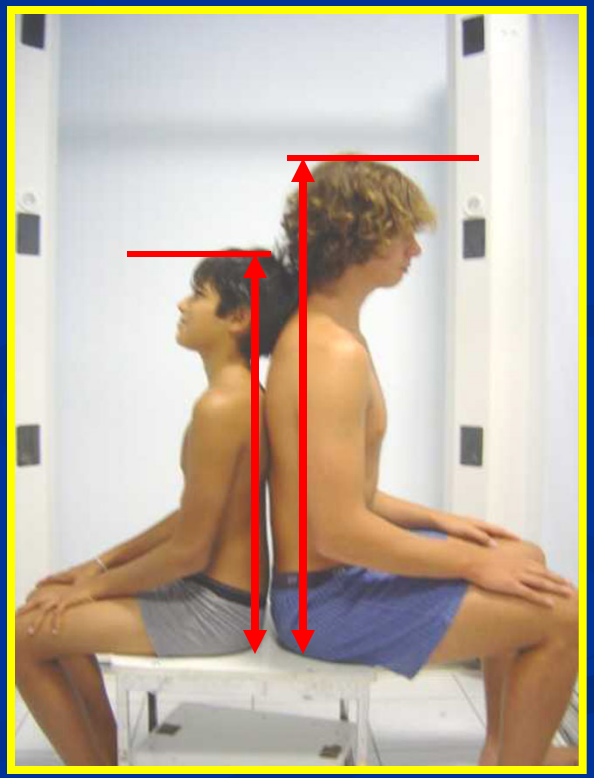
Constant relationships during growth

Thoracic perimeter

r = 0.93

Sitting height

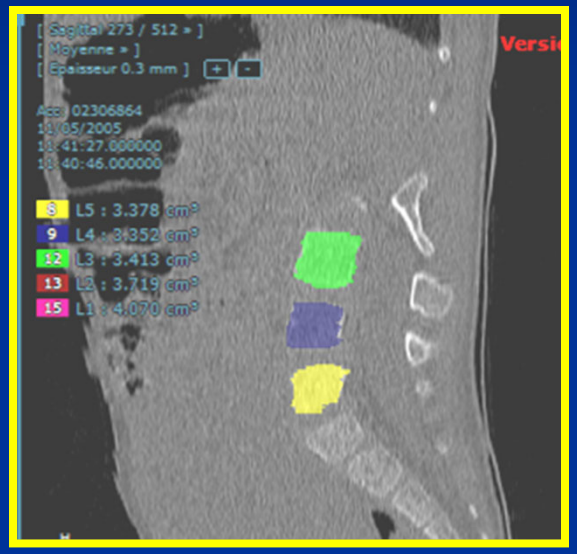


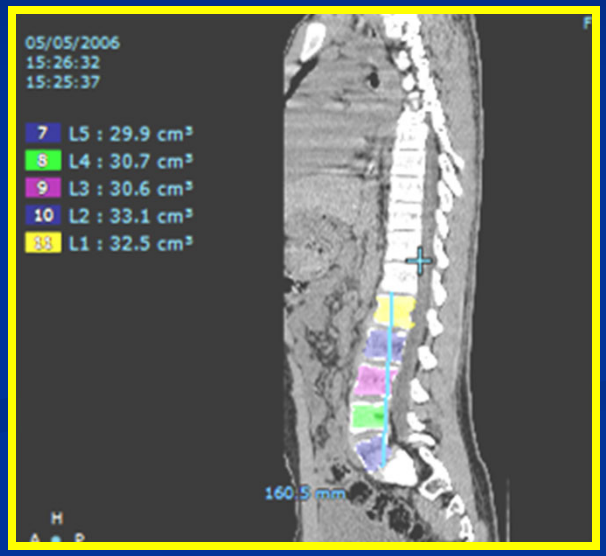


At five years:

- the remaining growth of the thorax is about 70%
- the remaining sitting height is 35%

LUMBAR VERTEBRA VOLUME



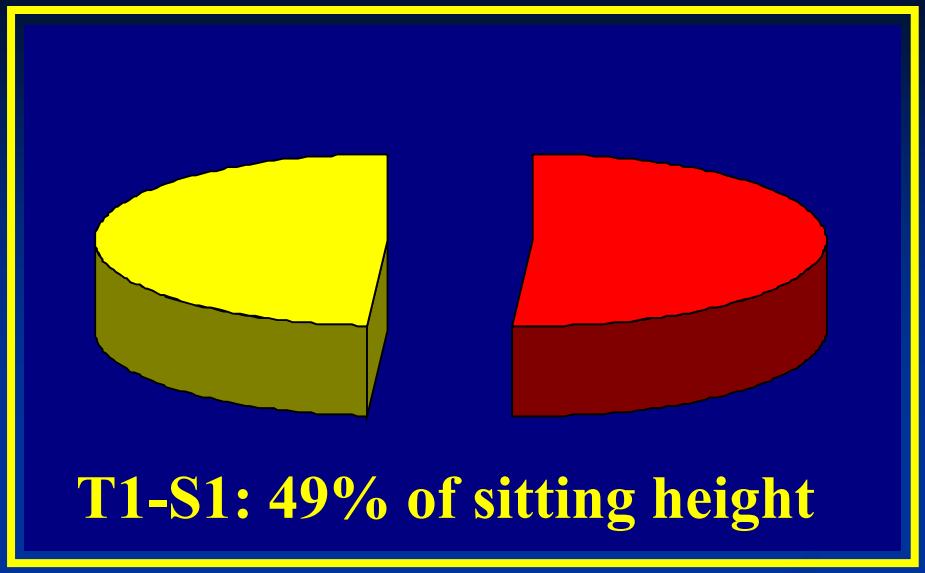


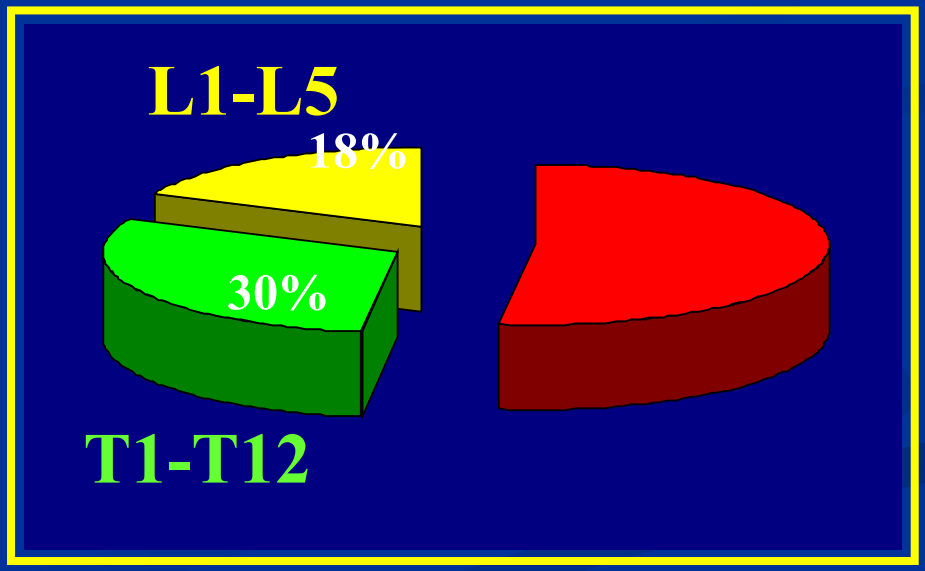
5 years: 5 cm^3

10 years: 10 cm^3

15 years: 30 cm^3

Deficit after spinal arthrodesis?

