



# The Long and Short of Childhood Growth

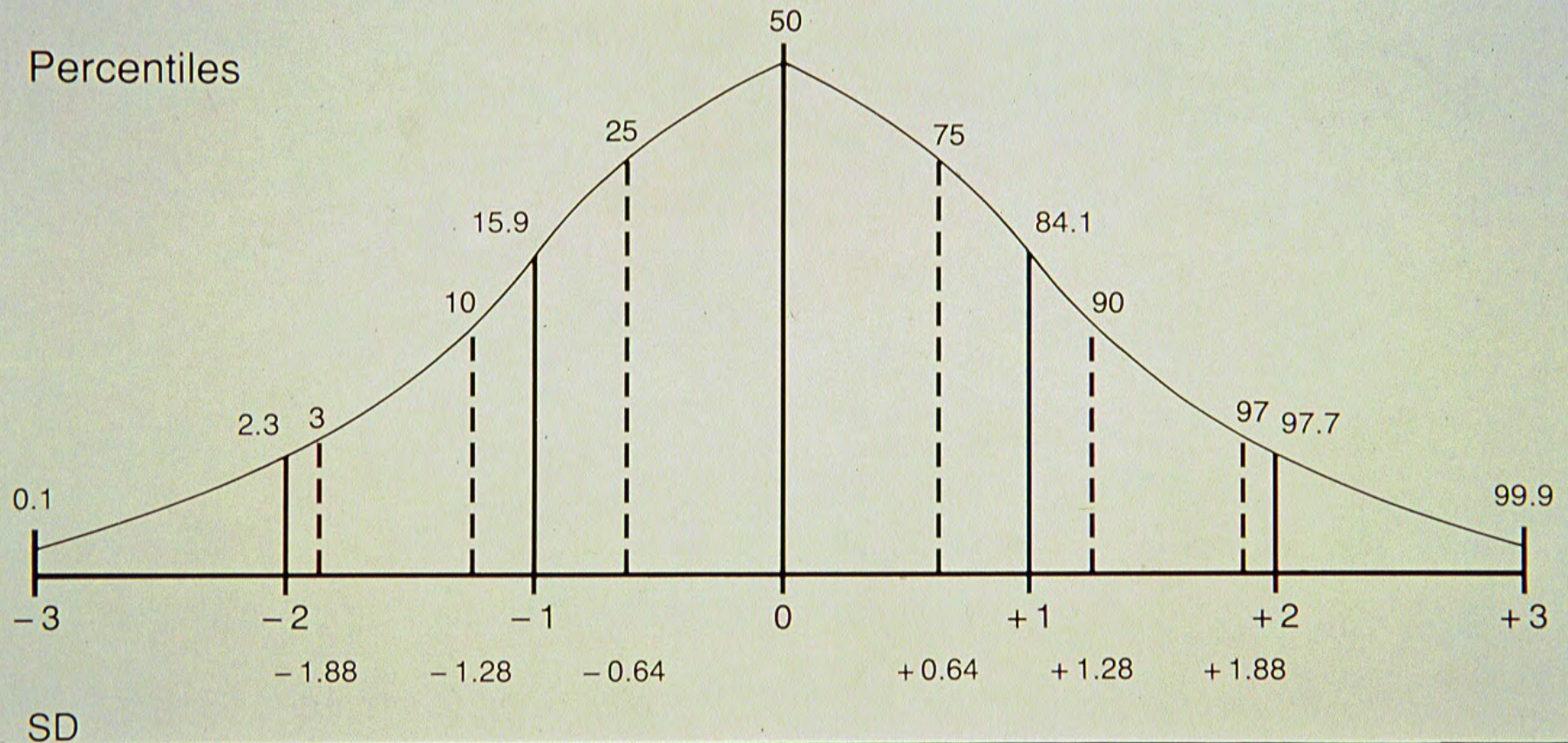
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## Percentiles



NB: 2.3% of the normal population have a height that is  $< -2.0SD$  and 2.3% have a height that is  $> +2.0SD$  BUT further you are from the mean the greater the likelihood of an underlying cause

# How to Approach Growth Disorders?

# Collecting Information

- Serial measurements are important  
(at least 6 months)
  - Blue book measurements
  - Beware device and inter-individual differences in height measurement

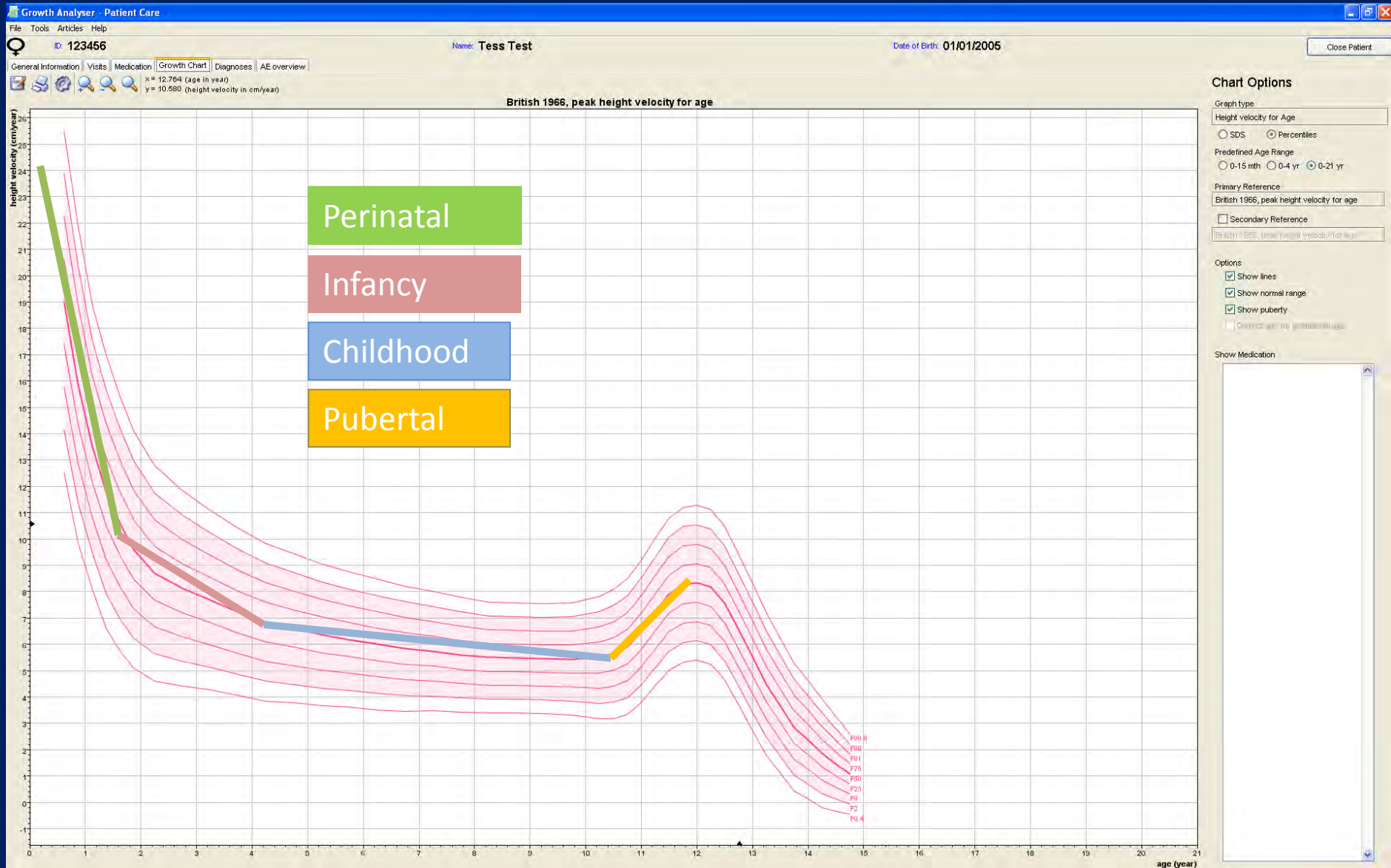
# Context is all important

- Progress compared with mid-parental target height \*
- Short vs. Growth Failure
  - was there a point of inflection (i.e. growth failure) vs.
  - growth along a lower percentile cf. target height or gradual deviation
- What is their height vs. weight