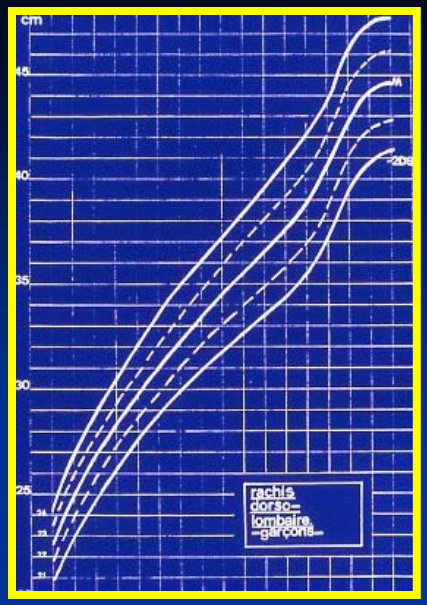




THORACIC SPINE 2/3

LUMBAR SPINE 1/3

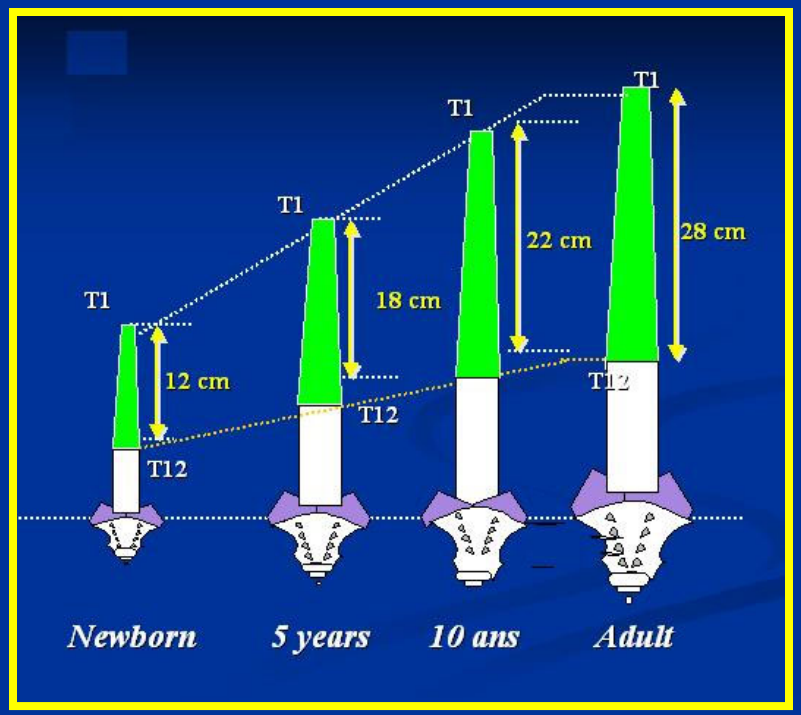
The growing spine, springer Velarg 1990



GROWTH CURVE T1 – S1

BOYS

From birth to skeletal maturity



GAIN

T1 – S1 : 25 cm

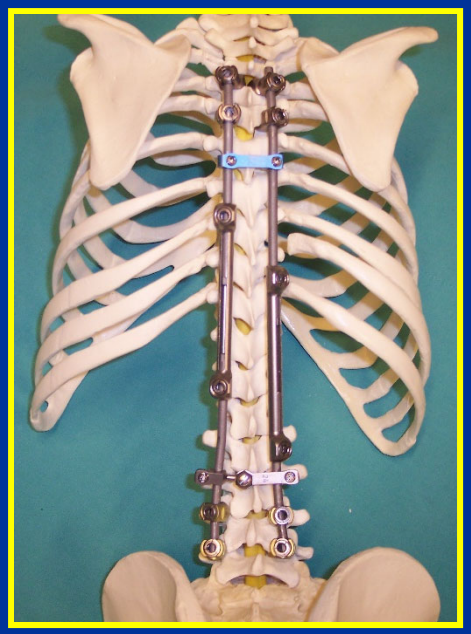
T1 – T12 : 16 cm

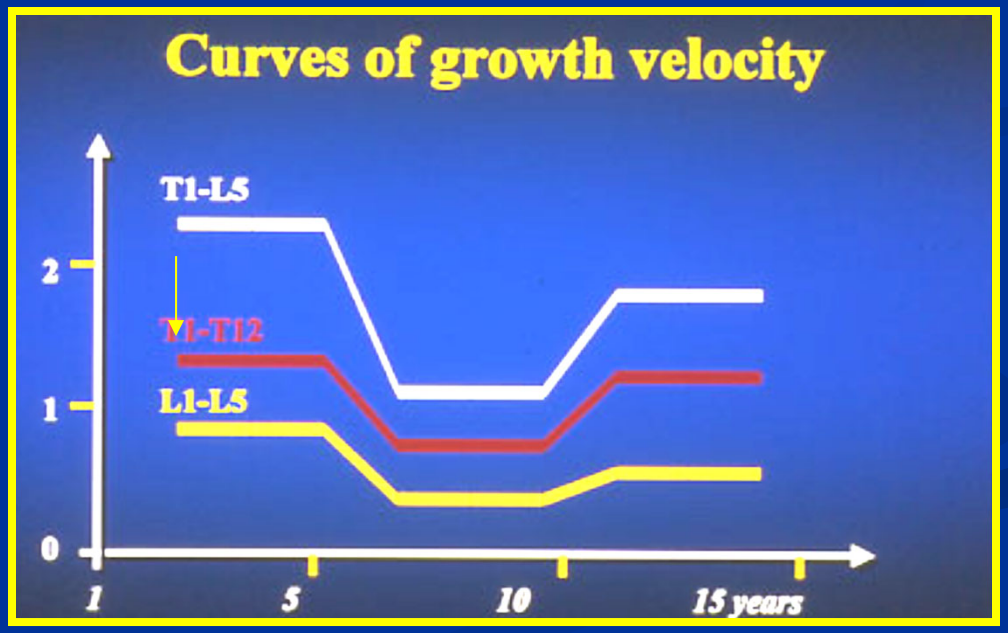
L1 – L5 : 9 cm

The growing spine, springer Velarg 1990

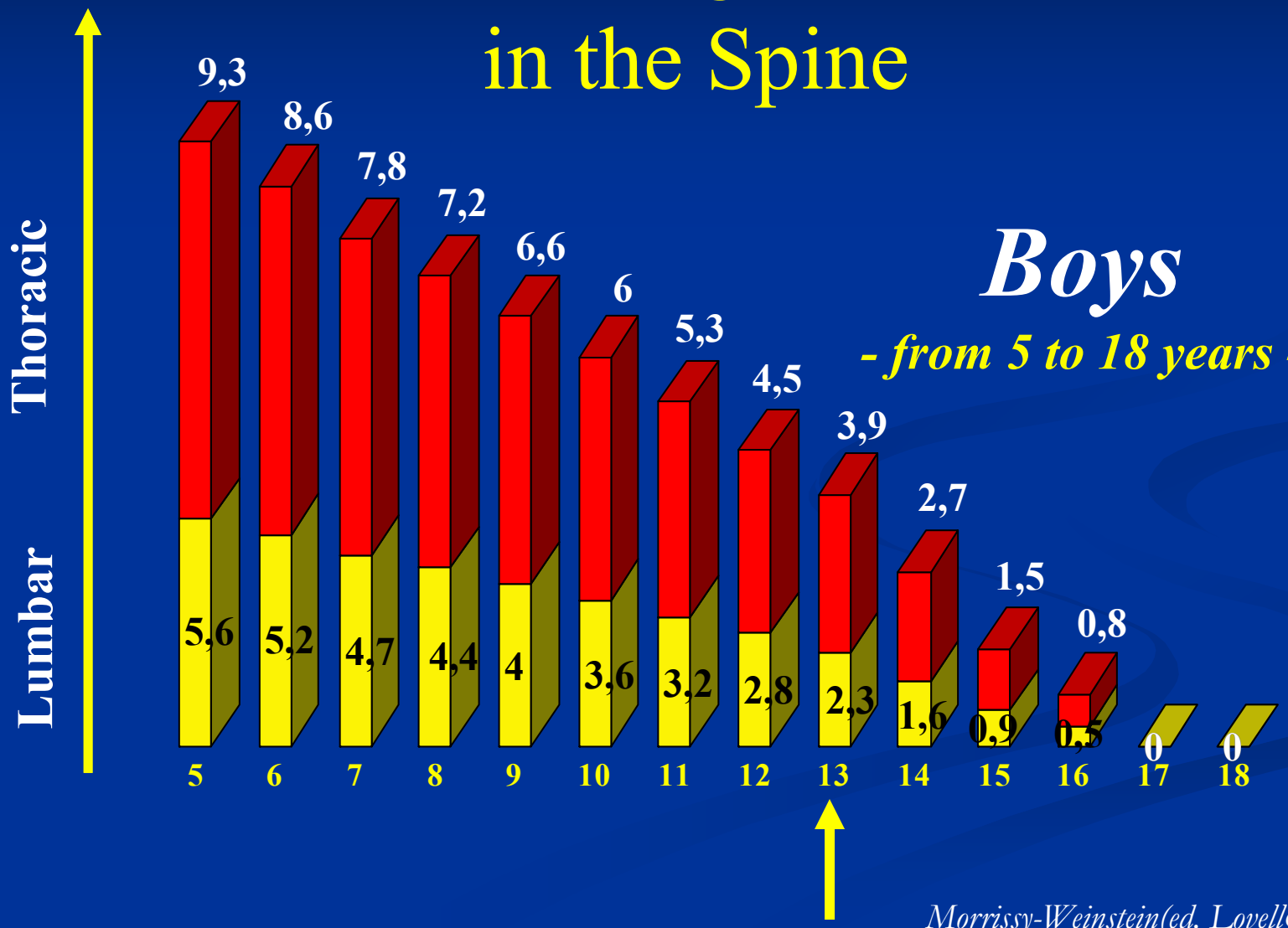
ANNUAL GROWTH VELOCITY T1 –L5

BIRTH – 5 yr	**2.2 cm**
5 yr – 10 yr	**1.1 cm**
10 yr – PUBERTY	**1.8 cm**





Remaining Growth in the Spine



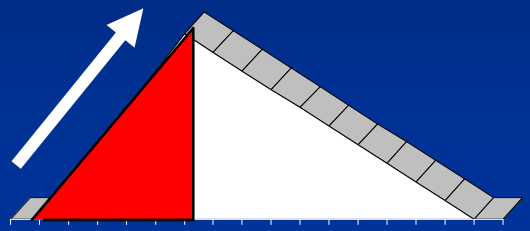
Boys

- from 5 to 18 years -

Morrissy-Weinstein(ed. Lovell& Winter)

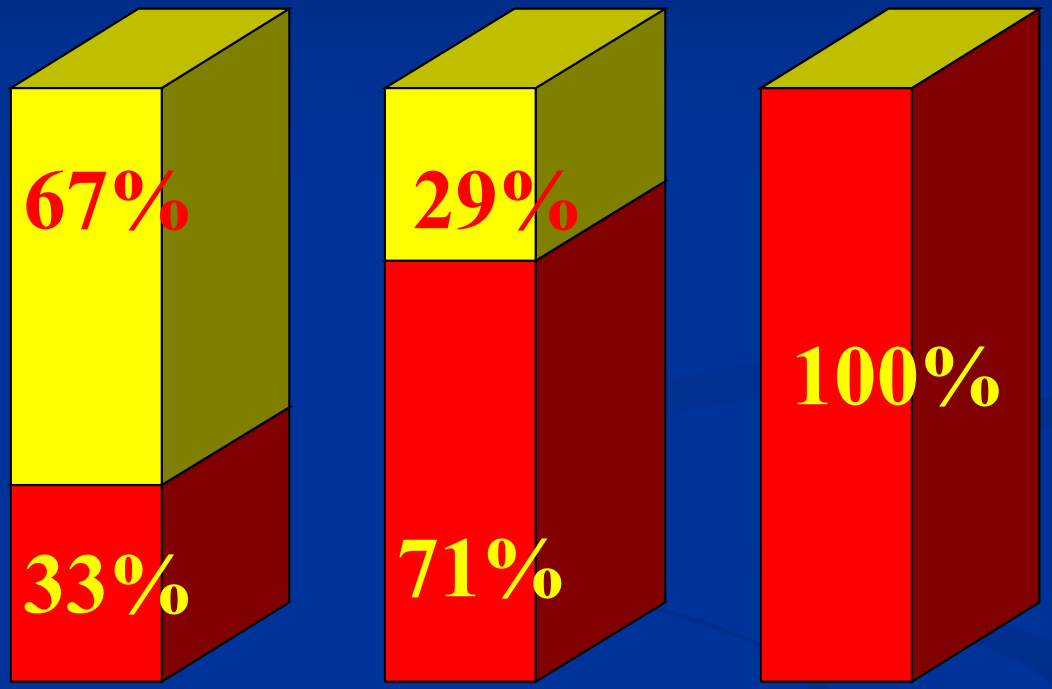
Annual curve progression velocity

n = 161 / 205 scoliosis at accelerating growth phase



Non-operated

Operated

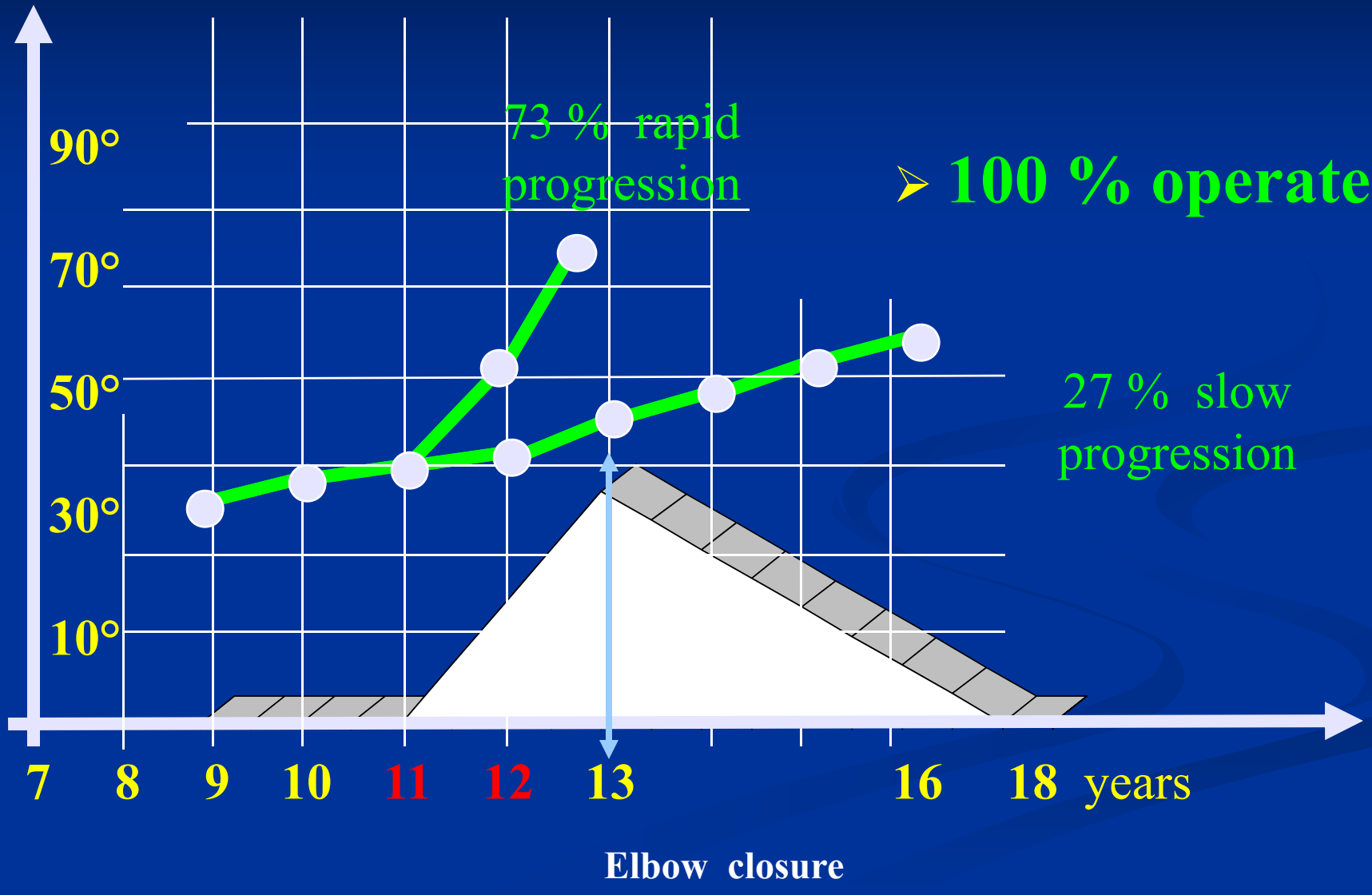


< 6° / year **6-10° / year** **> 10° / year**

Spine August 2006

Curves > 30° at onset of puberty

n = 40 / 205



- **100 % operated**

Spine August 2006

Dorsal arthrodesis of the thoracic spine in pre-pubertal rabbits and effects on thoracic growth

- Dorsal arthrodesis causes a decrease in
  - AP thoracic diameter
  - Vertebral body volume
  - Thoracic volume

Dimeglio et al EPOS 2006

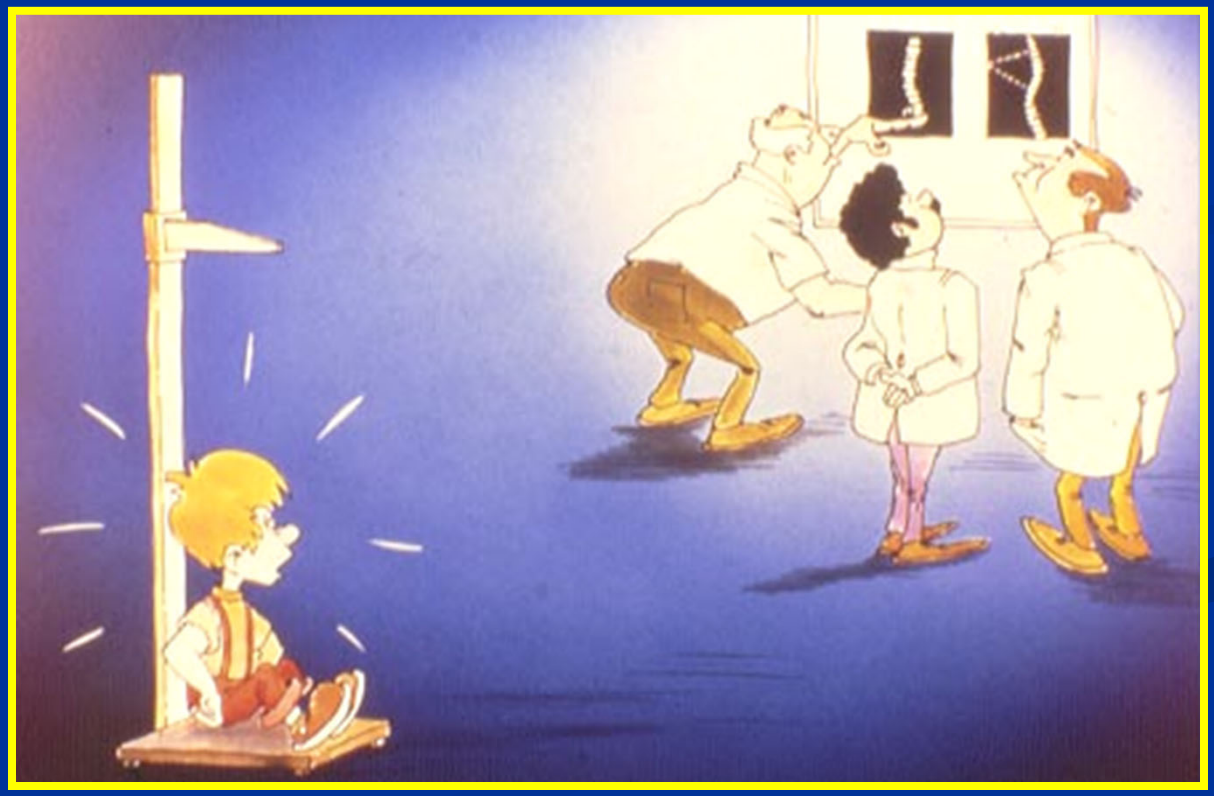
Summary

- The thorax is the fourth dimension of the spine
- Before the age of 5 years, treat the retraction of the thorax to preserve the pulmonary growth
- Between the age of 5 years and the beginning of the puberty, preserve spinal mobility by avoiding arthrodesis and using the dual rod instead (Abkarnia).
- Treat by anticipation and detect soon aggressive scoliosis.
- Consider the surgical risk; at the beginning of puberty a curve of 30 degrees has a 100% surgical risk.

To control growth,Consider:

- Annual Velocity on the trunk
- Skeletal maturation (elbow, and pelvis)
- Tanner signs

Don’t stick to one parameter

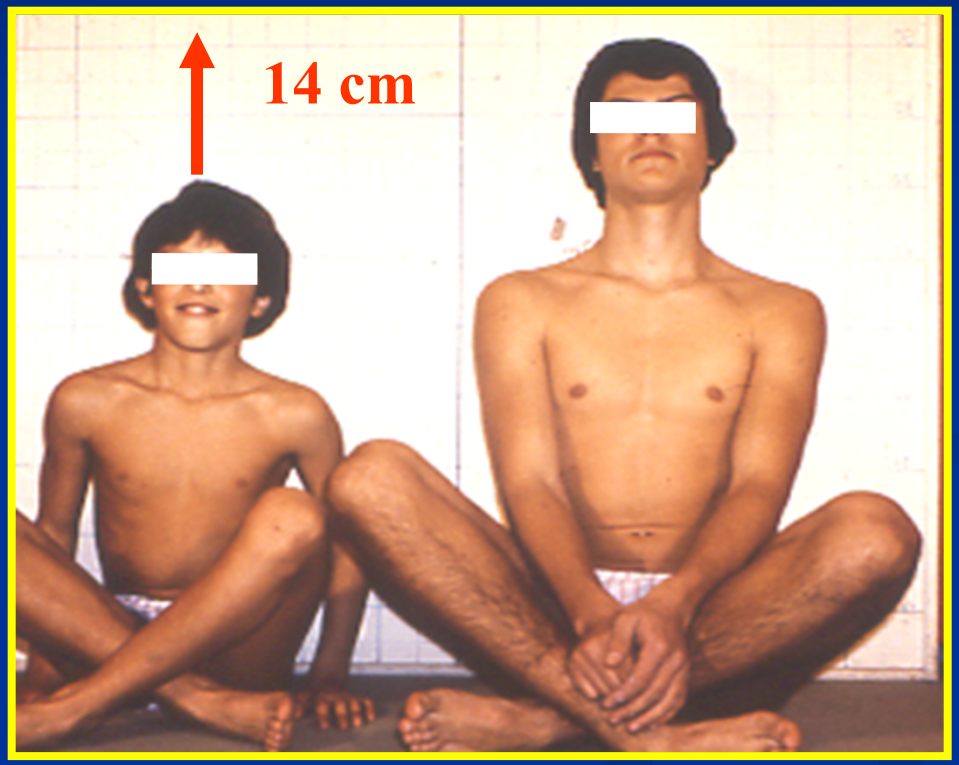



Montpellier

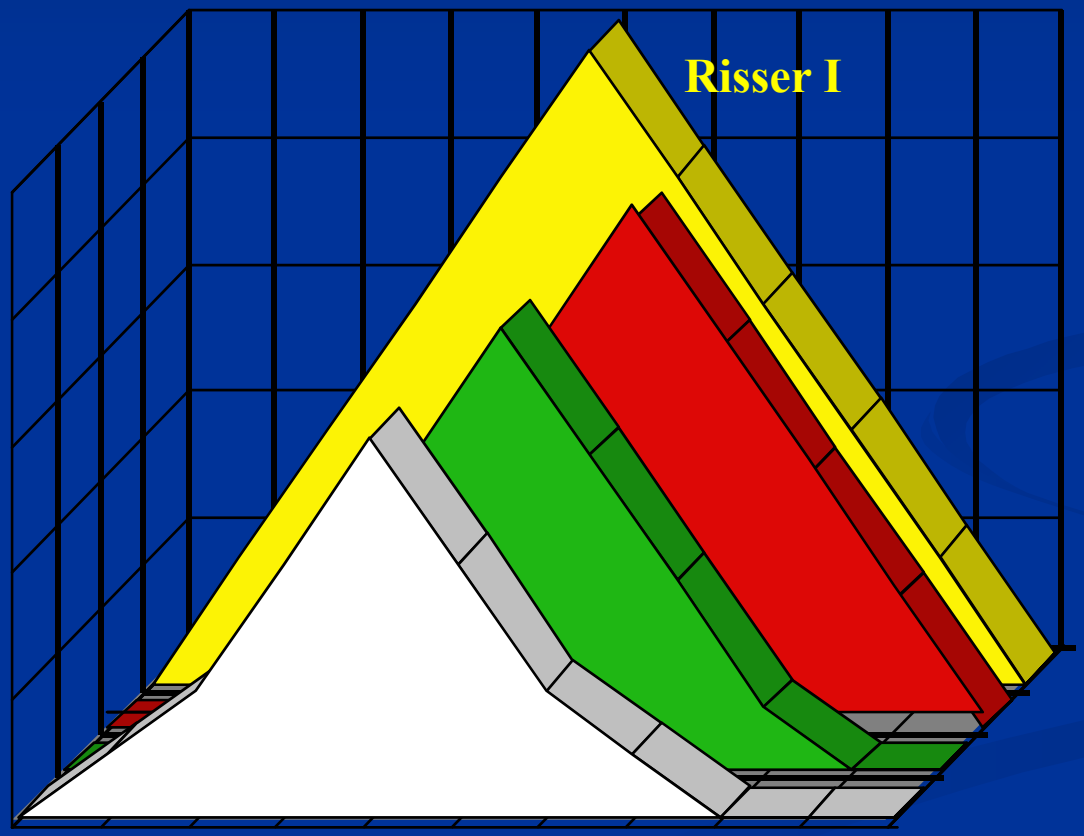

Vincent


MONTPELLIER


22 cm


14 cm

3 Periods in growth
Standing height



Standing height

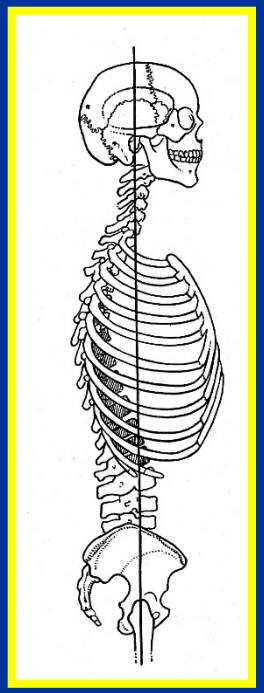
Thorax

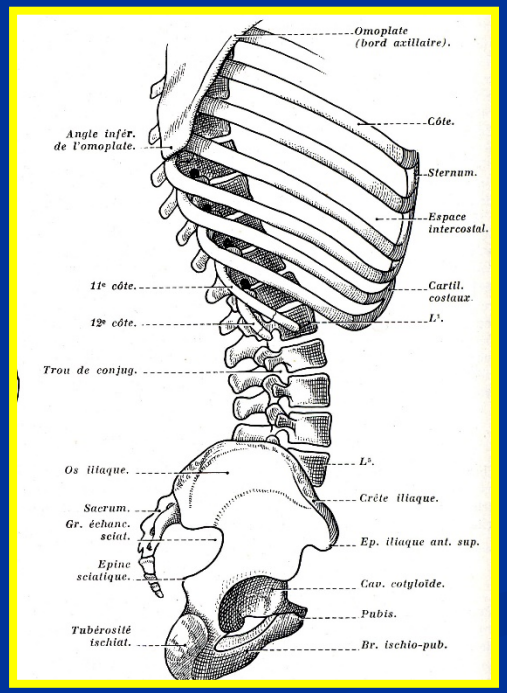
Sitting height

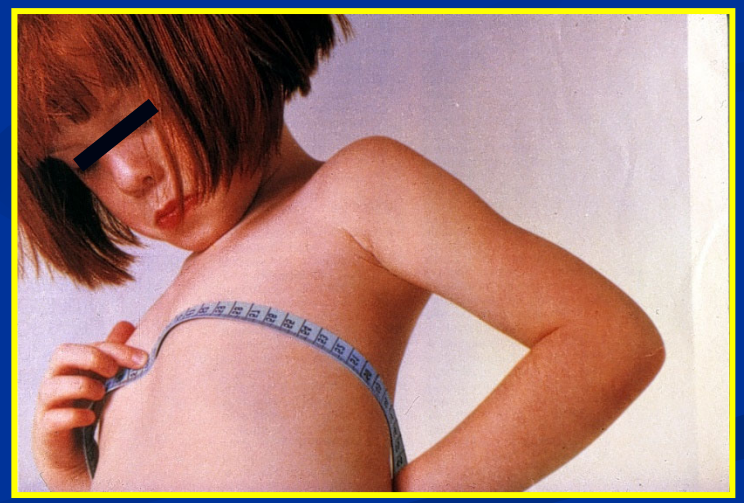
Lower limb

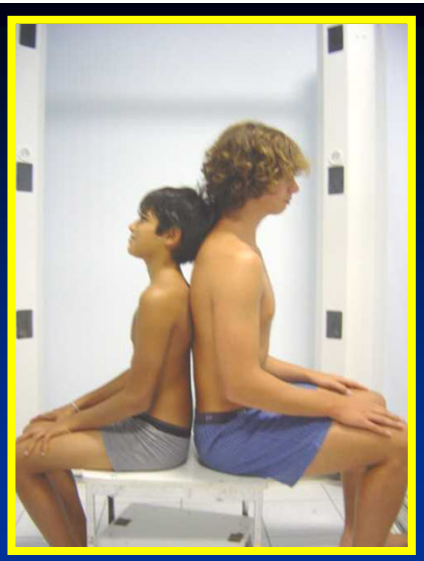
Puberty is a juxtaposition of three micro-peaks: the first peak occurs in the lower limb, the second peak occurs in the trunk and the third peak occurs in the thorax just after Risser I.

GROWTH OF THE THORAX IS THE FOURTH DIMENSION OF THE SPINE









THE THORACIC VOLUME DOUBLES BETWEEN 10Y AND SKELETAL MATURITY

Infantile scoliosis, 16 Years
Deficit on the sitting height 25 cm
Weight 22 kgs
Normal Length of the lower limbs


ing No cut
Mar 2
13.5mm/rot
1.2sp

BONE AGE

W. Churchill

“Capitalism is the worst system except all the others”

Bone age is the worst parameter except all the others.

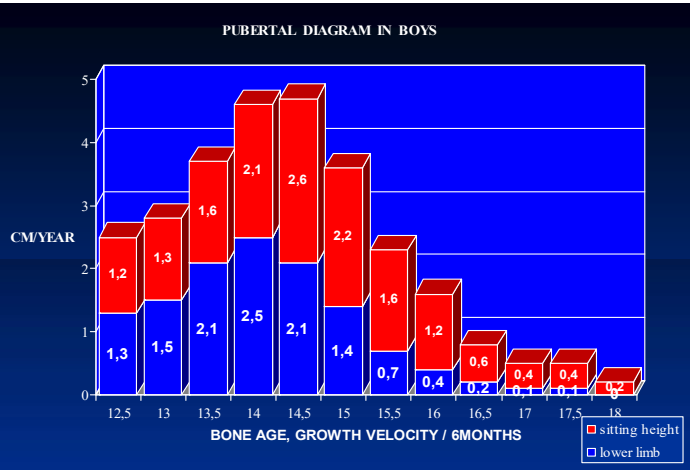
20 % bone age in delay

30 % bone age in advance

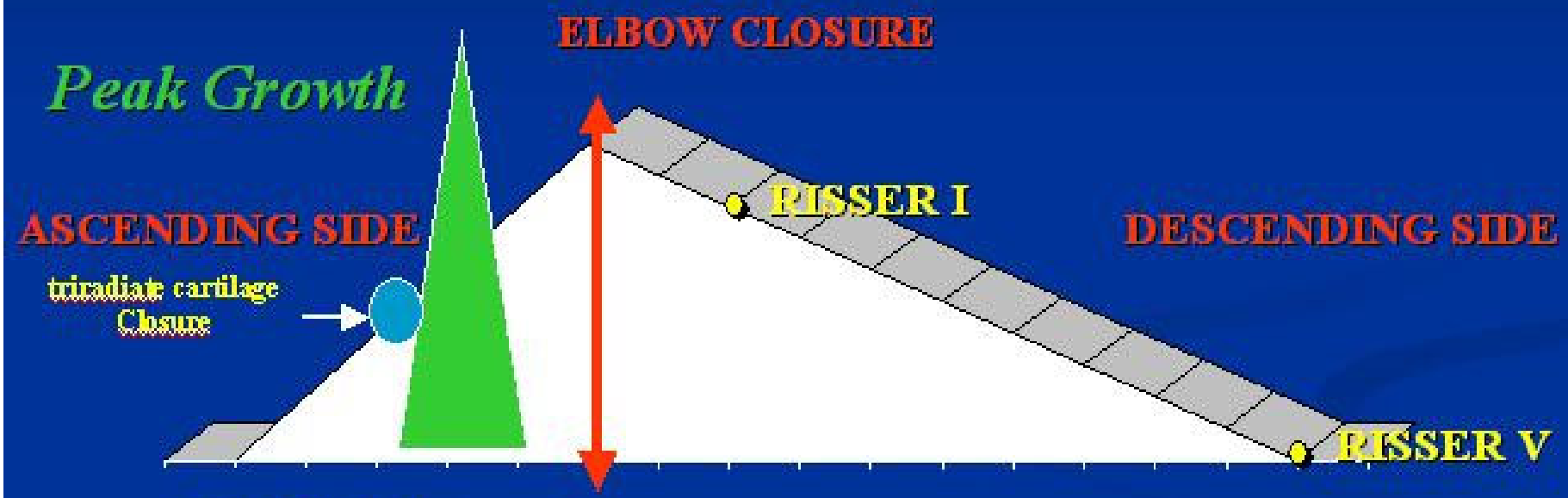
About 50 % of children are in harmony with their chronological age during puberty