\*BOYS = (Parental heights +12.5cm)/2

\*GIRLS = (Parental heights – 12.5cm)/2

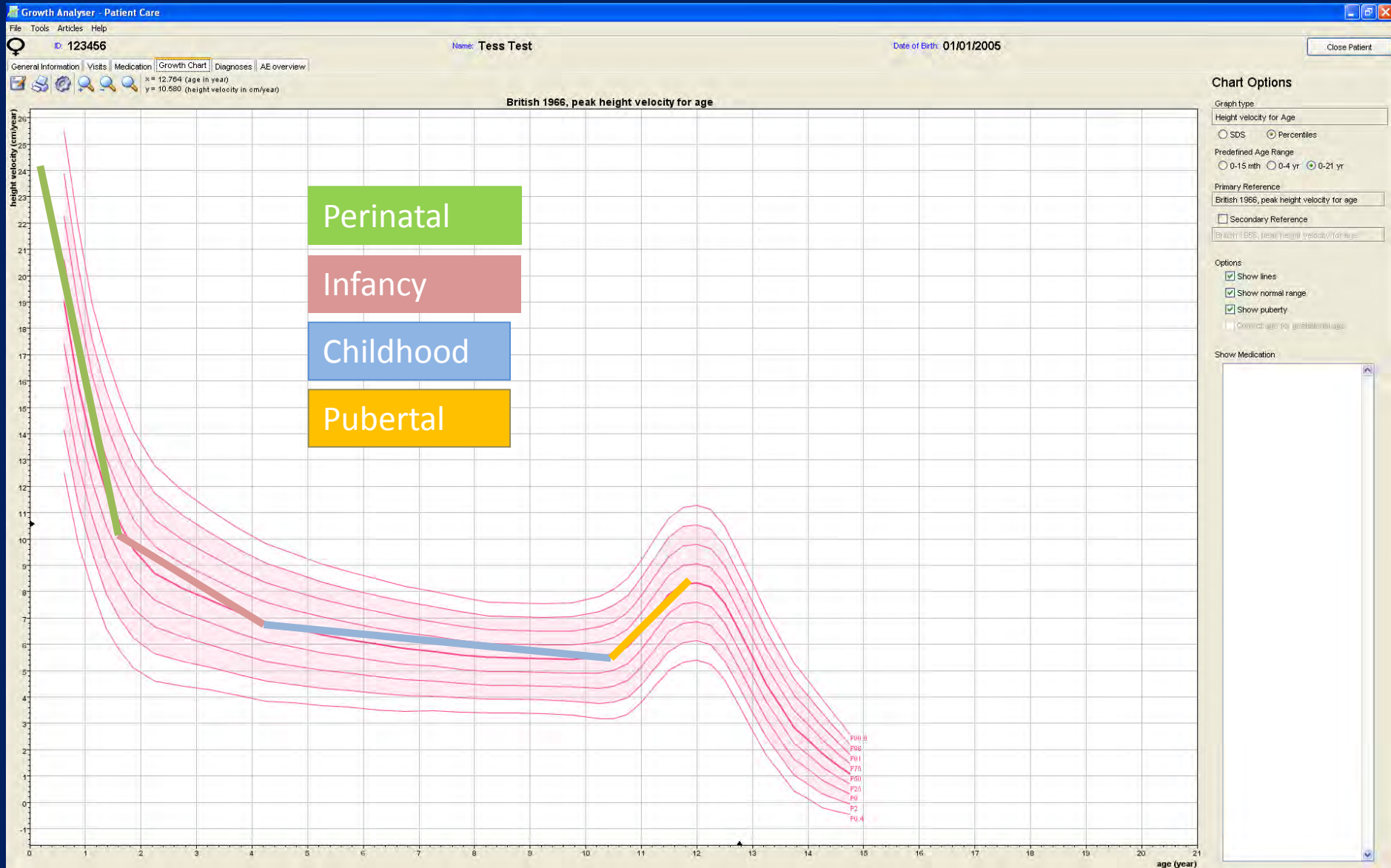
# Phases of Growth





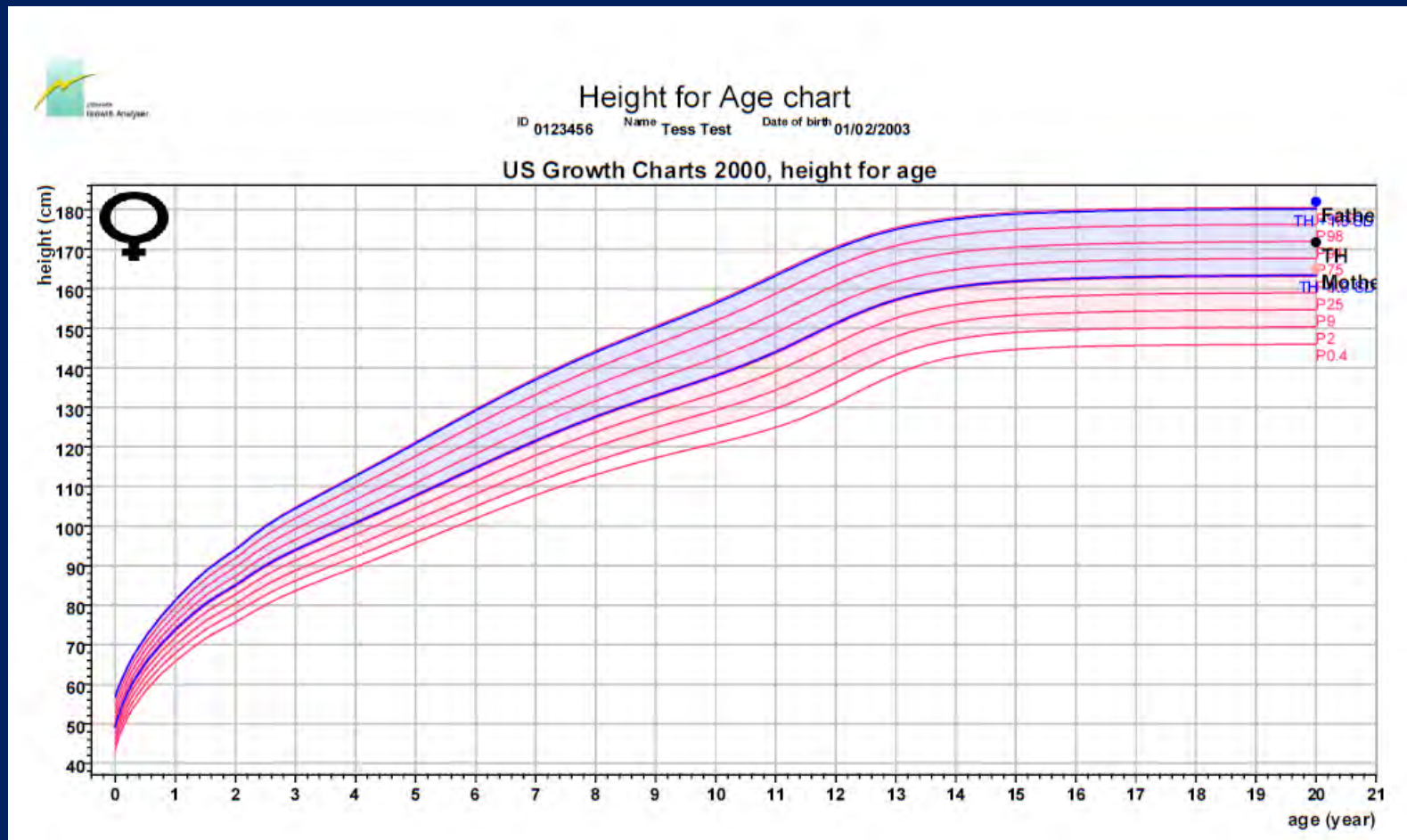
- Delayed transition between the different phases can mimic a growth disorder
  - Delayed transition :
    - Between from postnatal to infancy growth rate results in apparent acceleration in the first 2-3 years
    - Delay in pubertal growth spurt results in slowing and can lead to crossing centiles – but organic pathology needs exclusion

# Phases of Growth





# Mid Parental Height (Target Height – TH)



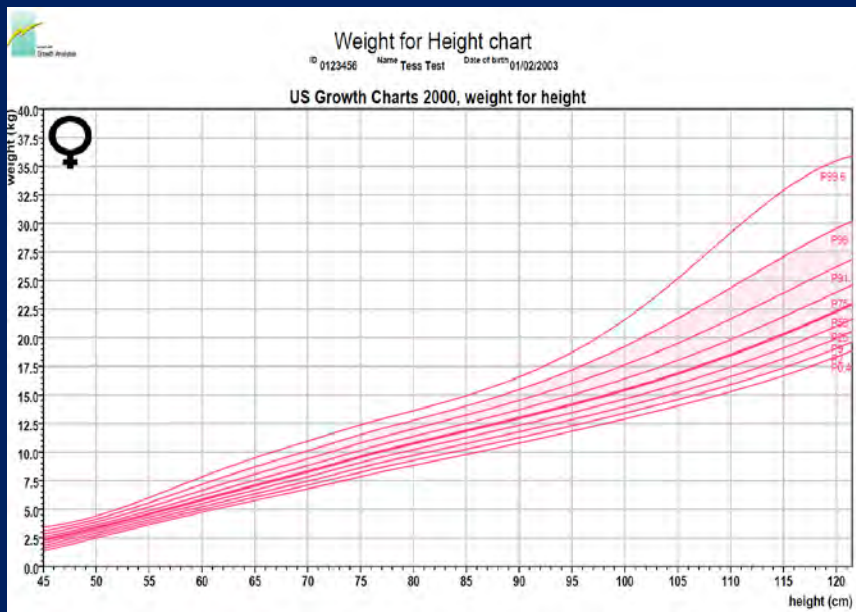
Anywhere in the blue region is expected for this girl (TH +/- 8.5cm)

# Normal variation

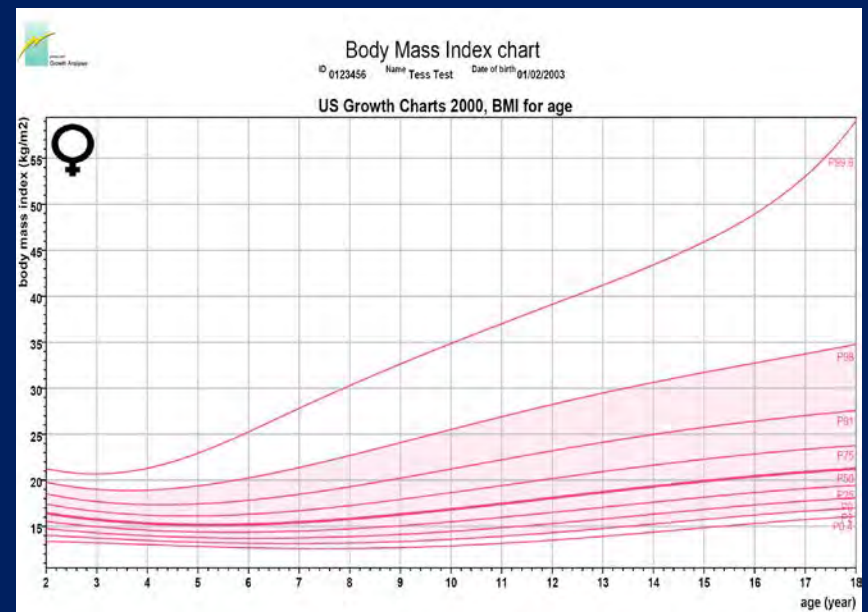
- Crossing one percentile is common in first 2-3 years and around puberty
- Growth parallel to centiles at other times is expected and likely to be normal if within fewer than 2 centiles of mid-parental height.
- BMI normally lies between 10<sup>th</sup> and 85<sup>th</sup> centiles

# Comparing Weight vs. Height

Waist to height ratio.... Should be  $< 0.5$  if  $>6$  yrs



Younger children



Children  $> 4$ -5yrs

# BMI influences Pubertal Onset

- Slim children who have low fat mass tend to enter puberty late
- Obesity and insulin resistance can trigger
  - Premature adrenarche
    - Pubic +/- axillary hair, oily skin +/- pimples
    - Increased risk of PCOS in later life and metabolic syndrome
  - Early puberty in girls but less predictable in boys

# Puberty Timing has a Major Influence on Height

- Normal onset
  - Boys 9-14      - peak height velocity ~2y after  
(Testes  $\geq$  4mL)      pubertal onset
  - Girls 8-14      - peak height velocity prior to  
(Breast buds)      menarche
- Estrogen causes epiphyseal fusion in both sexes.
- Precocious onset of puberty if not above target before starting may compromise final height

# Approach to short stature

- Disproportion of trunk vs. limbs +/- Head
  - E.g. achondroplasia/ hypochondroplasia
  - Short trunk
  - Short limbs – proximal, medial or distal  
(rhizomelic, mesomelic, acromelic)
- Dysmorphism
  - Face, limbs, major organs
  - Prader Willi, Noonan, Turner many others
- Normal vs. subnormal height velocity
  - Timing may suggest cause
    - Congenital with lack of catch up (Russell Silver syndrome).



# Investigation of Short Stature

## History

- Birth Wt/Length
- Growth rate
  - Accurate repeated measures
- Past history
- Medications
- Detailed Systems review
  - Esp. GI and CNS
- Parents and Sibs
  - Heights
  - Age at puberty

## Exam

- Dysmorphism and Nutrition
- BP and pulse
- Body Proportions
  - Height and Weight (serial)
  - BMI
  - Head circumference
  - Limb to trunk length
    - Arm span, pubis to floor
- Thyroid (clinical and goitre)
- Full general exam
- Visual fields and fundi
- Skin (eg. NF1)
- Puberty

# Short Stature Causes

## Common vs

- Familial (genetic short stature)
- Constitutional delay in growth and puberty

## IMPORTANT not to miss

- Idiopathic
- Neglect
- Endocrine
  - Thyroid
  - Pituitary
  - Hypogonadism
  - Steroid excess
- Syndromic
- Skeletal dysplasia
- Chronic Illness

# Key investigations

- Chromosomes (girls)
- FBE/Fe/ESR/TTG
- EUC
- TFT IGF-1 (prolactin)
- Older children LH/FSH
- Bone age x-ray

Tall Stature

# Tall Stature

## Common

- Familial tall stature
- Constitutional advancement in growth and puberty
- Nutritional excess esp. with insulin resistance
  - Insulin can drive growth

## Important

- Precocious puberty
- Male sex chromosome aneuploidies (may present pre-adolescence)
- Androgen excess
  - Gonads
  - Adrenals
- Genetic overgrowth syndromes
  - RARE** causes
- Growth hormone excess
- Delayed fusion of epiphyses

# Evaluation

## Measurements

### Face (dysmorphism)

- Learning and behaviour
- Forehead, ears, palate,
- Vision, lenses, acuity
- Malar flush and tongue