Risser 0 covers two third of puberty

PUBERTAL DIAGRAM



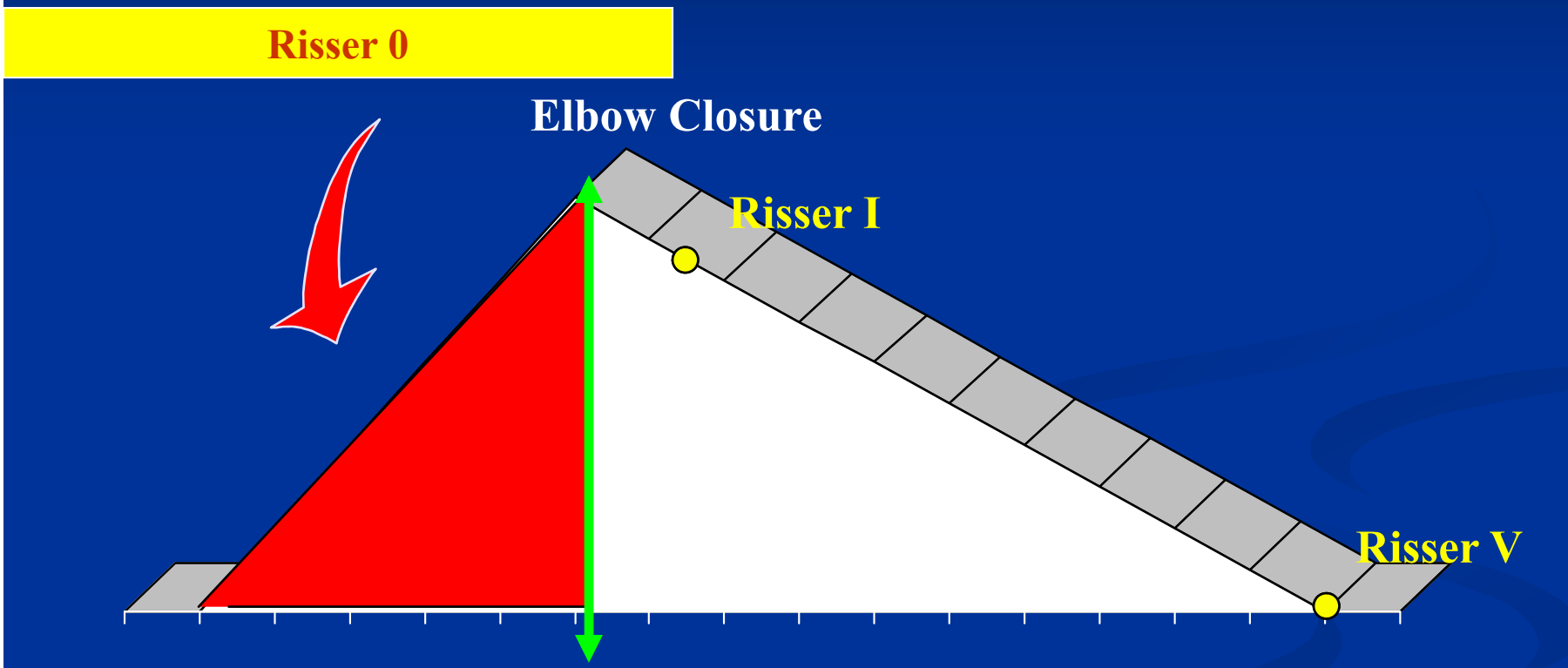
RISSER 0



11 GIRLS 13

13 BOYS 15

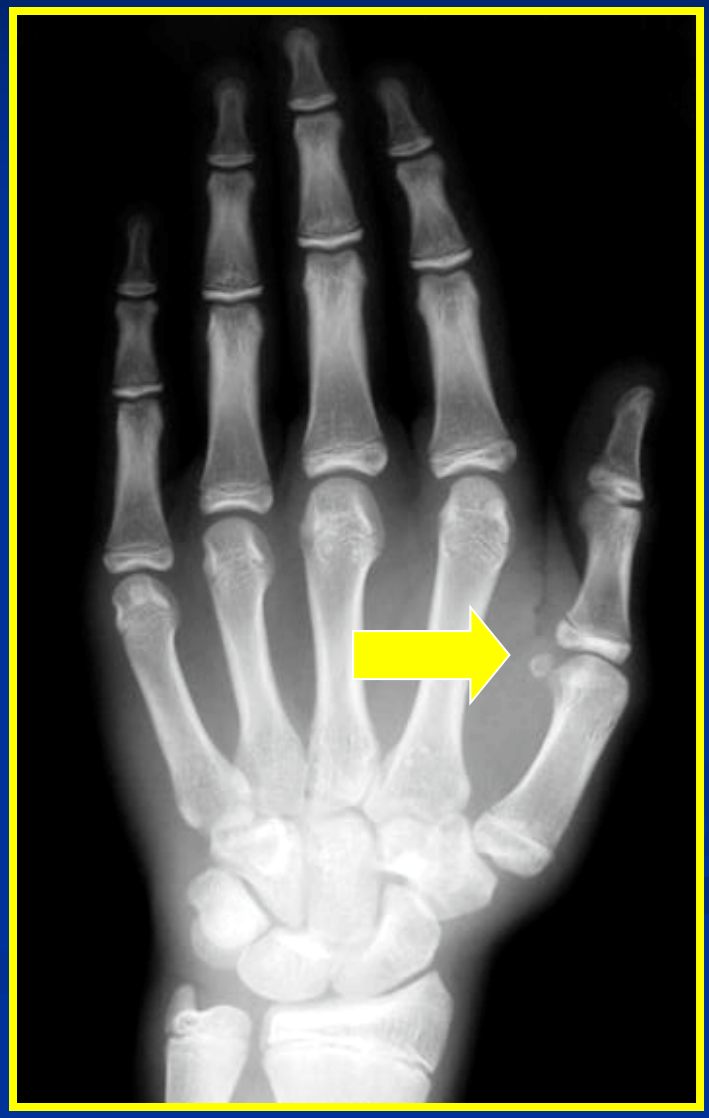
Critical Zone



No change on the hand

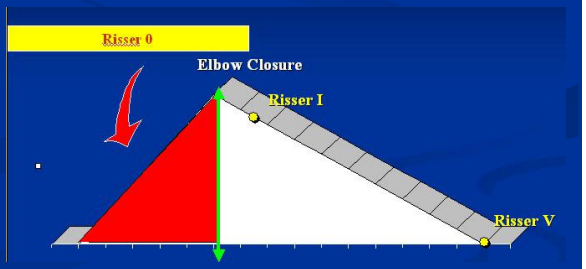
Girls 11 Y
Boys 13 Y

Girls 13 Y
Boys 15 Y

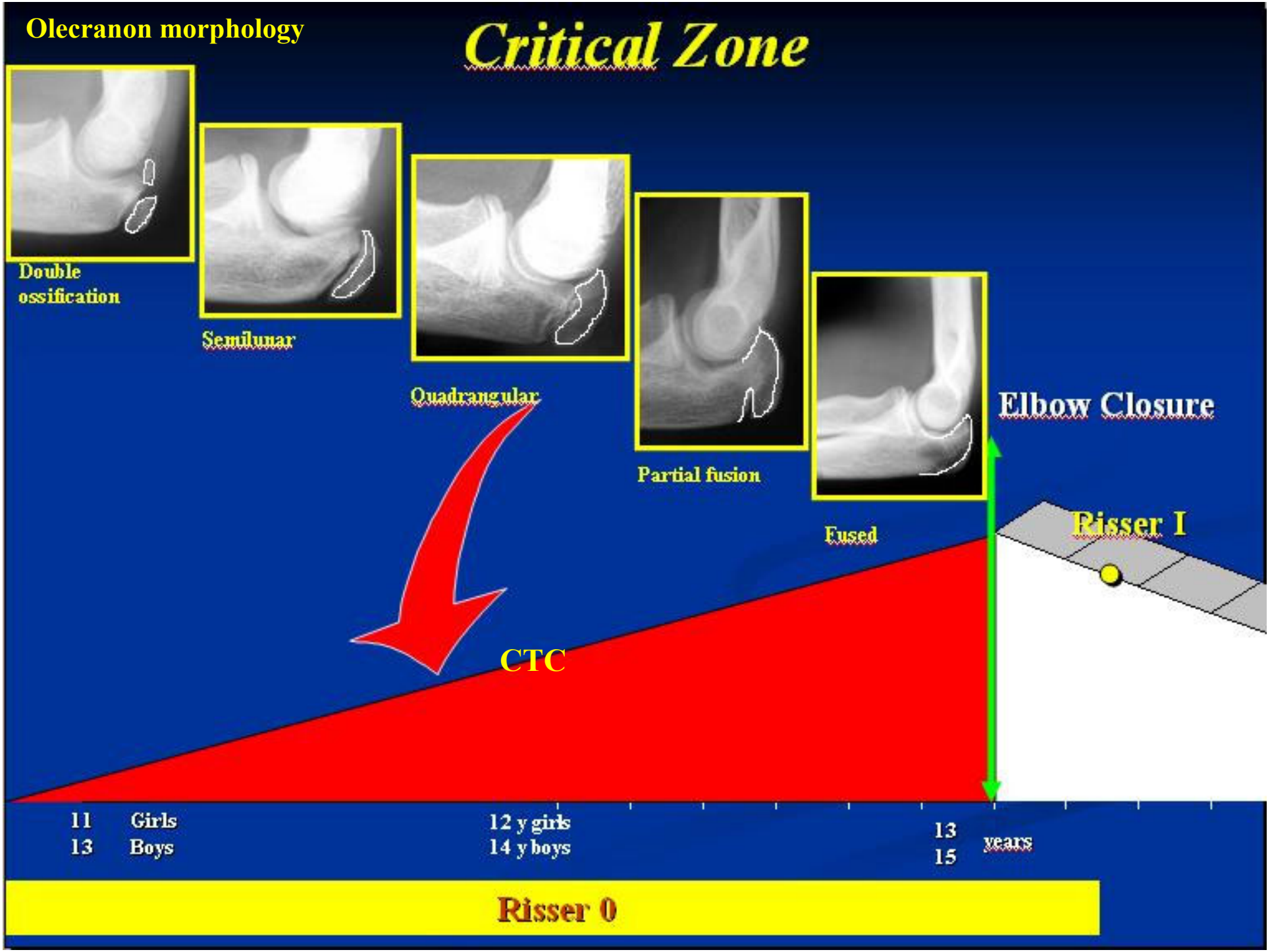


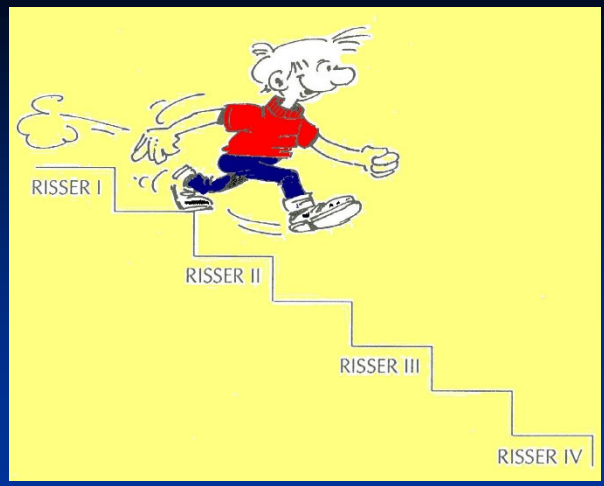
Beginning puberty
11 Y Girls
13 Y Boys
Elbow wide open

13 Y Girl
15 Y Boys
Elbow closed

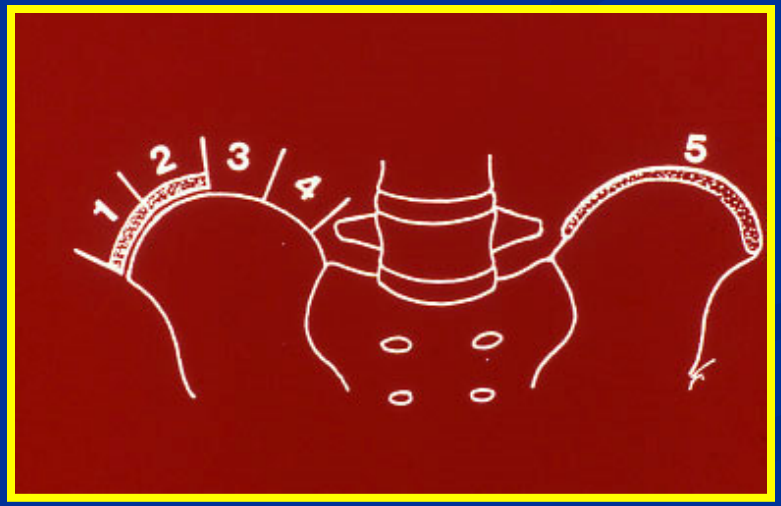


Elbow method, JBJSA, 2005

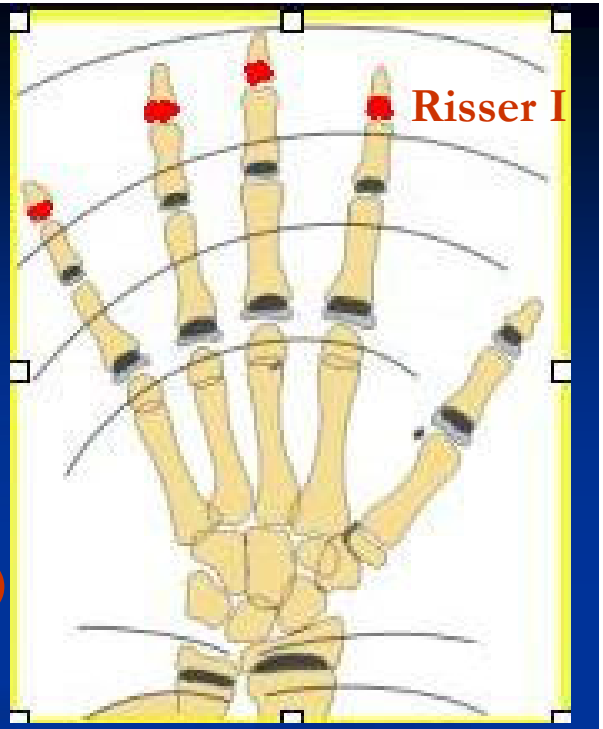

Olecranon morphology
Critical Zone
Double ossification
Semilunar
Quadrangular
Partial fusion
Fused
Elbow Closure
Risser I
CTC
11 Girls
13 Boys
12 y girls
14 y boys
13
15
years
Risser 0



WHAT IS THE VALUE OF THE RISSER SIGN ?



CLOSURE OF DISTAL PHALANX



Elbow closure

RISSER I

(Menarche)

Closure of the triradiate cartilage

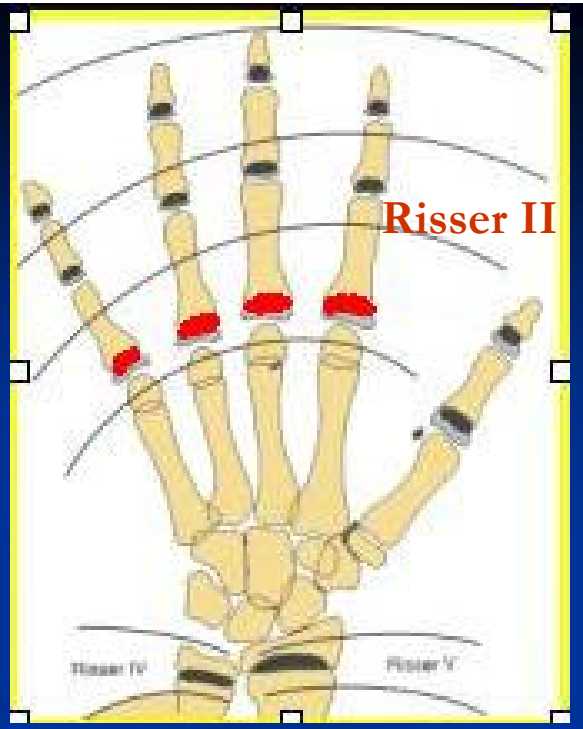
11	12	13	*Girls*	18 years
13	14	15	*Boys*	18 years

ASCENDING SIDE

DESCENDING SIDE

Risser I: NO FURTHER GROWTH IN LOWER LIMB, REMAINING GROWTH 4 cm

CLOSURE OF DISTAL PHALANX



Elbow closure

RISSER I

RISSER II

Closure of the triradiate cartilage

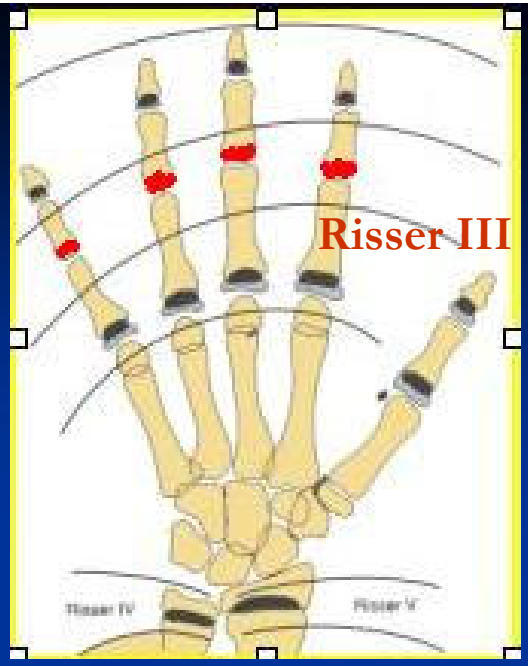
11	12	13	*Girls*	18 years
13	14	15	*Boys*	18 years

ASCENDING SIDE

DESCENDING SIDE

Risser II: CLOSURE OF MT-P JOINT, REMAINING GROWTH 3 cm

CLOSURE OF DISTAL PHALANX



Elbow closure

RISSER I

RISSER II

RISSER III, CGT

Closure of the triradiate cartilage

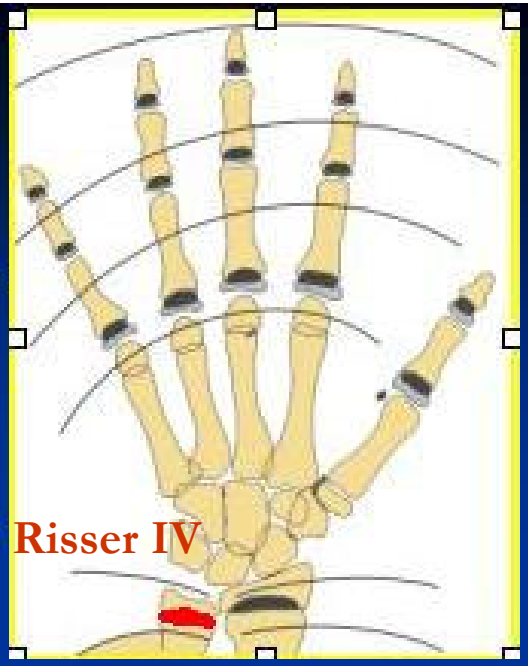
11	12	13	*Girls*	18 years
13	14	15	*Boys*	18 years

ASCENDING SIDE

DESCENDING SIDE

Risser III: CLOSURE OF THE I-P JOINT, REMAINING GROWTH 2 cm
CLOSURE OF THE GREATER TROCHANTER

CLOSURE OF DISTAL PHALANX



Elbow closure

RISSER I

RISSER II

RISSER III, CGT

RISSER IV

Closure of the triradiate cartilage

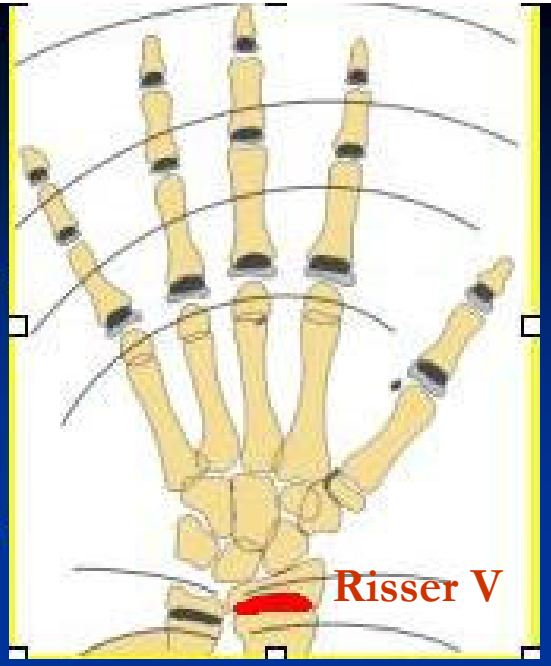
11	12	13	*Girls*	18 years
13	14	15	*Boys*	18 years

ASCENDING SIDE

DESCENDING SIDE

Risser IV: REMAINING GROWTH 1 cm
CLOSURE OF THE ULNAR EPIPHYSIS

CLOSURE OF DISTAL PHALANX



Elbow closure

RISSER I

RISSER II

RISSER III, CGT

RISSER IV

RISSER V ?

Closure of the triradiate cartilage

11	12	13	*Girls*	18 years
13	14	15	*Boys*	18 years

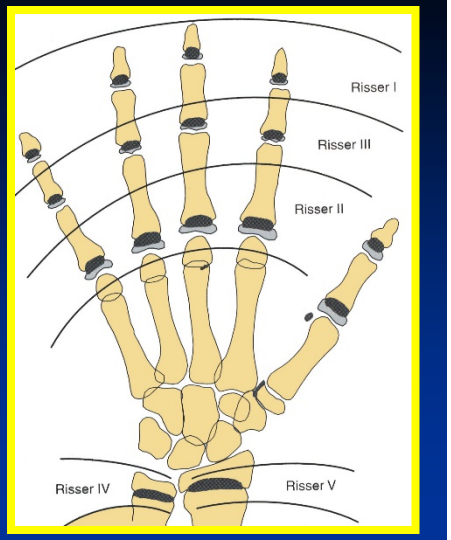
ASCENDING SIDE

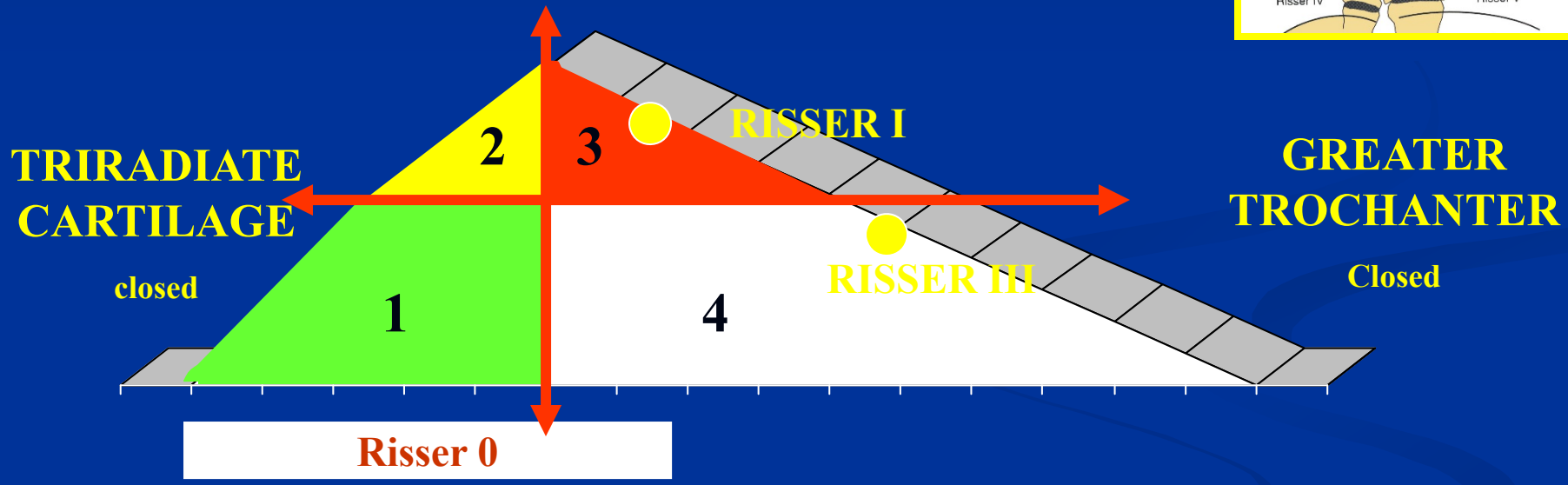
DESCENDING SIDE

Risser V: CLOSURE OF THE RADIAL EPIPHYSIS

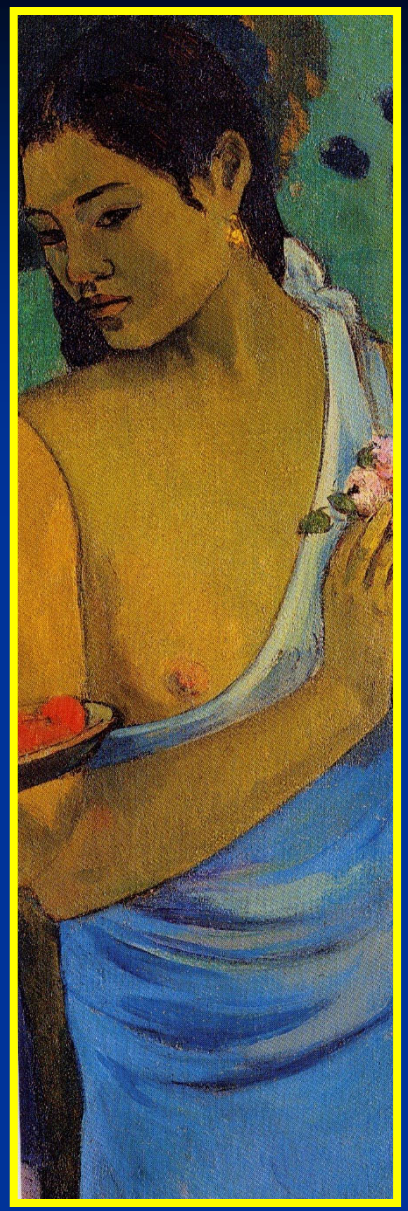
IT WILL BE FUTILE TO WAIT UNTIL THE ILIAC CREST IS COMPLETELY BEFORE DISCONTINUING THE TREATMENT OF SCOLIOSIS !!!

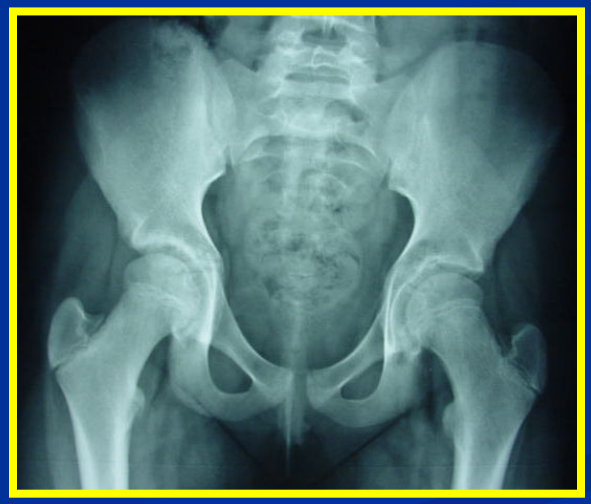
PUBERTAL DIAGRAM



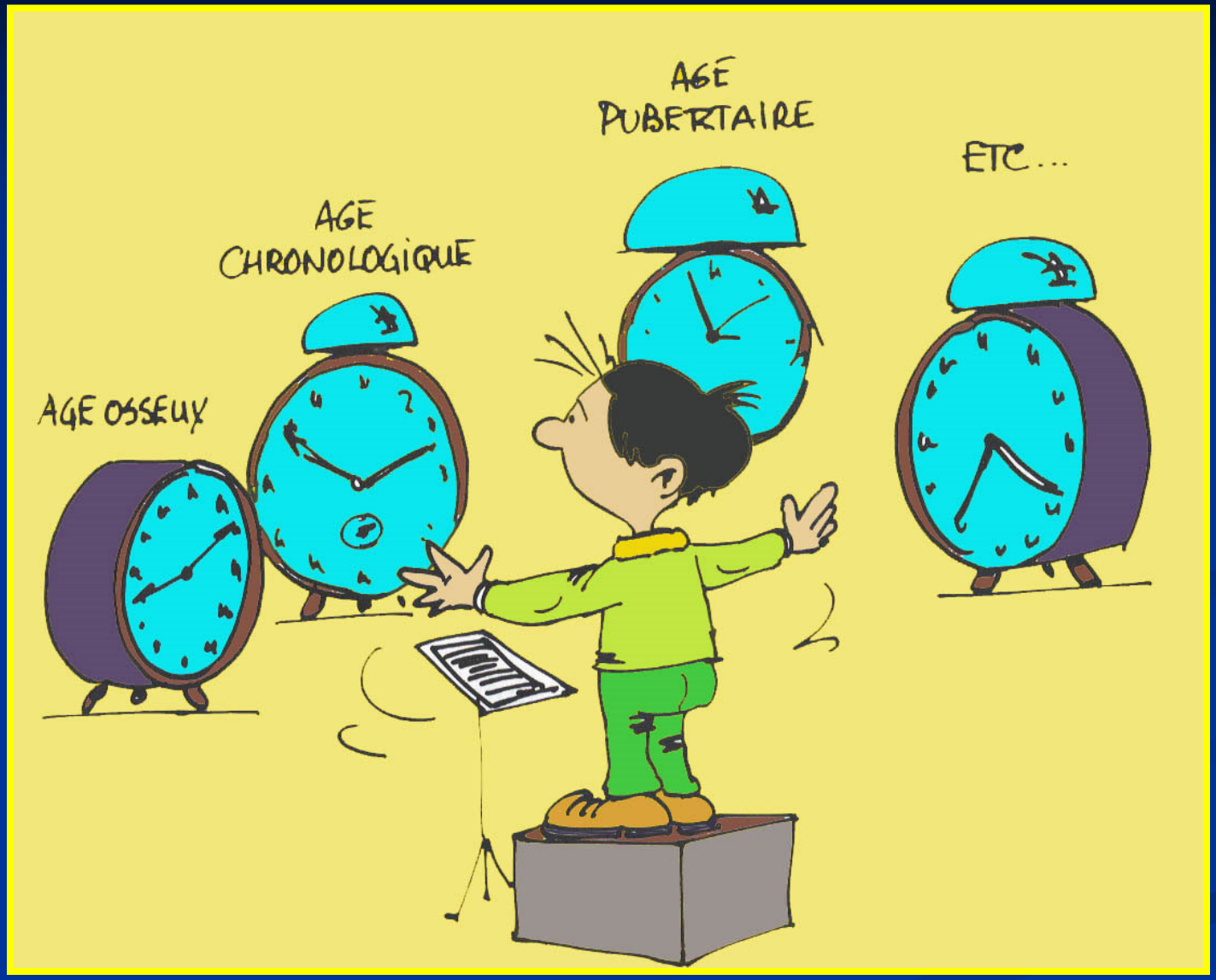


Zone 1: Risser 0, triradiate open
Zone 2: Risser 0, triradiate closed
Zone 3: Risser I-II, Greater trochanter open
Zone 4: Risser III-IV, Greater trochanter closed

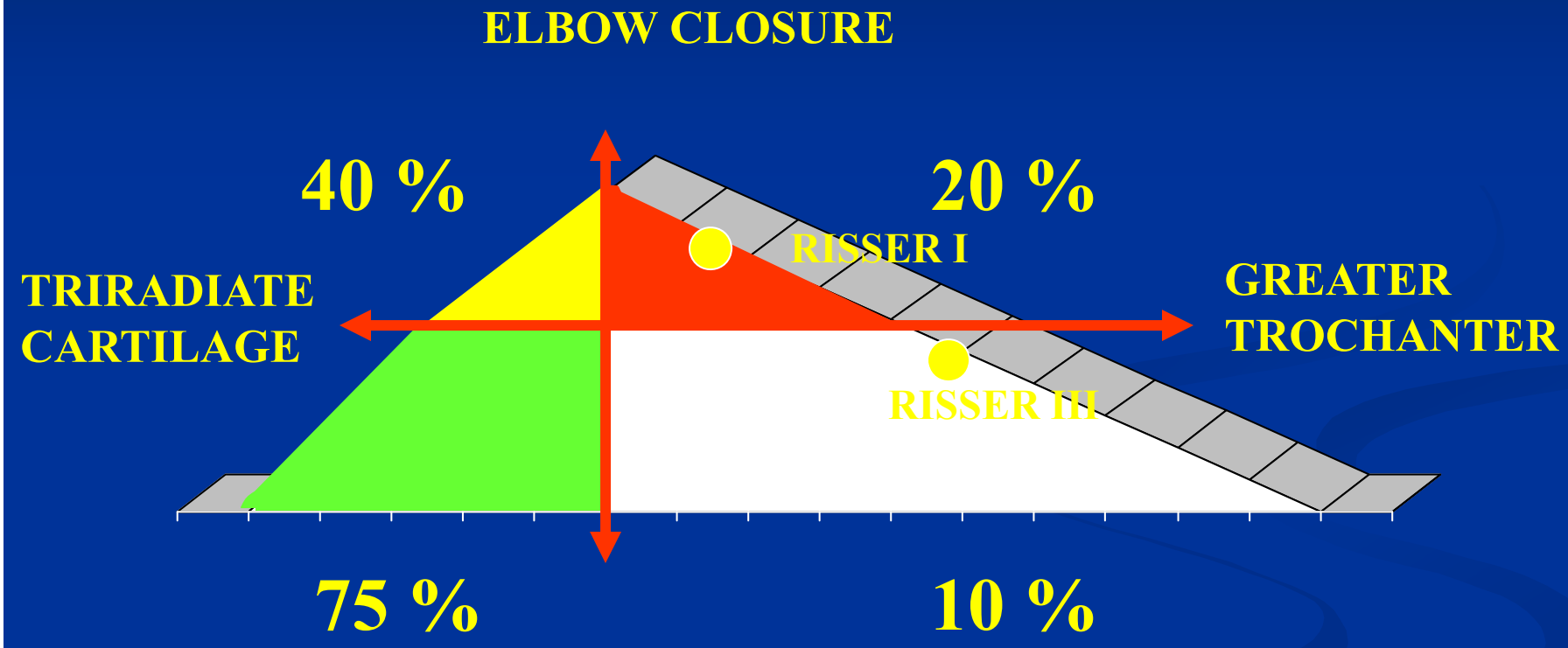


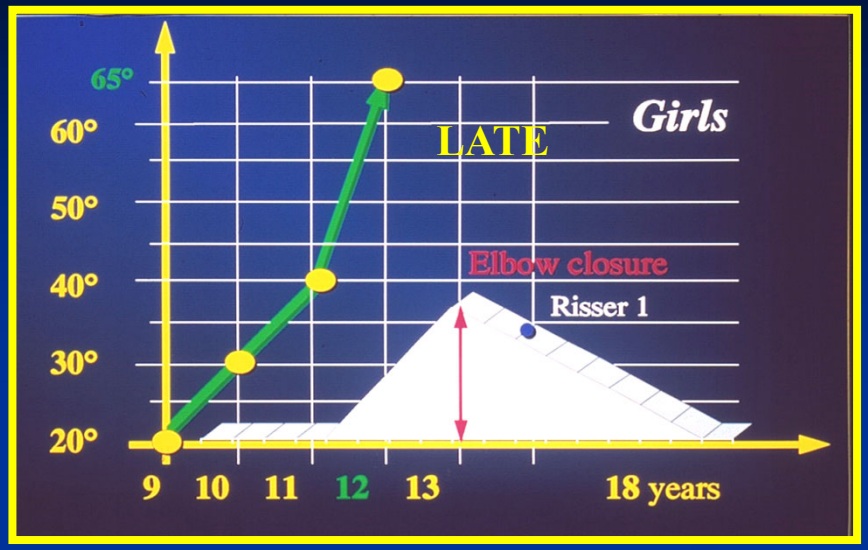


Combine the different parameters: annual growth velocity , tanner signs, pelvis, elbow and hand


AGE OSSEUX
AGE CHRONOLOGIQUE
AGE PUBERTAIRE
ETC...