### Limbs

- Arm span
- Arachnodactyly
- Hypermobility

### Chest and Heart

- Pectus
- Scoliosis
- Heart - MV prolapse

### Genitalia

- Signs of puberty
- Testicular size



# Evaluation is cause dependent

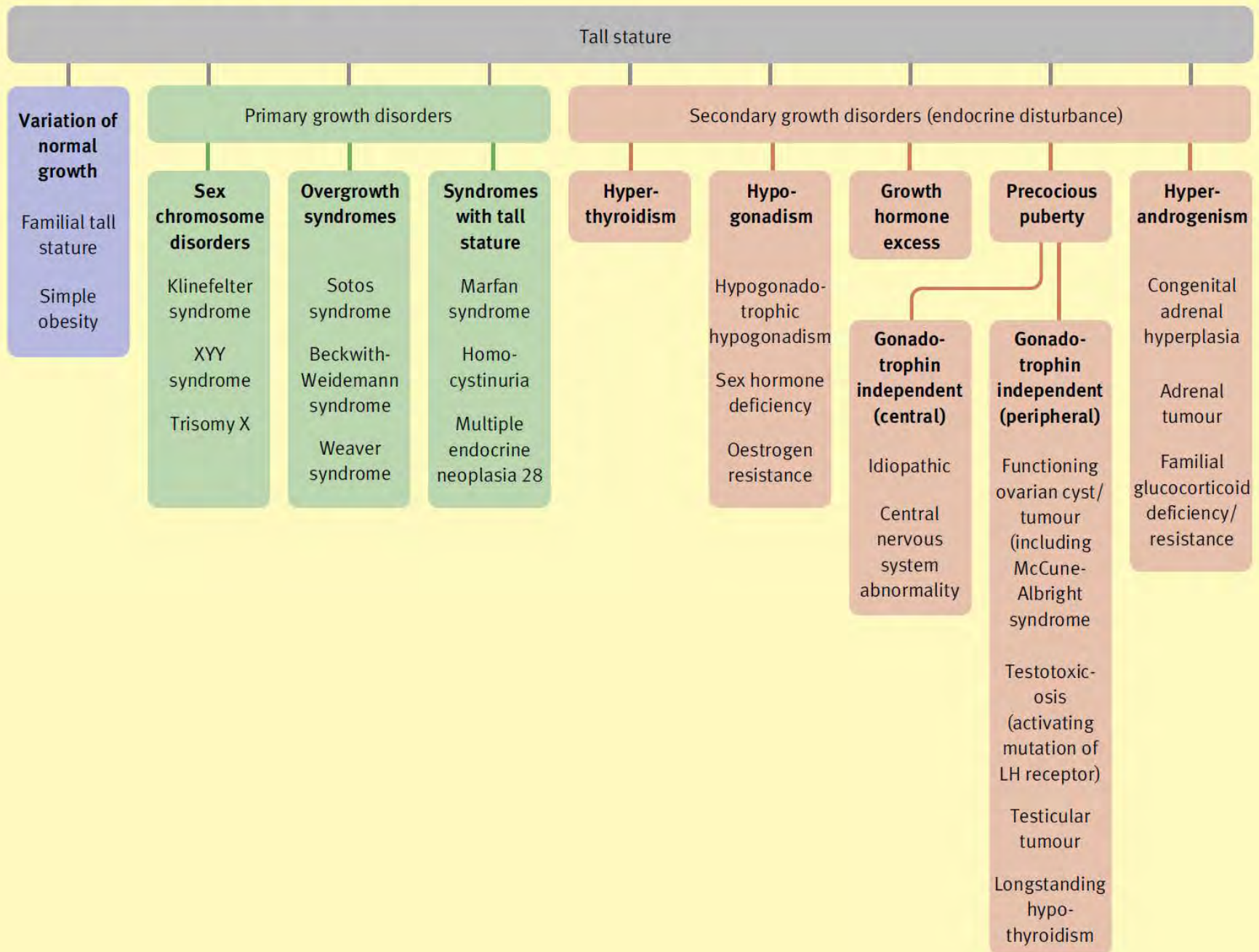
## Tall stature

vs.

## Overgrowth

- Familial tall stature is commonest
    - Both parents tall
    - No evaluation needed
  - Klinefelter syndrome incidence 1:500-700
    - Only 10% diagnosed before puberty
    - Educational and metabolic benefits in doing so
    - Only 25% ever diagnosed
- Obesity results in tall stature in childhood
    - Early intervention has best outcomes
    - Final height is normal
    - Metabolic risks long term
  - Endocrine causes
    - Thyroid puberty and androgens
  - Most other conditions are uncommon to rare
    - Some associated with increased neoplasia risk (eg. Beckwith Wiedemann Synd)

# Differential diagnosis of tall stature



# Who to refer

- Growth greater than  $\pm 2.0$ SD especially if disproportionate for target height
- Documented growth failure or acceleration regardless of growth compared with target height
- Proven endocrine disorders

# Where to refer

- Paediatric Endocrine clinic:
- Dr Tony Lafferty and Dr Cecilia Garcia-Rudaz
  - Disproportionate growth for parents
    - With or without bone age advance or delay
  - Turner Syndrome and variants
  - Klinefelter Syndrome
- For advice
  - Non-urgent 6174 7605
  - Urgent: 0466 655 068

# Assessing Growth in Children

Tony Lafferty



# In Utero and Infancy

- Growth does not occur at a constant rate throughout childhood.
- Determinants of *in utero* growth include:
  - Maternal nutrition
  - Maternal illness
  - Placental function
  - Foetal factors



# In Utero and Infancy

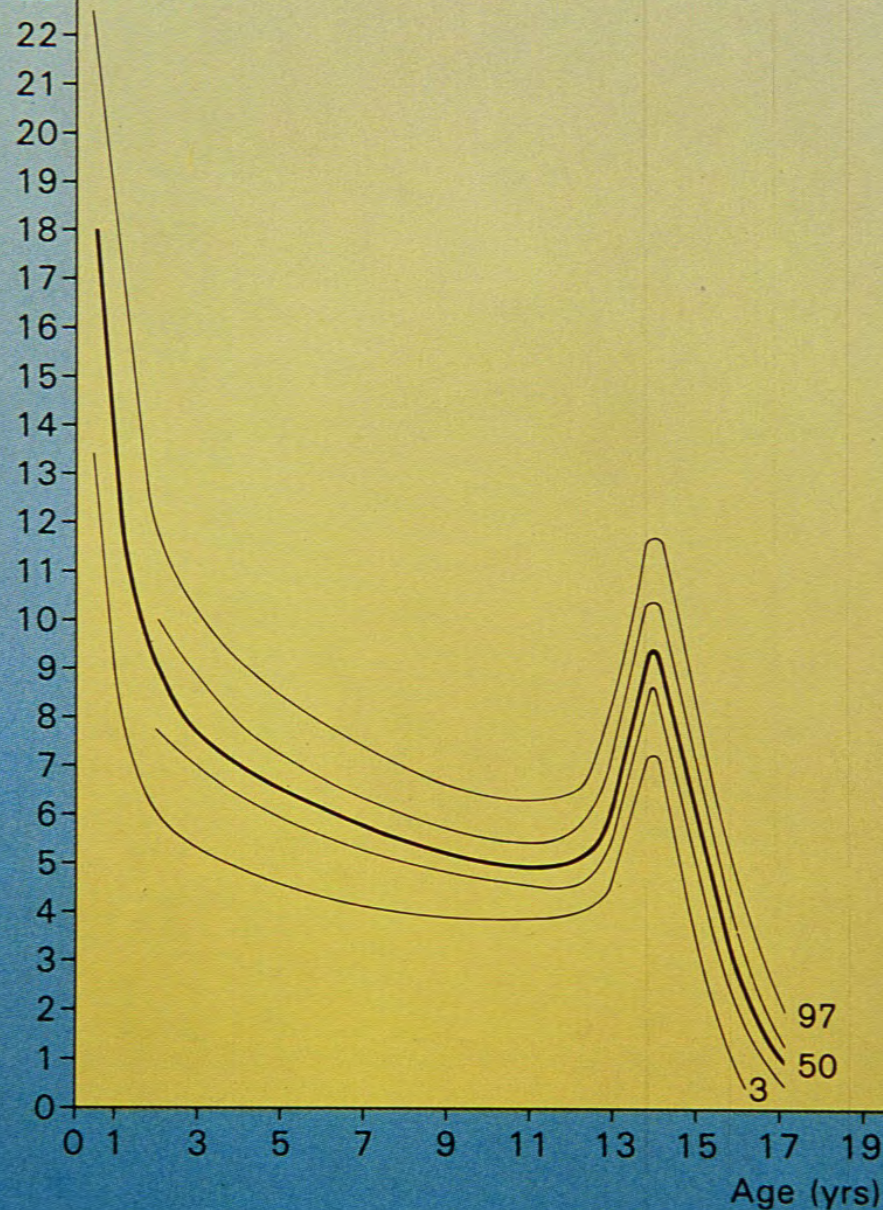
- A newborn will triple their birthweight and increase their birth length by 50% in the first year
- Growth rate can be as high as 2.5cm per month in first 2 months
- Falls to around 30% of this by 10 months
- Falls rapidly until 2-3 years

# Childhood

- From age 4 until puberty growth approximates 5-6 cm/ year

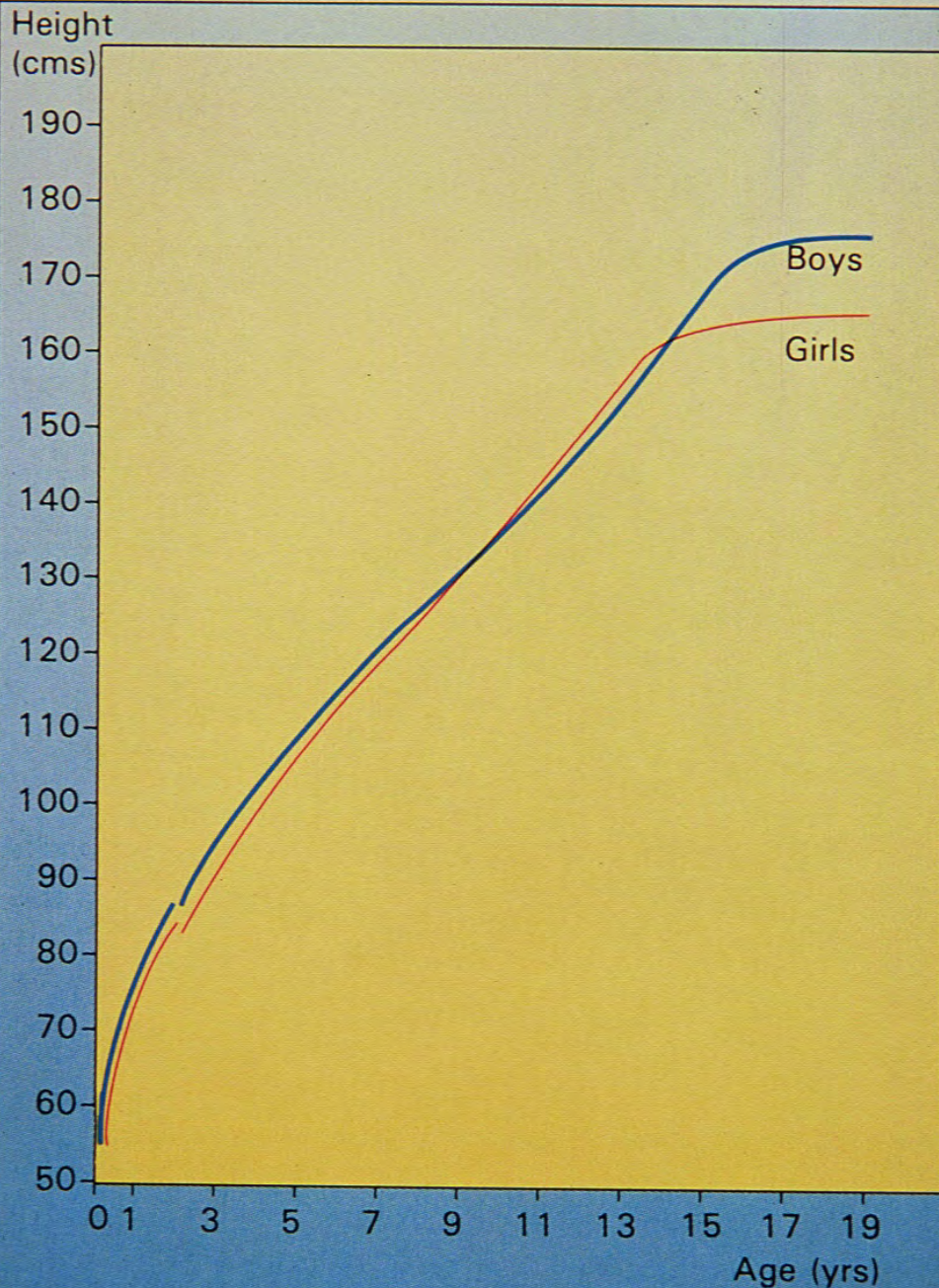
Height velocity (cms/yr)