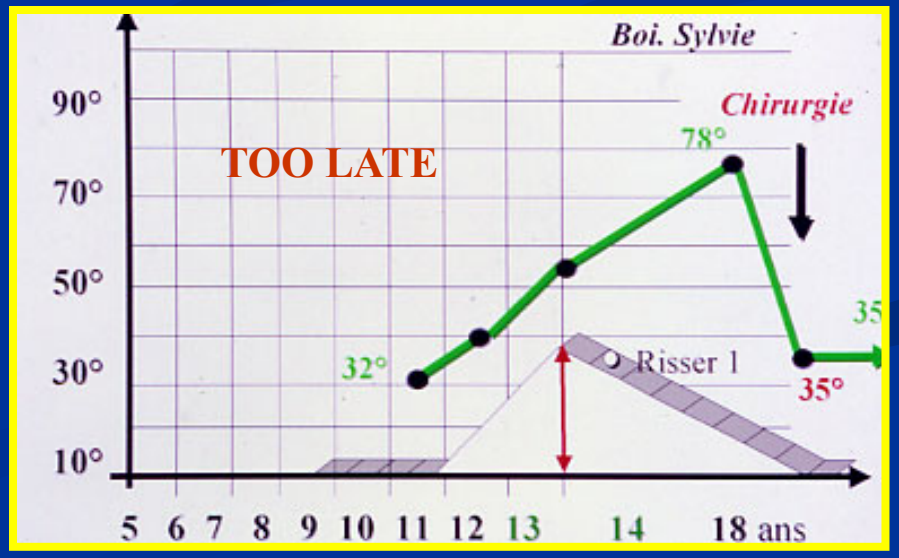
RISK OF CRANKSHAFT PHENOMENON

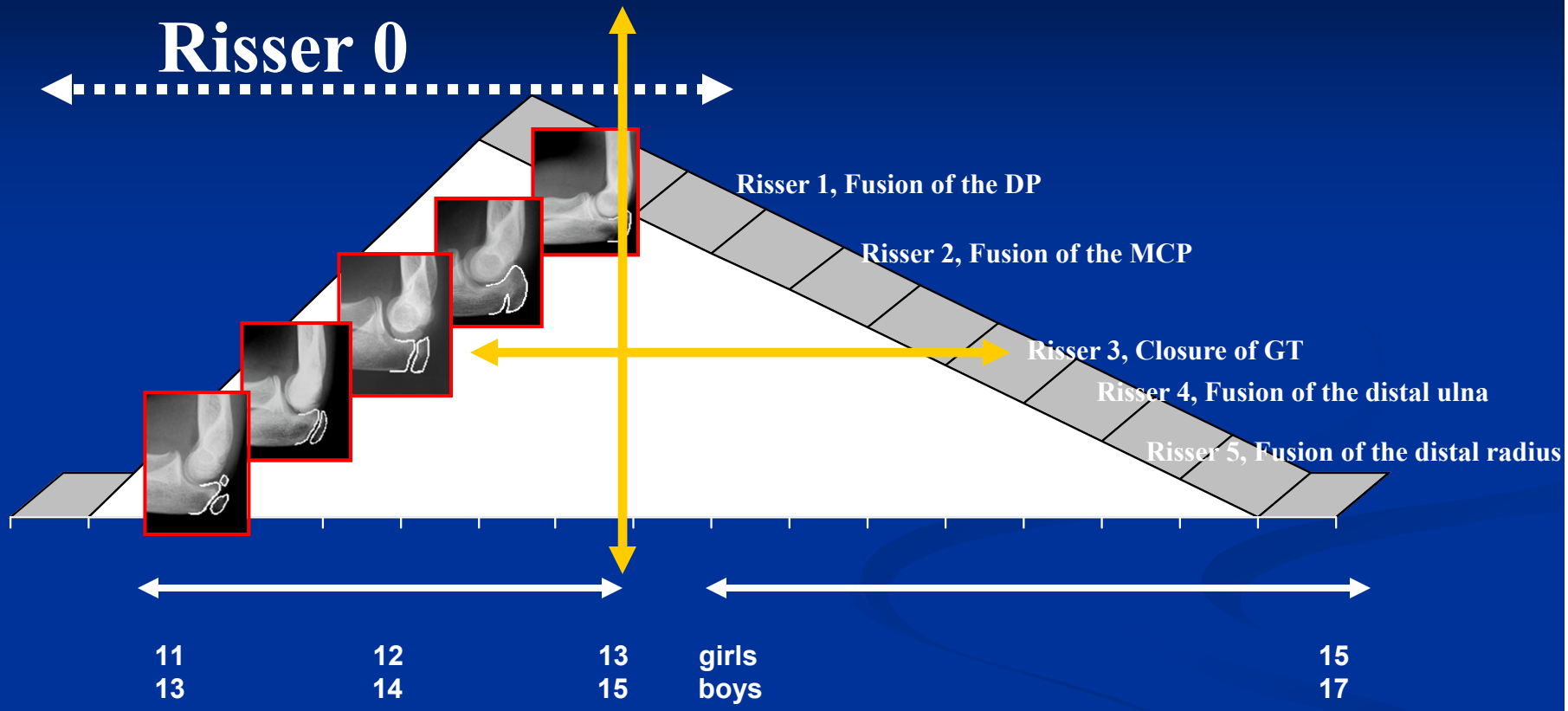




TREAT EARLY

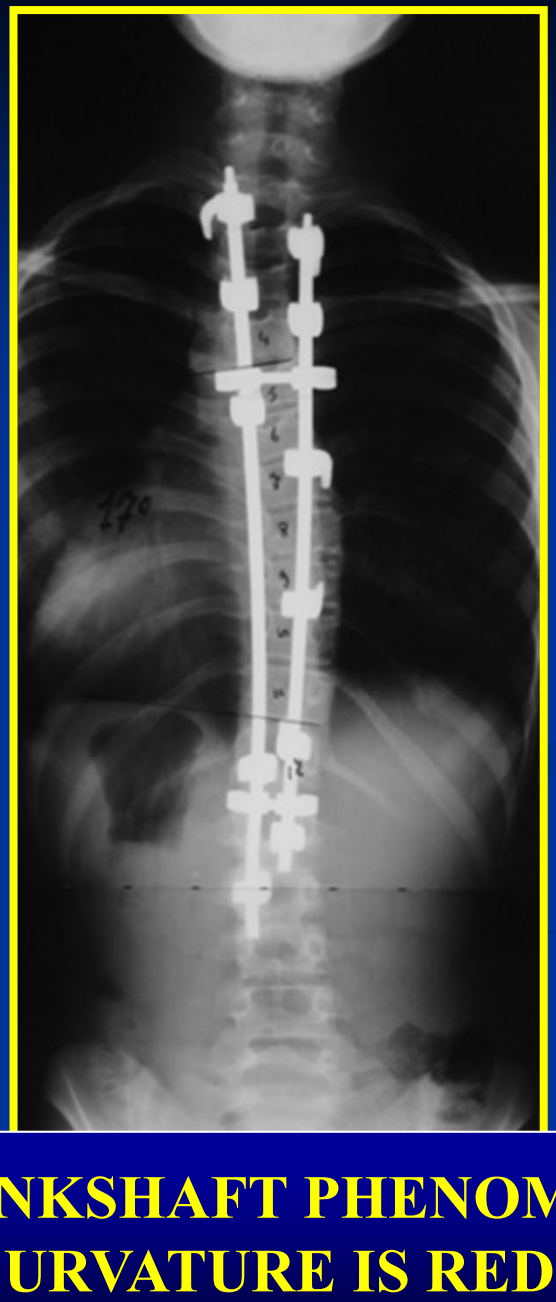
Detect soon aggressive scoliosis

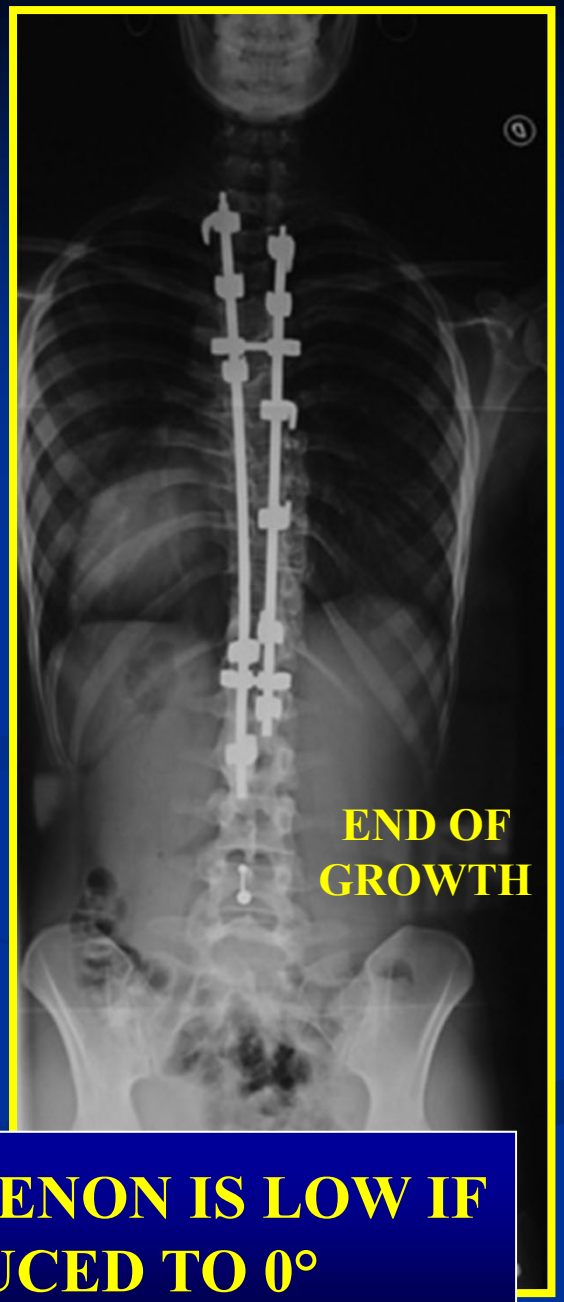




Zone 1: Risser 0, triradiate open
Zone 2: Risser 0, triradiate closed
Zone 3: Risser I-II, Greater trochanter open
Zone 4: Risser III-IV, Greater trochanter closed

Girl 11 years old



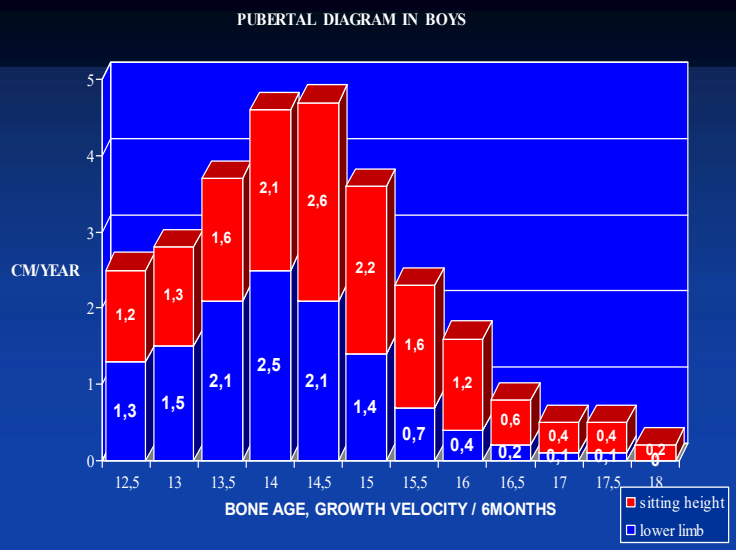


THE RISK OF CRANKSHAFT PHENOMENON IS LOW IF THE SPINE CURVATURE IS REDUCED TO 0°

RETT SYNDROME

A.T. – F – 10 years

BOYS



22.5 cm
(± 1cm)

Elbow closure

Closure of the triradiate cartilage 14

Risser 1

13

15

18

Bone Age

8.5 cm

4.5 cm sitting height

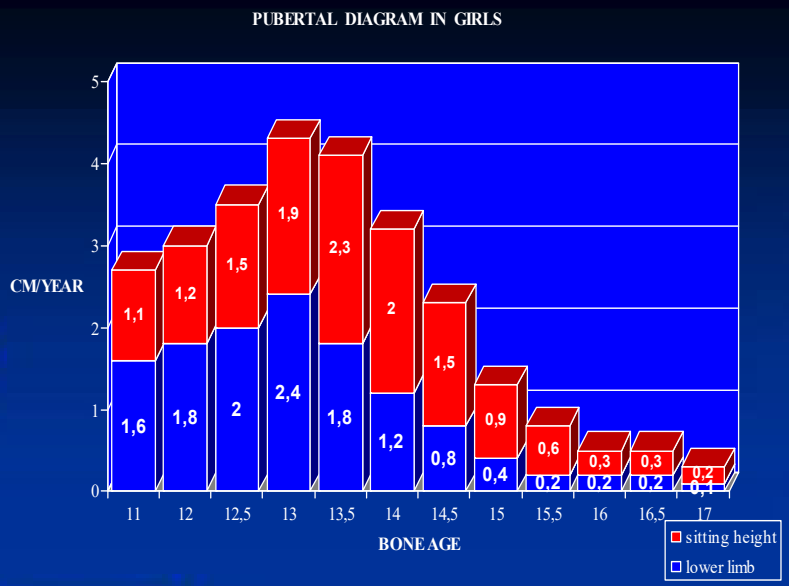
8 cm

1.5 cm lower limb

Remaining growth: 13%
Multiplying factor: 1.14

Morrissy-Weinstein(ed. Lovell& Winter)