BOYS



Tall children grow quicker than short children in order to maintain their position on the growth chart





- Boys are taller than girls for most of childhood until pubertal growth spurt in girls
- Oestrogen results in slowing and completion in growth due to fusion of epiphyseal growth plates in both sexes



Height velocity (cms/yr)



Puberty starts  
around the same age  
in both sexes  
**but** peak growth is  
~ 2yrs later in boys  
than girls

# Case 1

- 14 year old male.
- Short stature.
- Reduced growth rate for 3 years.
- Absence of secondary sexual development.
- Has withdrawn from all sport.

# Other history

- *Mum's first period was not until 15*
- *Dad did not grow until he was 17!!.*

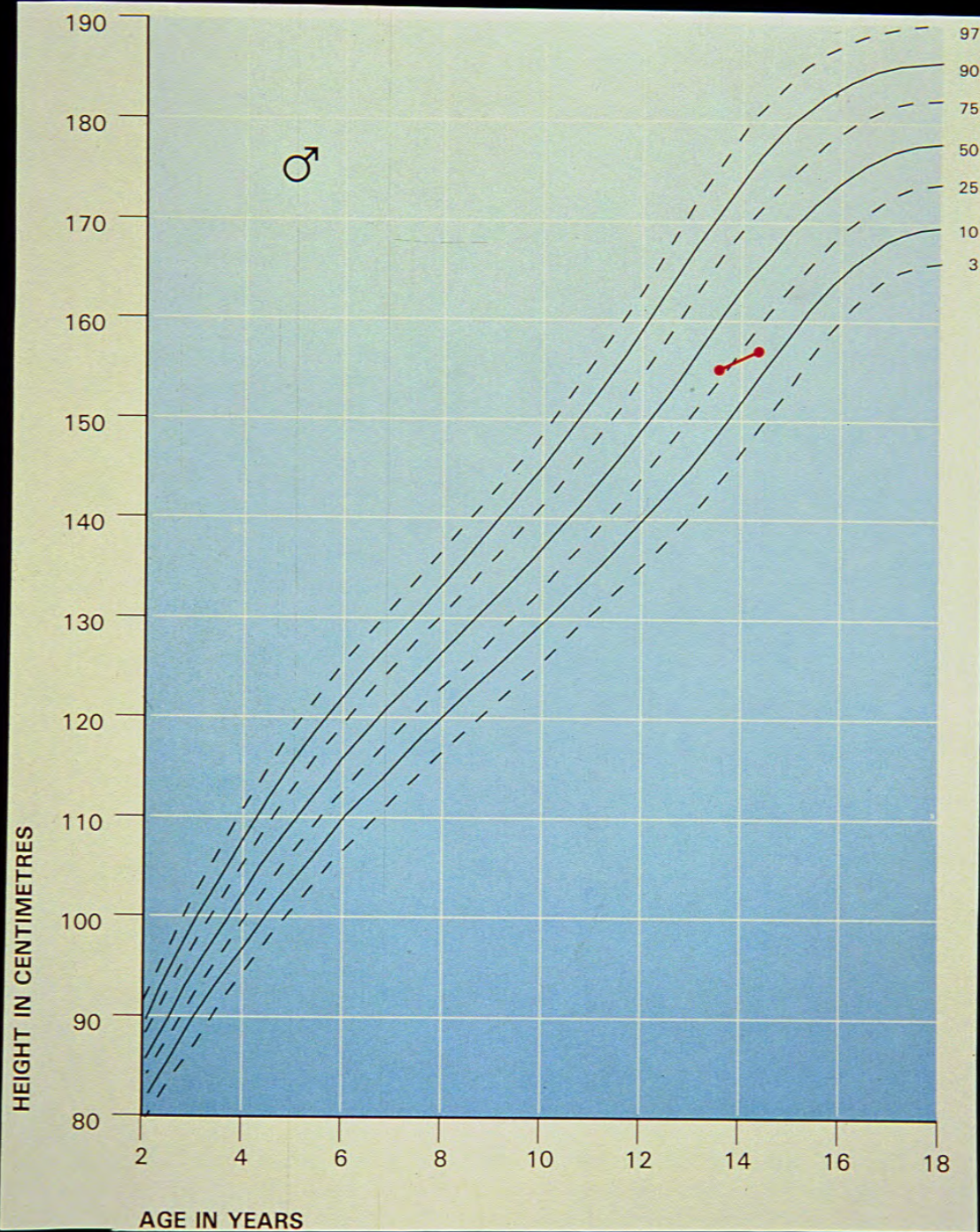
# Case 1

- *HEIGHT* - 5 cms below 3rd percentile line.
- *WEIGHT* at 3rd percentile line.
- *Clinically Normal*
- *3 mL testes (prepubertal)*
- *No pubic hair (Stage 1)*



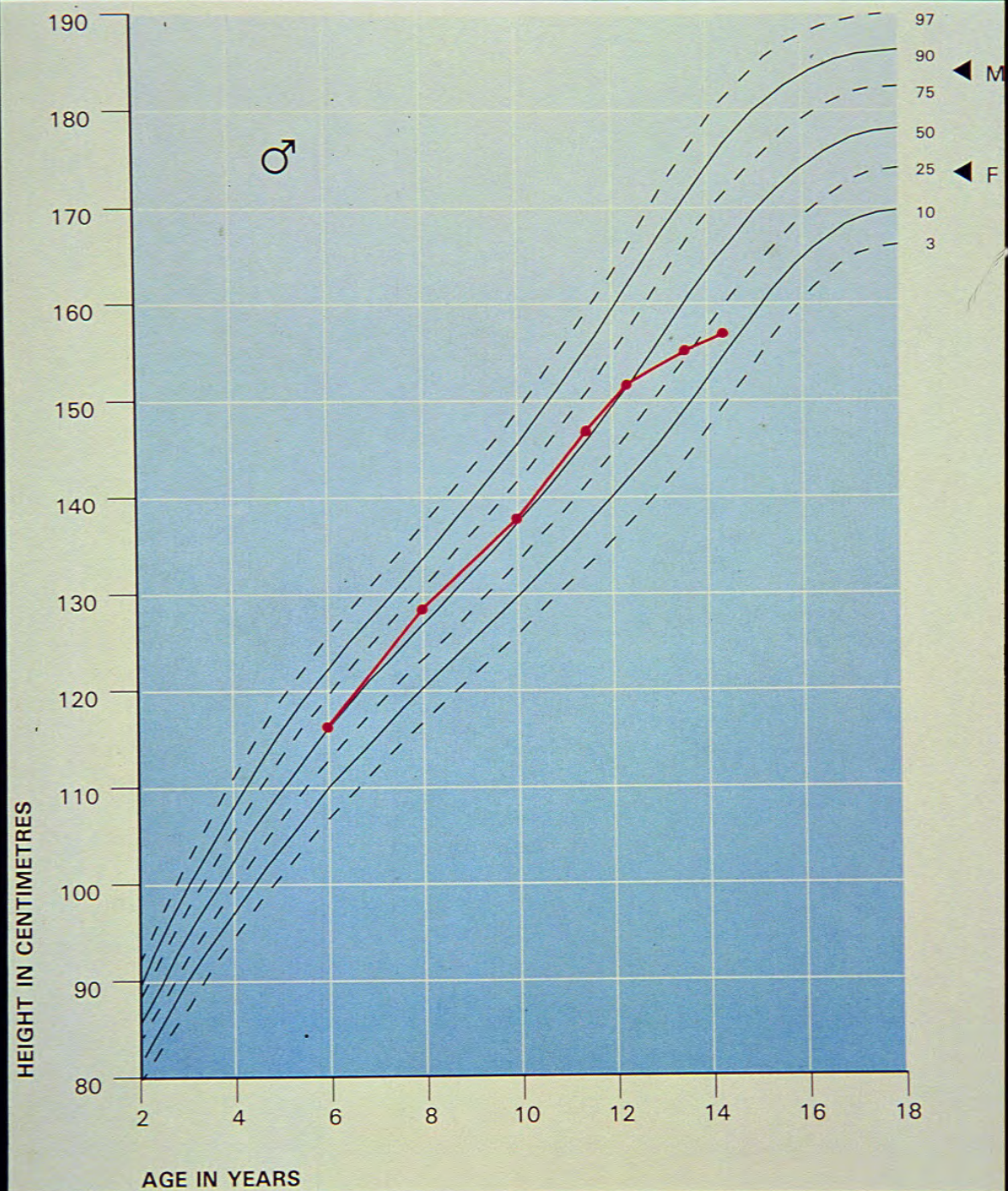
# Case 1

- Plasma prolactin and screening tests for coeliac disease were normal.
- LH, FSH and testosterone were all in the prepubertal range
  - No signs of testicular failure.
- Bone age was equivalent to a 12 year old male.

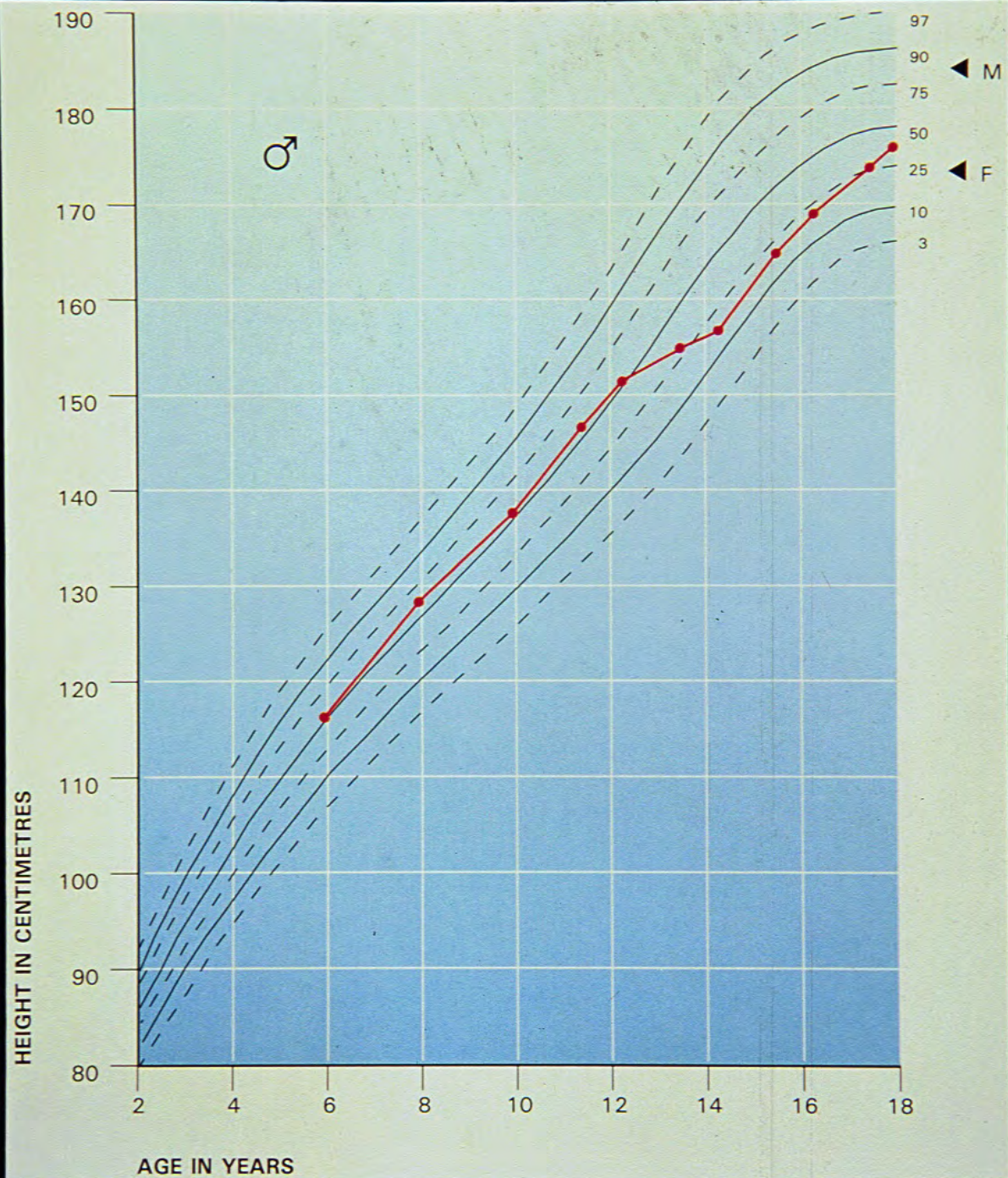


What about previous growth?







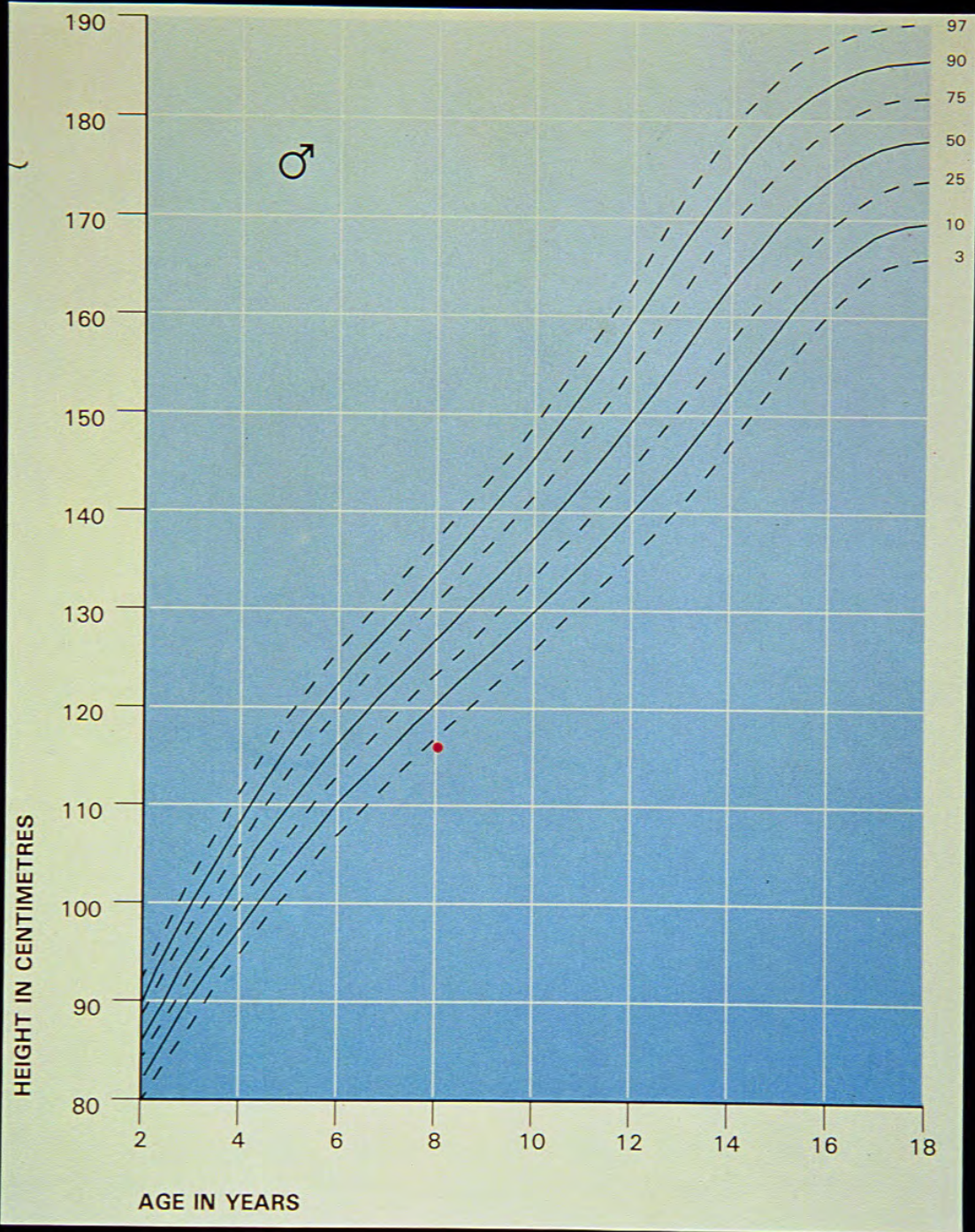




## Case 2

- 8 yr old boy
- Always shorter than friends
- Comes to the appointment with his mother
- He would like to be taller because he is teased at school





## Case 2

- Is he short?
  - YES
- Is his growth and height normal?
- What extra information may help to determine this
  - Past history
  - Medications
  - Parents height



## Case 2

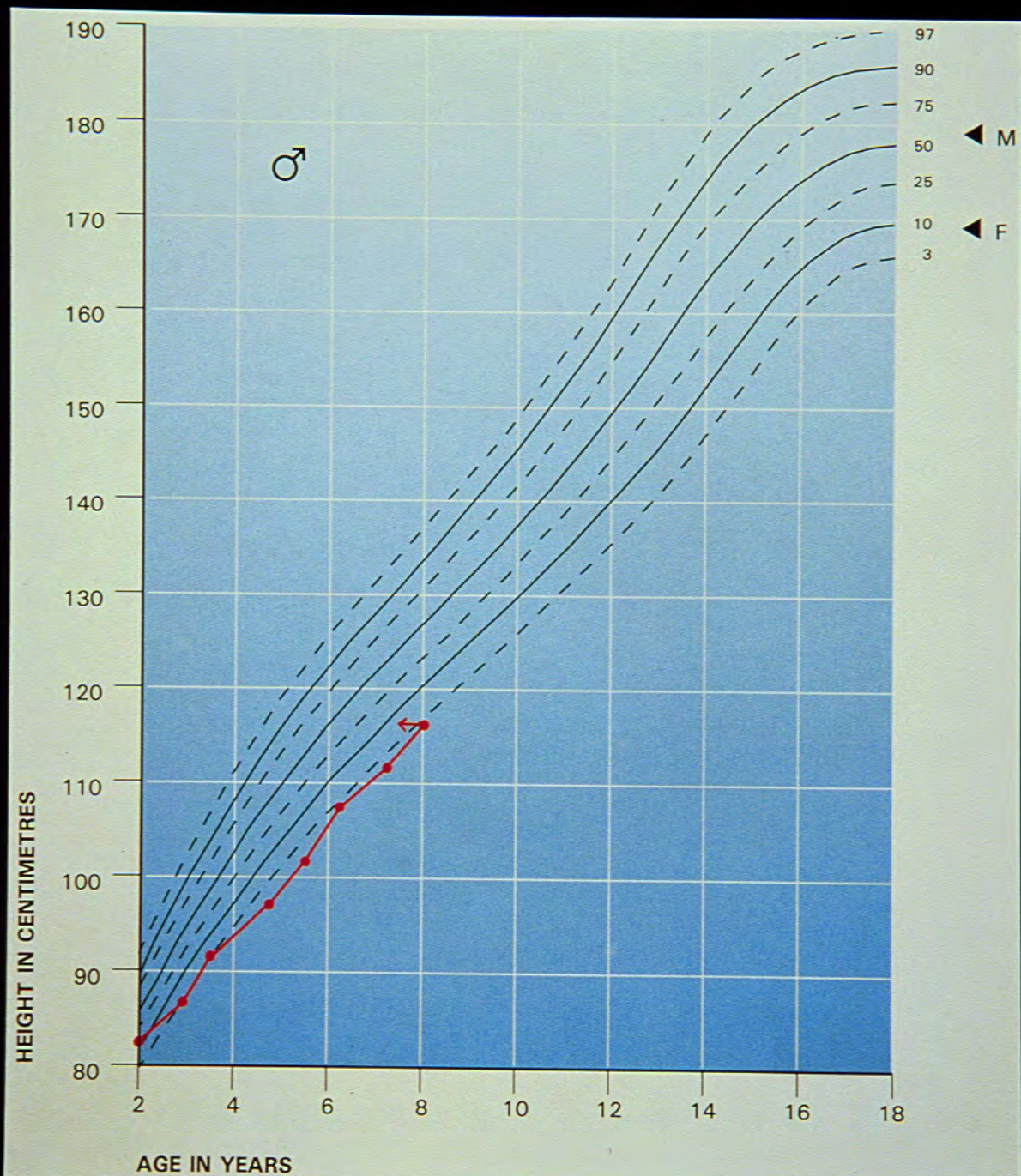
- How does his height relate to MID PARENTAL HEIGHT?