GIRLS



Elbow closure

20.5 cm (± 1cm)

Closure of the triradiate cartilage

12

Risser 1 : menarche

11

13

18 years

Bone Age

7.5 cm

7 cm

4.5 cm

1.5 cm

sitting height

lower limb

Remaining growth: 12%
Multiplying factor: 1.13

Morrissy-Weinstein(ed. Lovell& Winter)

Thoracic deformity in severe scoliosis

- **Thoracic insufficiency Syndrome**

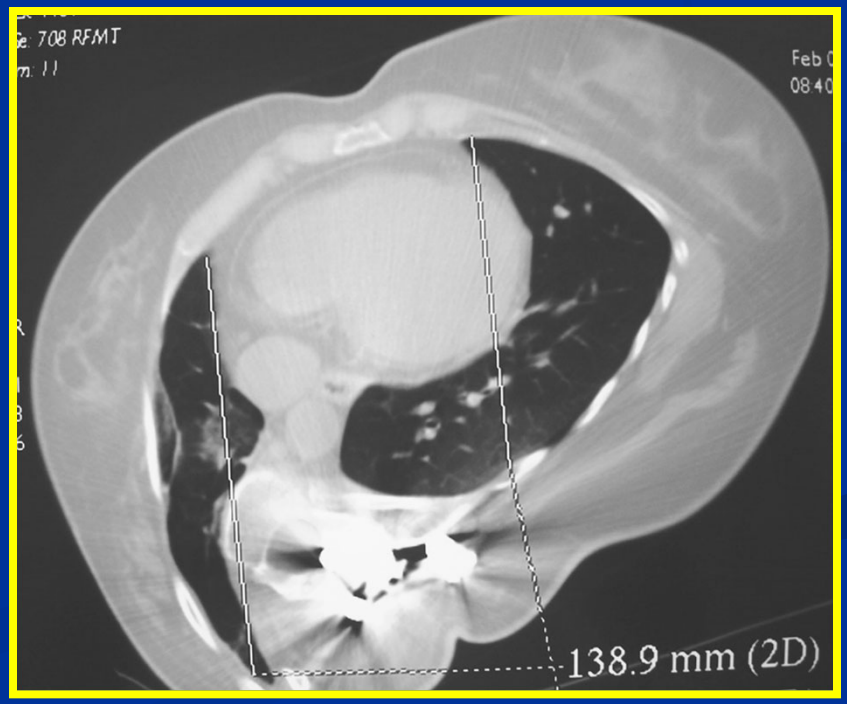
  Congenital scoliosis and fused ribs

  Campbell et al.
  J Bone Joint Surg (Am) 2003

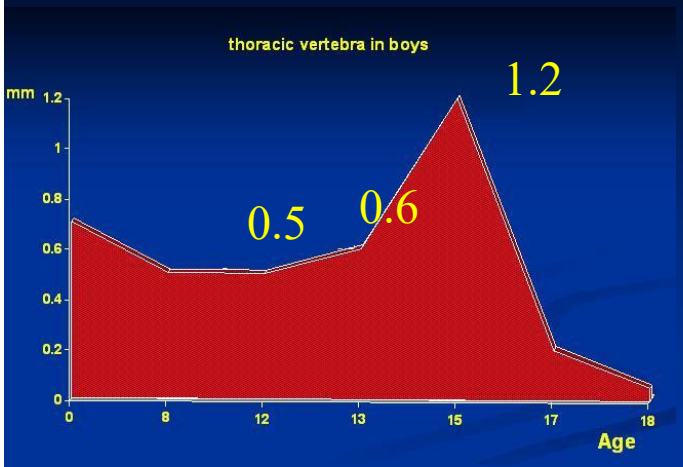
- **Spinal penetration index**

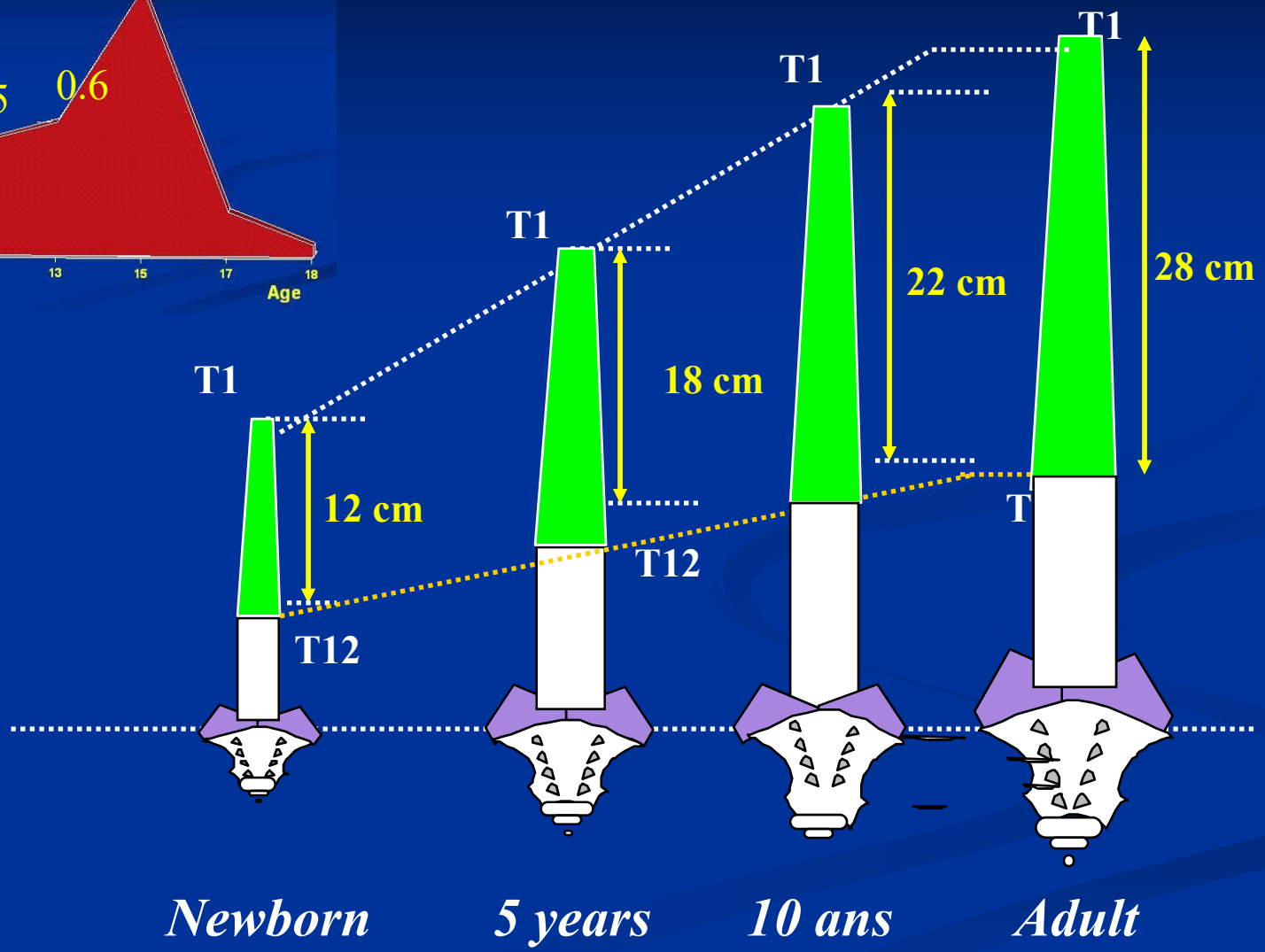
  Neuromuscular scoliosis Syndromes

  Dubousset et al.
  J Orthop Sci 2003

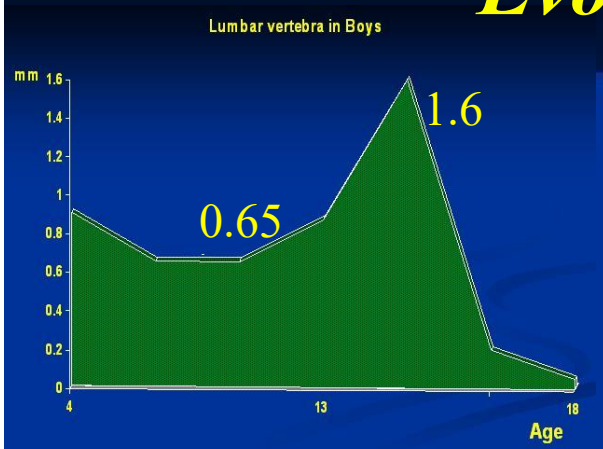


Evolution of T1-T12 Segment





Evolution of L1-L5 Segment



Newborn 5 years 10 years Adult

THORACIC VERTEBRA

Deficit 2,5% …sitting height

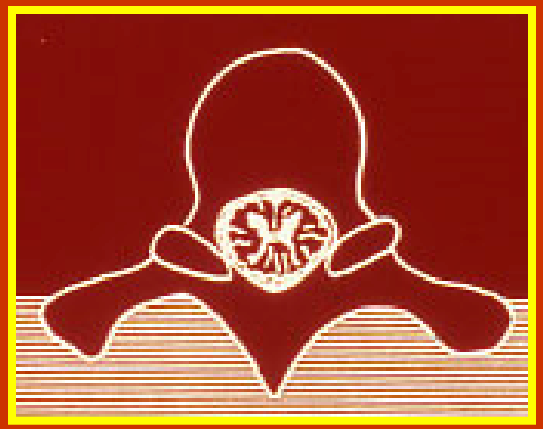
Circumferential arthrodesis

LUMBAR VERTEBRA

Deficit 3,5% …sitting height

THORACIC VERTEBRA

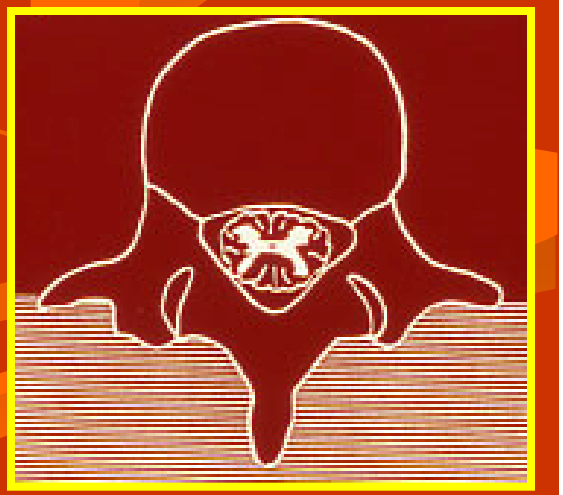
Deficit < less than 1% …sitting height