Mother(cm) + Father(cm) +13

2

(For girl, subtract 13)

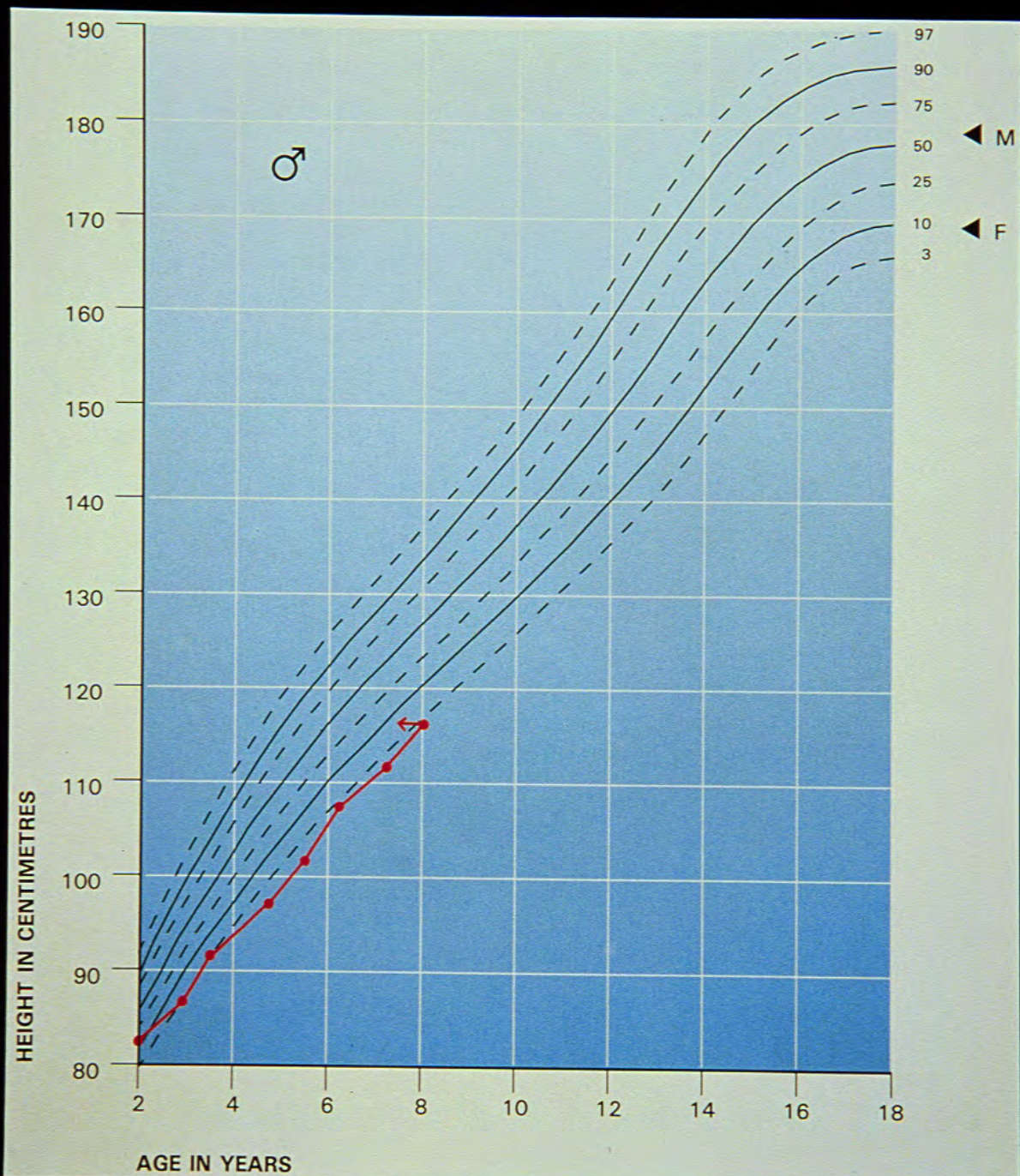
- How has he been growing previously?



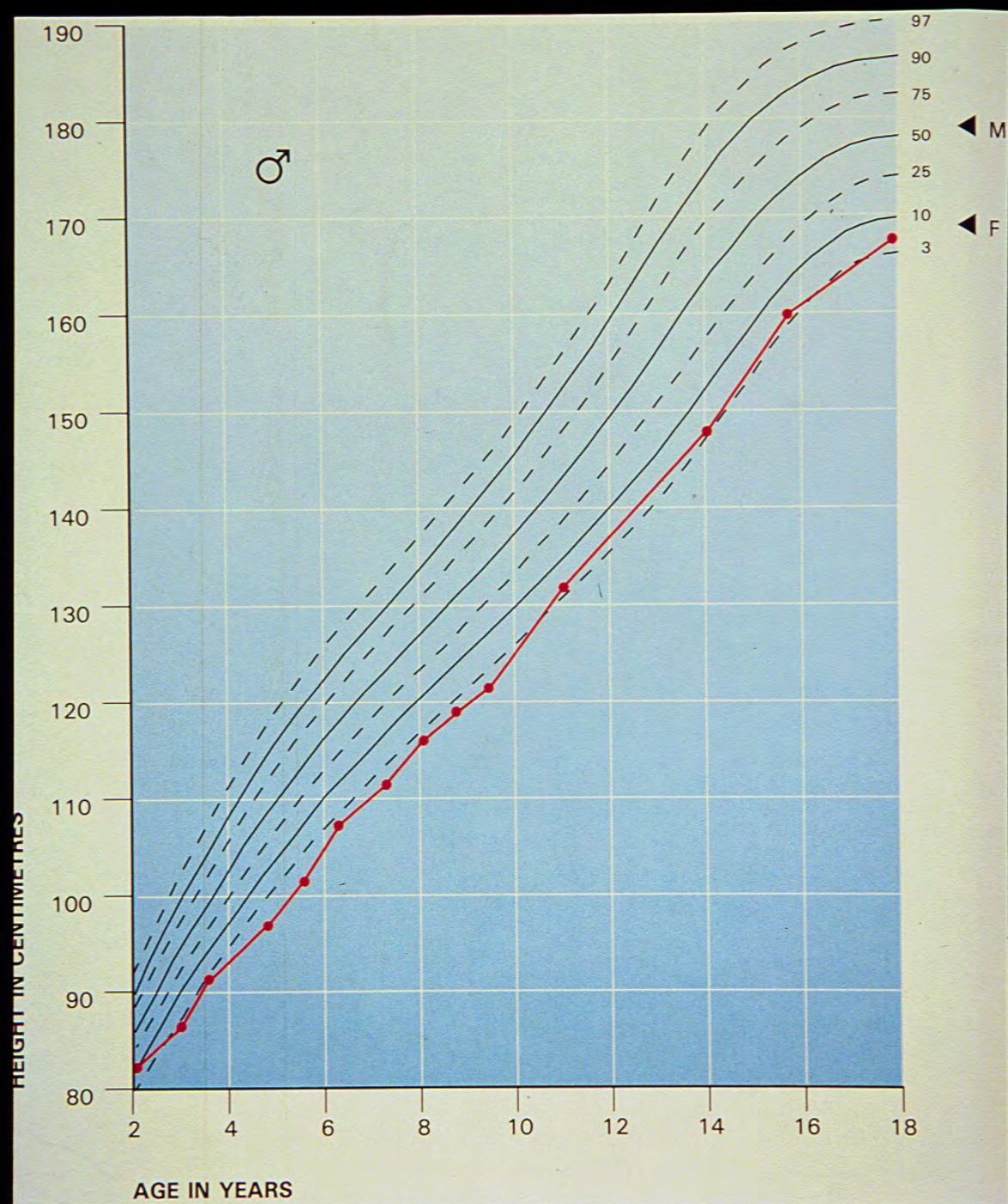
## Case 2

- Likely diagnosis
  - Familial short stature
  - ? Constitutional delay – how can we tell??
    - BONE AGE X-RAY





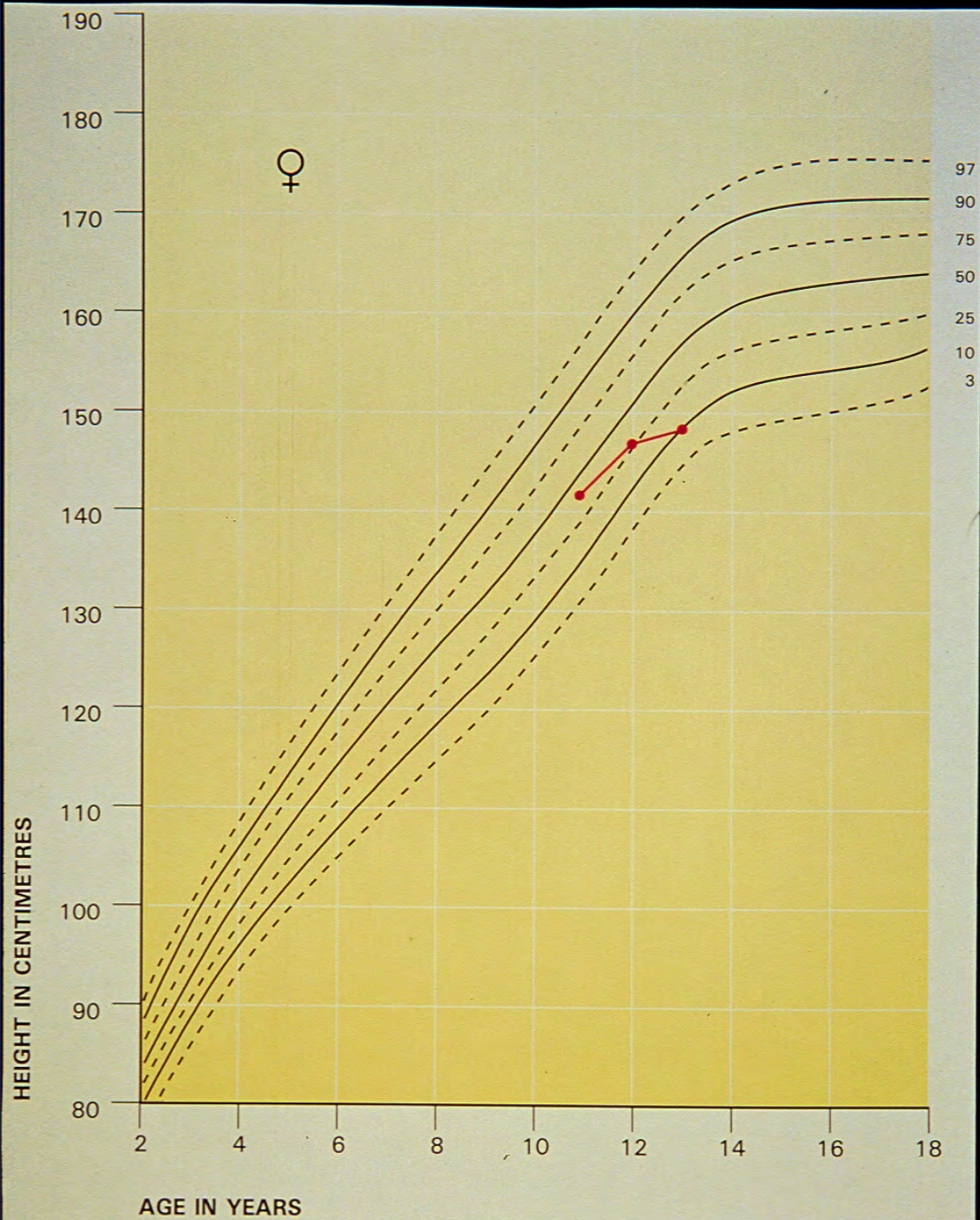




## Case 3

- 13 yr old girl born in India
- Adopted in infancy
- Worried growth slower than friends