Posterior arthrodesis

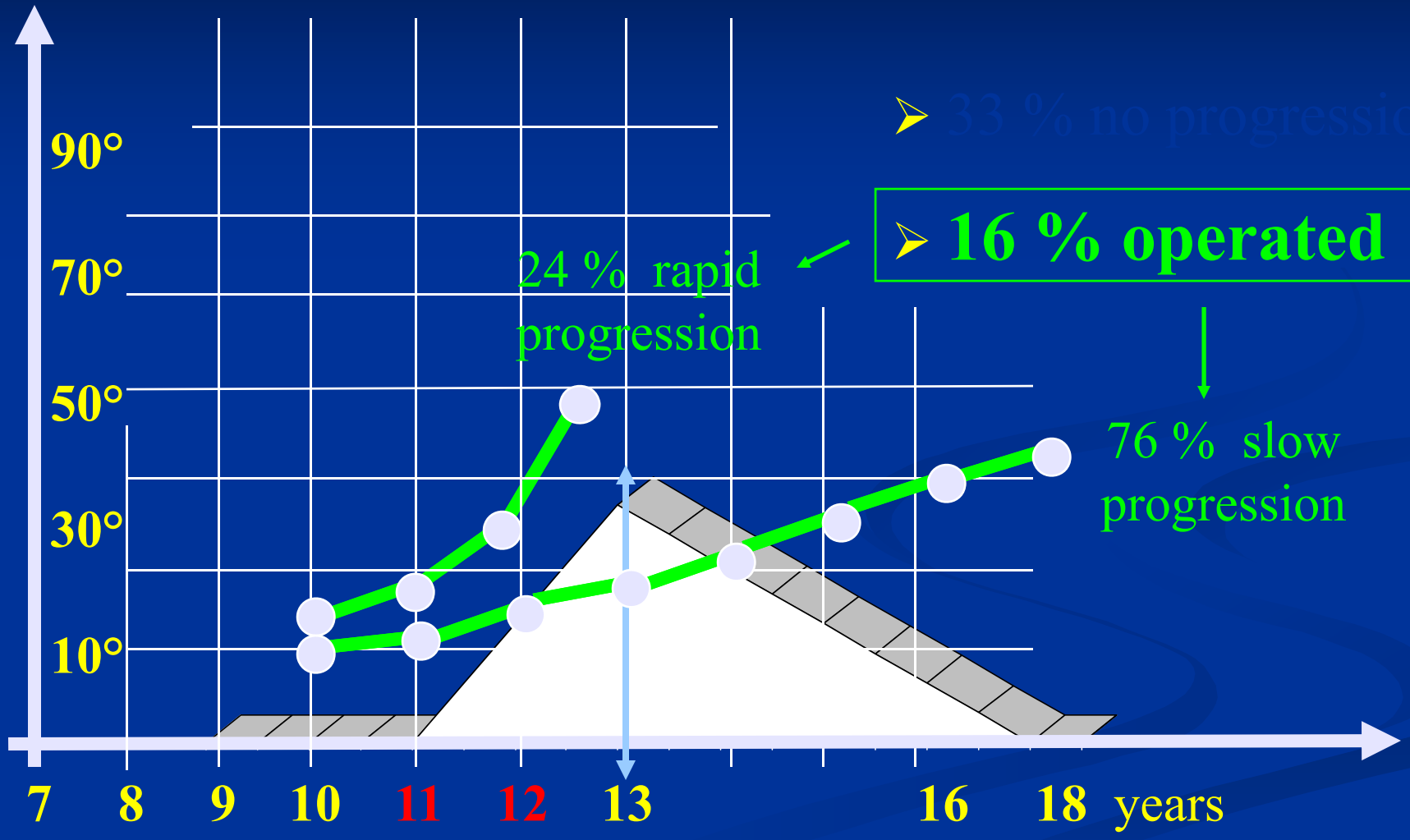
LUMBAR VERTEBRA

Deficit > more than 1% …sitting height



Curves < 20° at onset of puberty

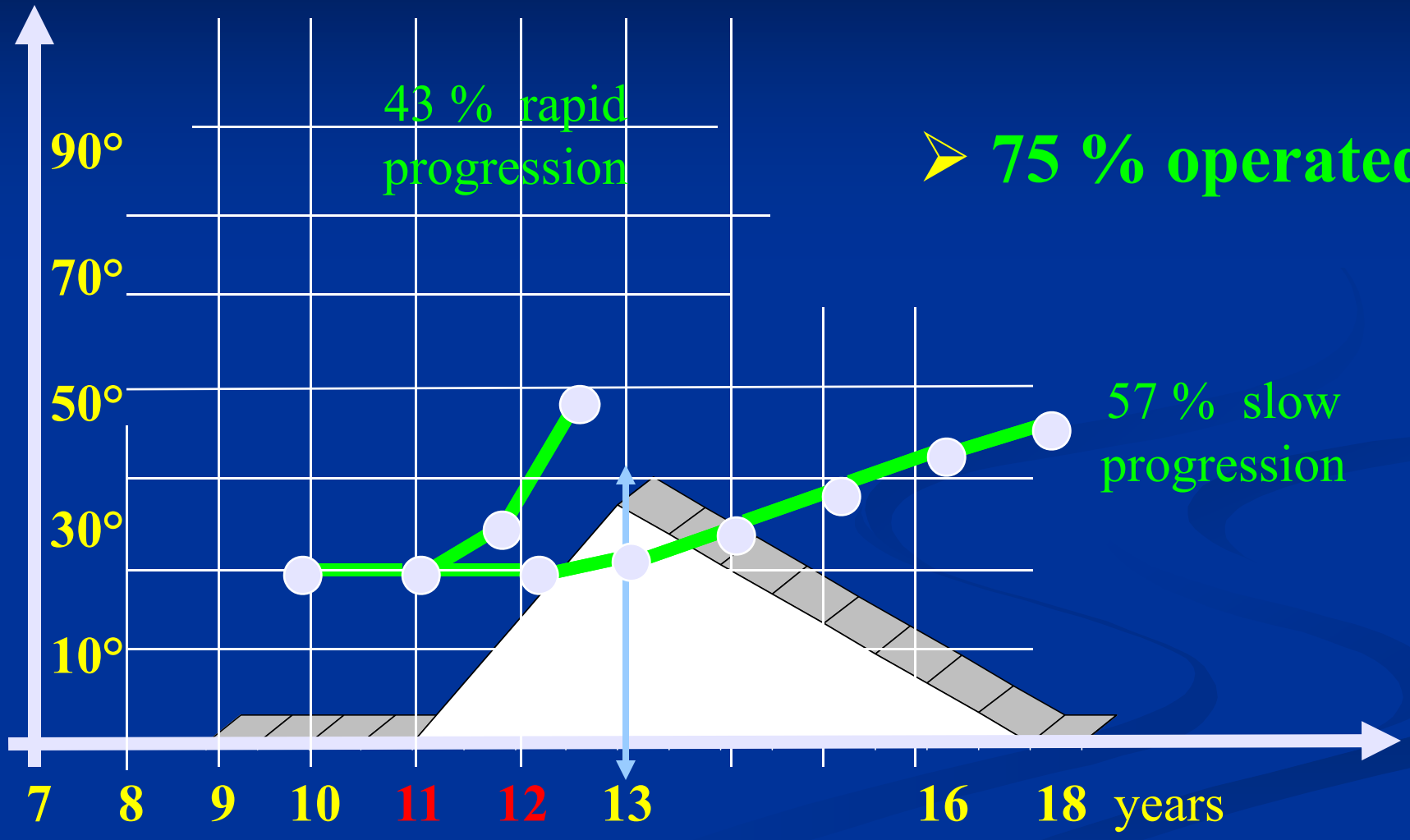
n = 105 / 205



Spine August 2006

Curves 20° - 30° at onset of puberty

n = 56 / 205



➢ **75 % operated**

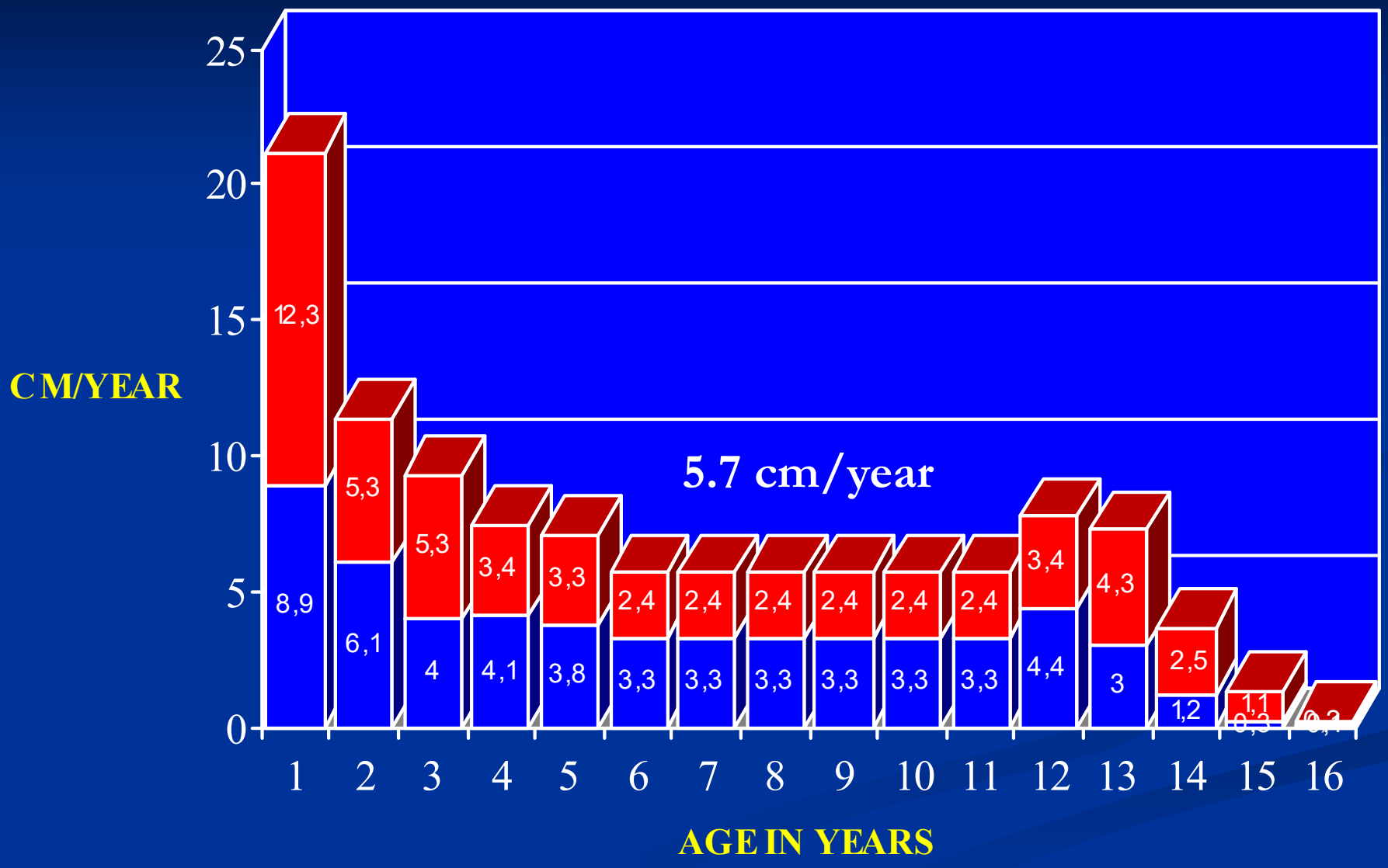
Spine August 2006

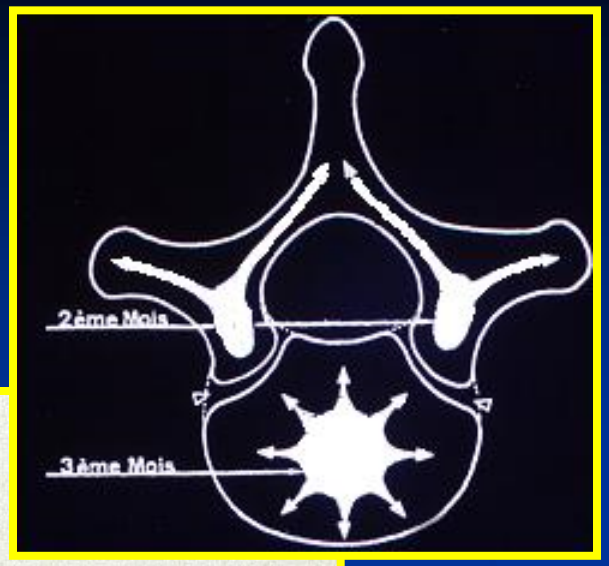
A PERI-VERTEBRAL ARTHRODESIS PERFORMED AT AGE 5 YEARS DOES NOT THREATEN THE WIDTH OF THE SPINAL CANAL

AFTER EARLY PERI-VERTEBRAL ARTHRODESIS THE DEFICIT ON THE SITTING HEIGHT IS OUTBALANCED BY THE CORRECTION OF THE CURVE

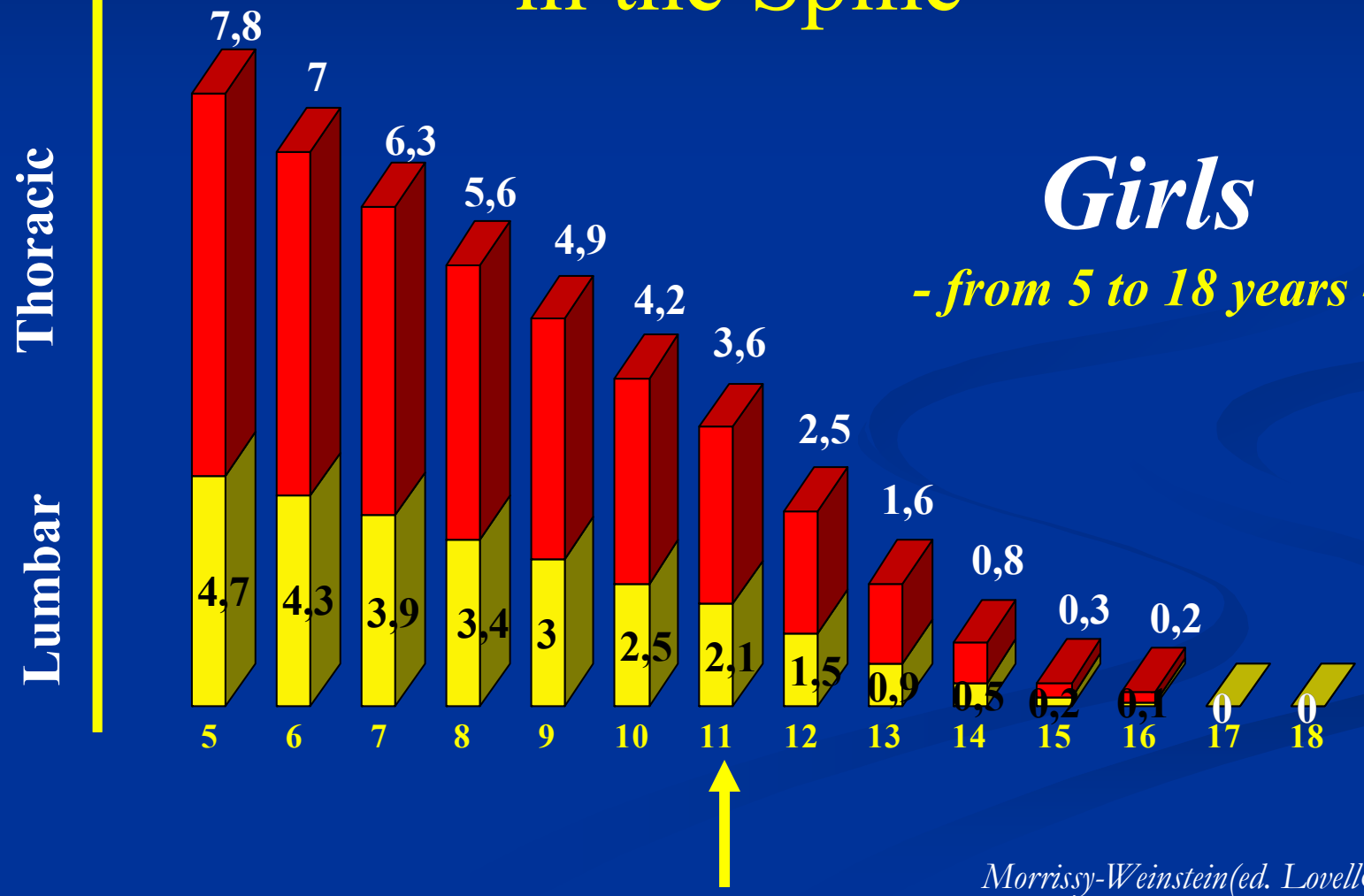
TREAT EARLY

GROWTH VELOCITY IN GIRLS




2ème Mois
3ème Mois

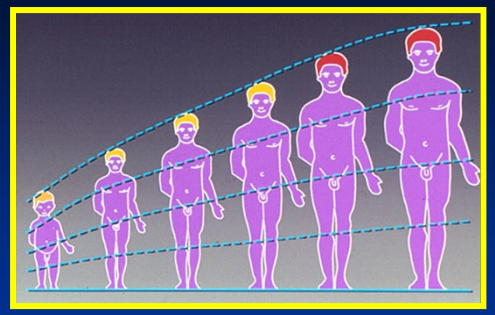
Remaining Growth in the Spine



Girls

- from 5 to 18 years -

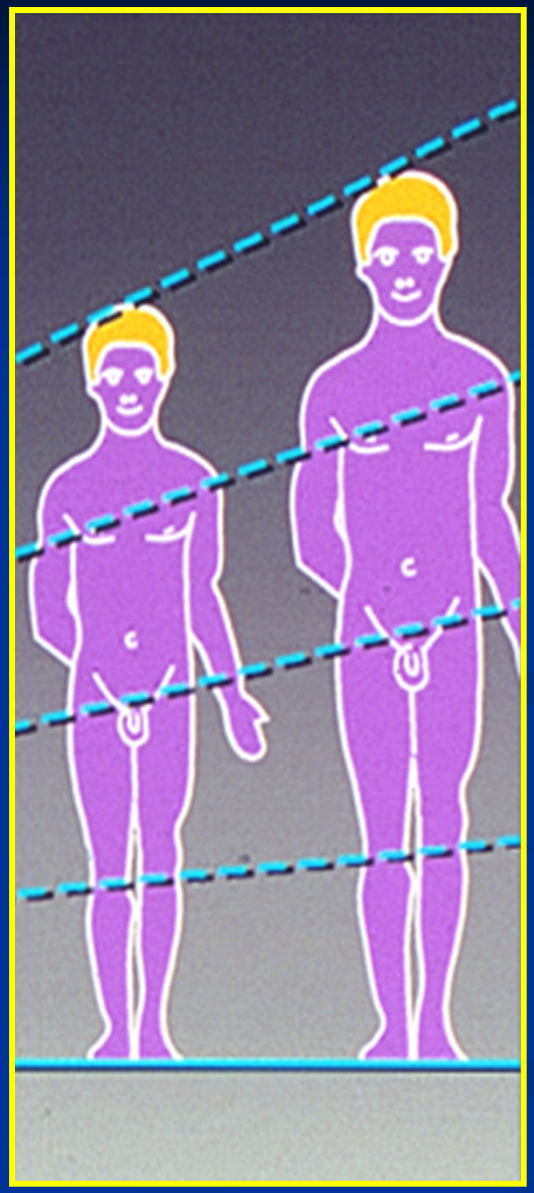
Morrissy-Weinstein(ed. Lovell& Winter)



Growth velocity

5.5 cm/year

5 - 10 Y



TOTAL GAIN

27.5 cm

SITTING HEIGHT
+ 10 cm
(1/3)

LOWER LIMB
+ 17.5 cm
(2/3)