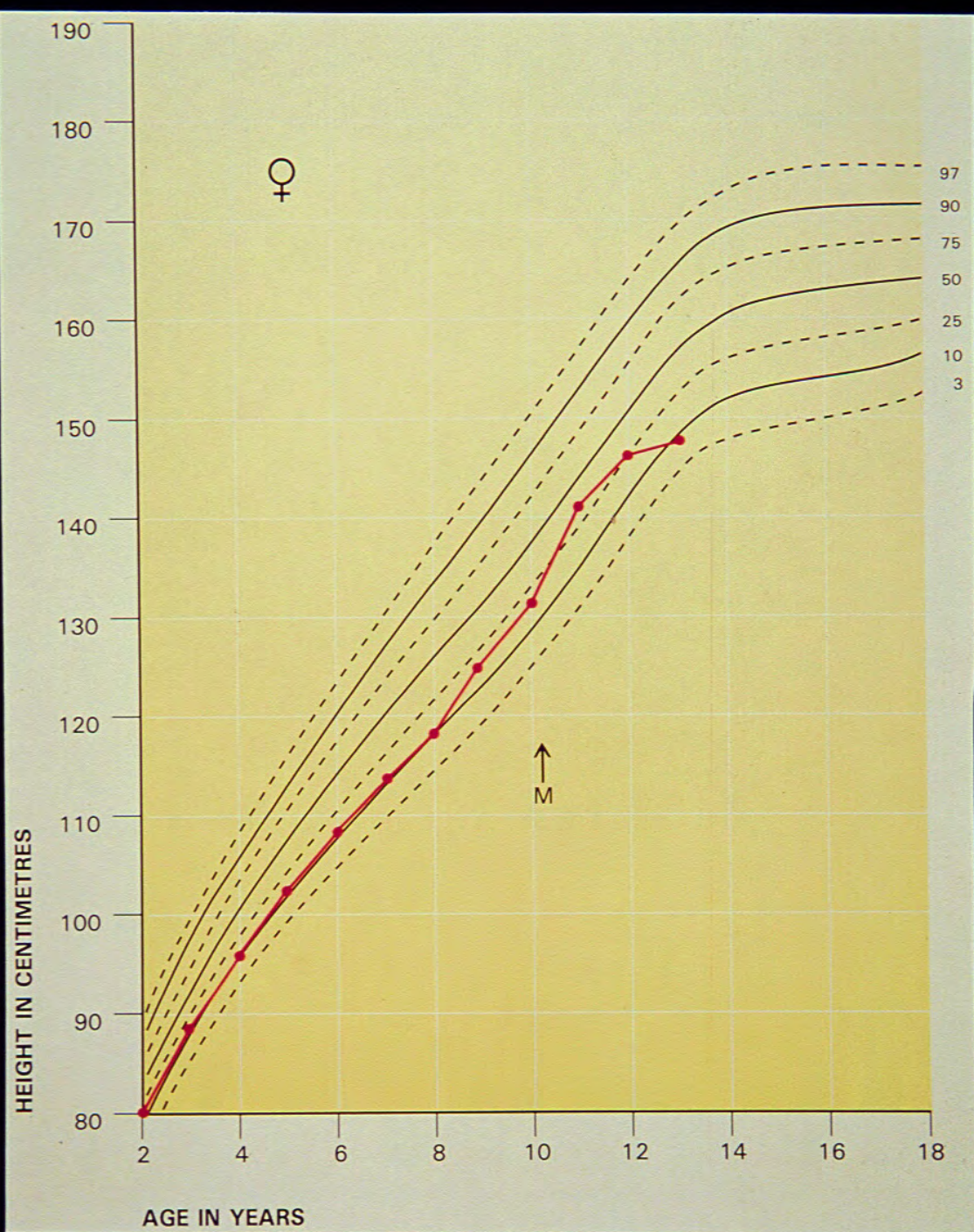




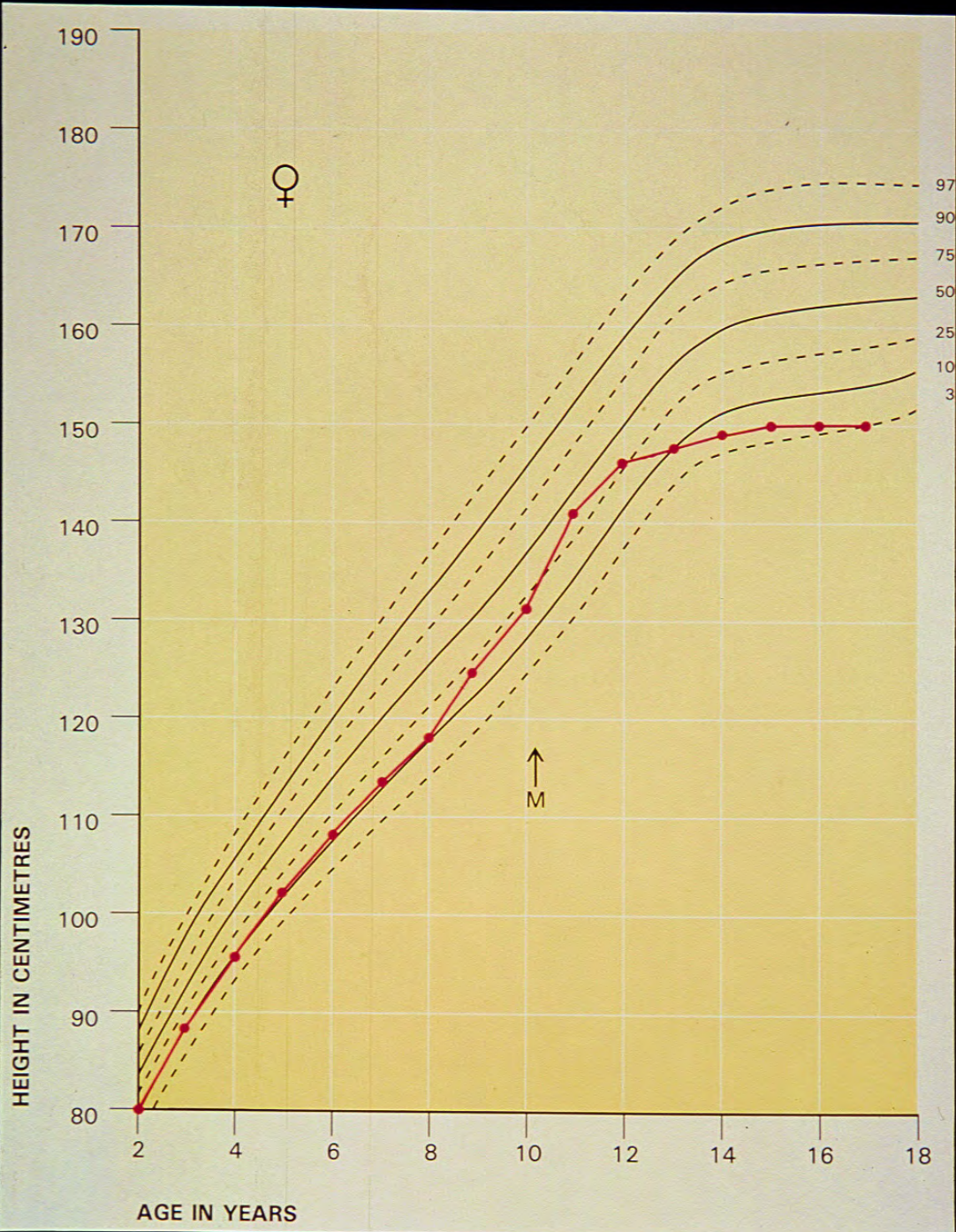
## Case 3

- Had her menarche started just after she turned 10 and is having regular periods
- Diagnosis:
  - Early Puberty with early growth spurt and normal slowing
- Early puberty quite common in children adopted from developing countries into Westernised societies
- ? related to improved nutrition





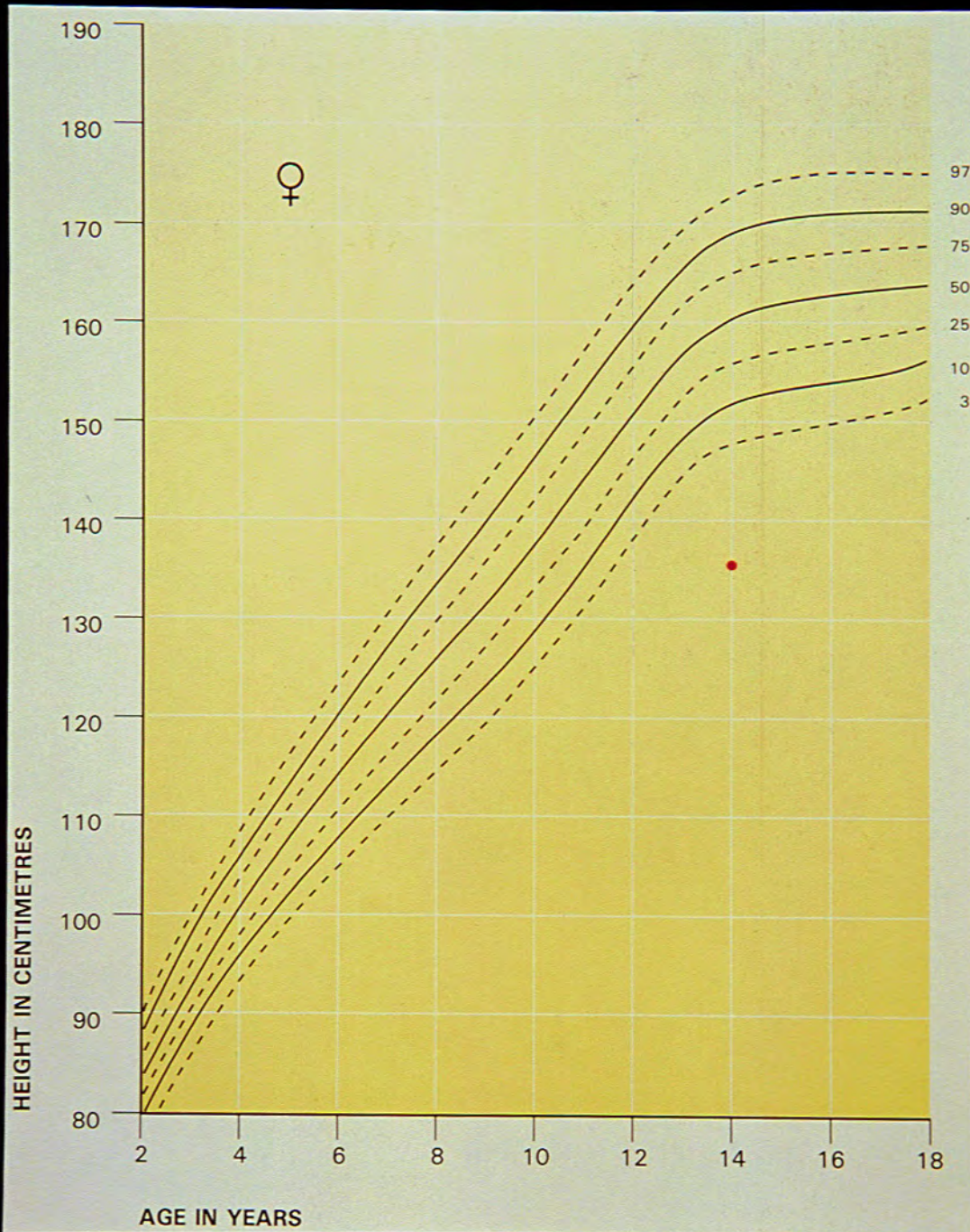




## Case 4

- 14 year old girl presents because she is worried ...
- Her friends are much taller than her
- They all have their period and hers hasn't started.

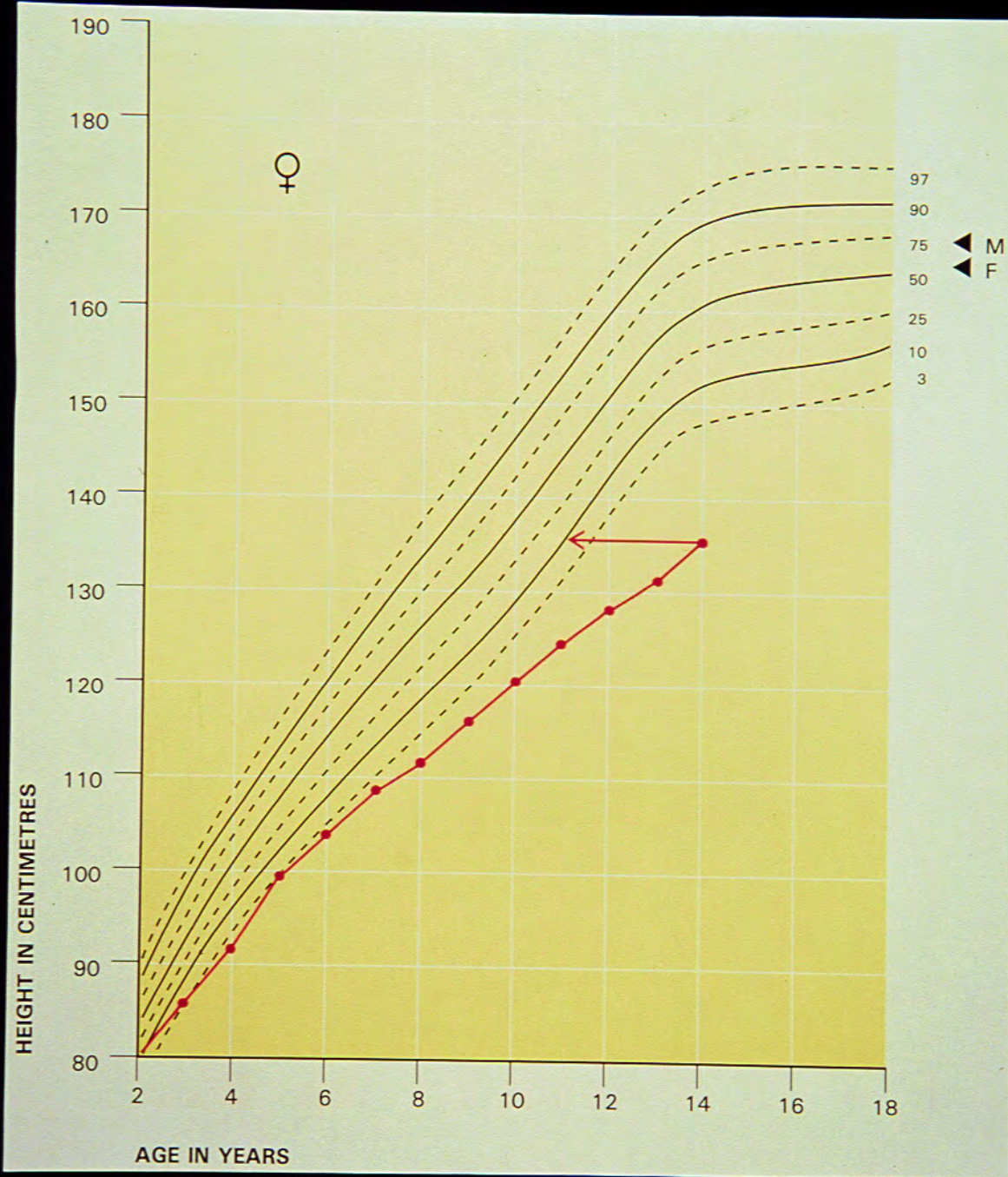




She is very short

What about  
previous growth?

What about her  
parents heights?



No signs of puberty  
(Tanner 1 breasts)

High arched palate

Low hairline

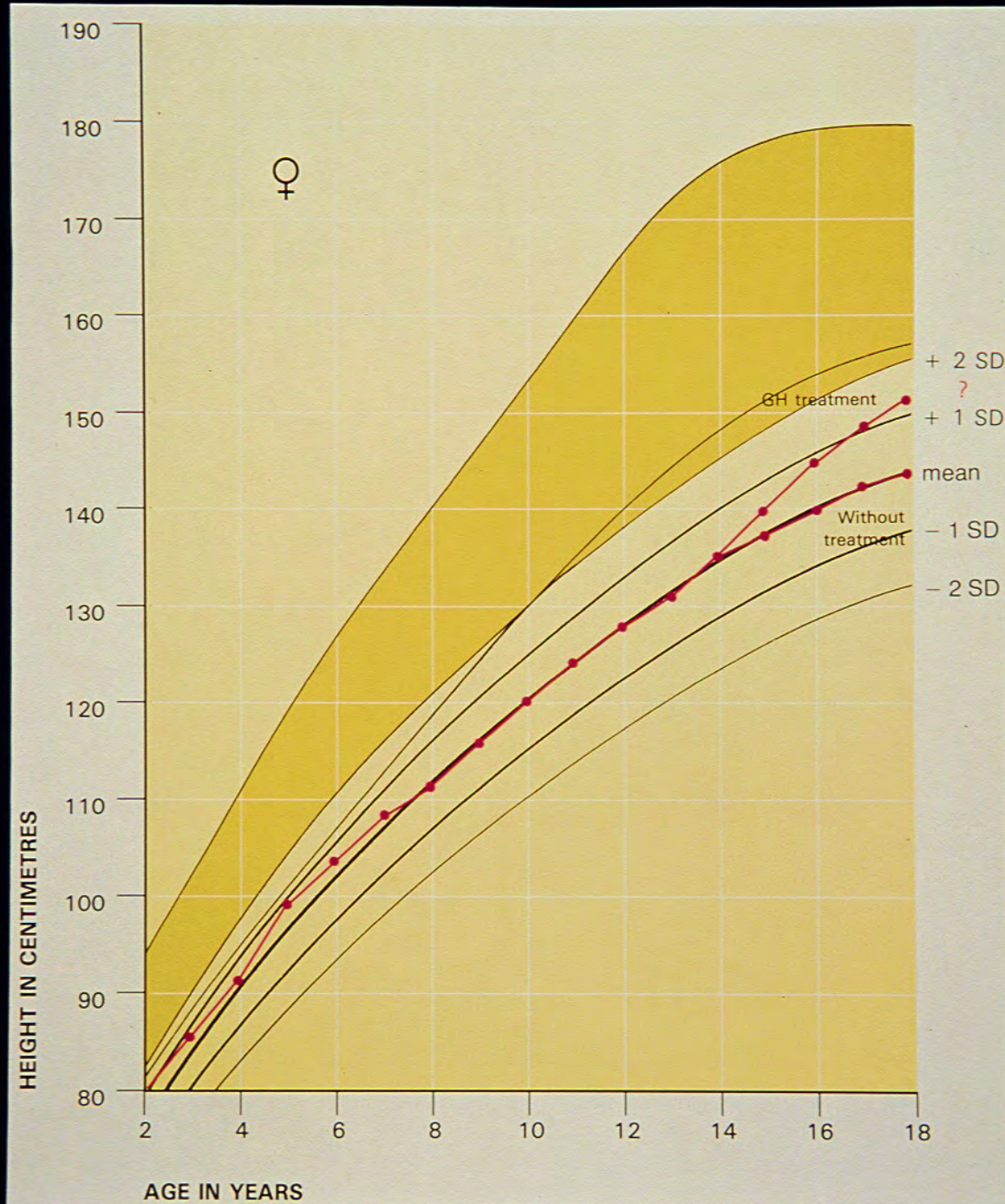
Broad chest

Otherwise well

THOUGHTS?

TURNER SYNDROME





Growth Hormone  
Treatment

Induction of Puberty

Counselling about  
condition

Investigation for  
associated features

Transition

Adult monitoring

# Turner Syndrome Features

- Growth failure 80-100%
- Gonadal dysgenesis 80-100%
- Inverted, widely spaced nipples 60-80%
- Webbed neck 60-80%
- Nail dysplasia 60-80%
- Defective dental development 60-80%
- Renal dysgenesis 40-60%
- Cardiac malformation 20-60%

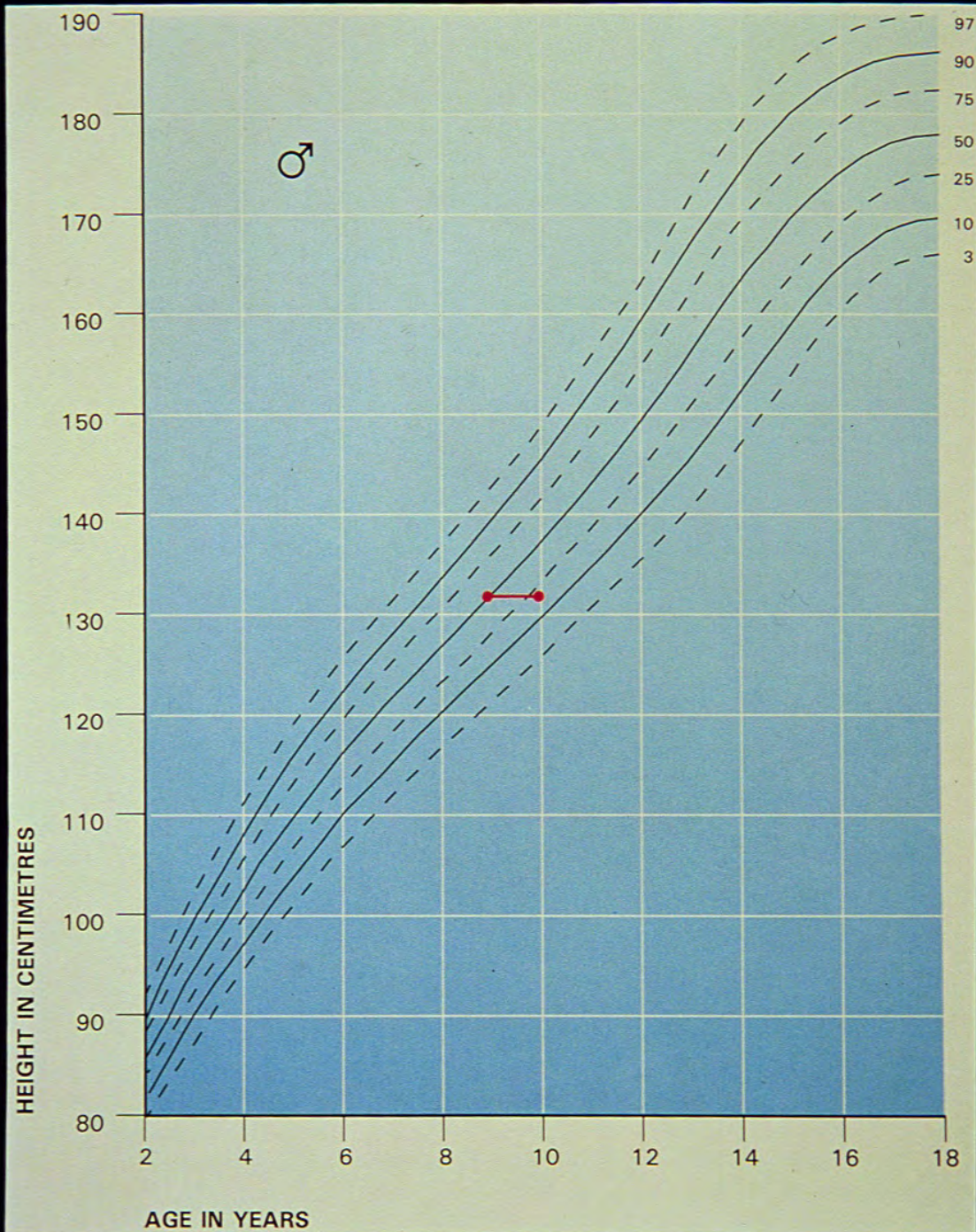
## Turner's Syndrome Features (cont)

- Skeletal dysgenesis 40-60%
- Otitis media 40-60%
- Neonatal oedema
  - hands and feet 0-40%
- Hypothyroidism 10-30%
- Scoliosis 10%
- Lipids/ Diabetes
- Specific learning difficulties
- Hearing - conductive and SNHL
- Gonadoblastoma risk - patients with y-chromosomal material require gonadectomy



# Case 5 - Michael

- 10 yr old boy presents as a new patient
- No growth last 12 months
- Dad is a Plastic Surgeon
- Michael is well and no meds
- No headaches

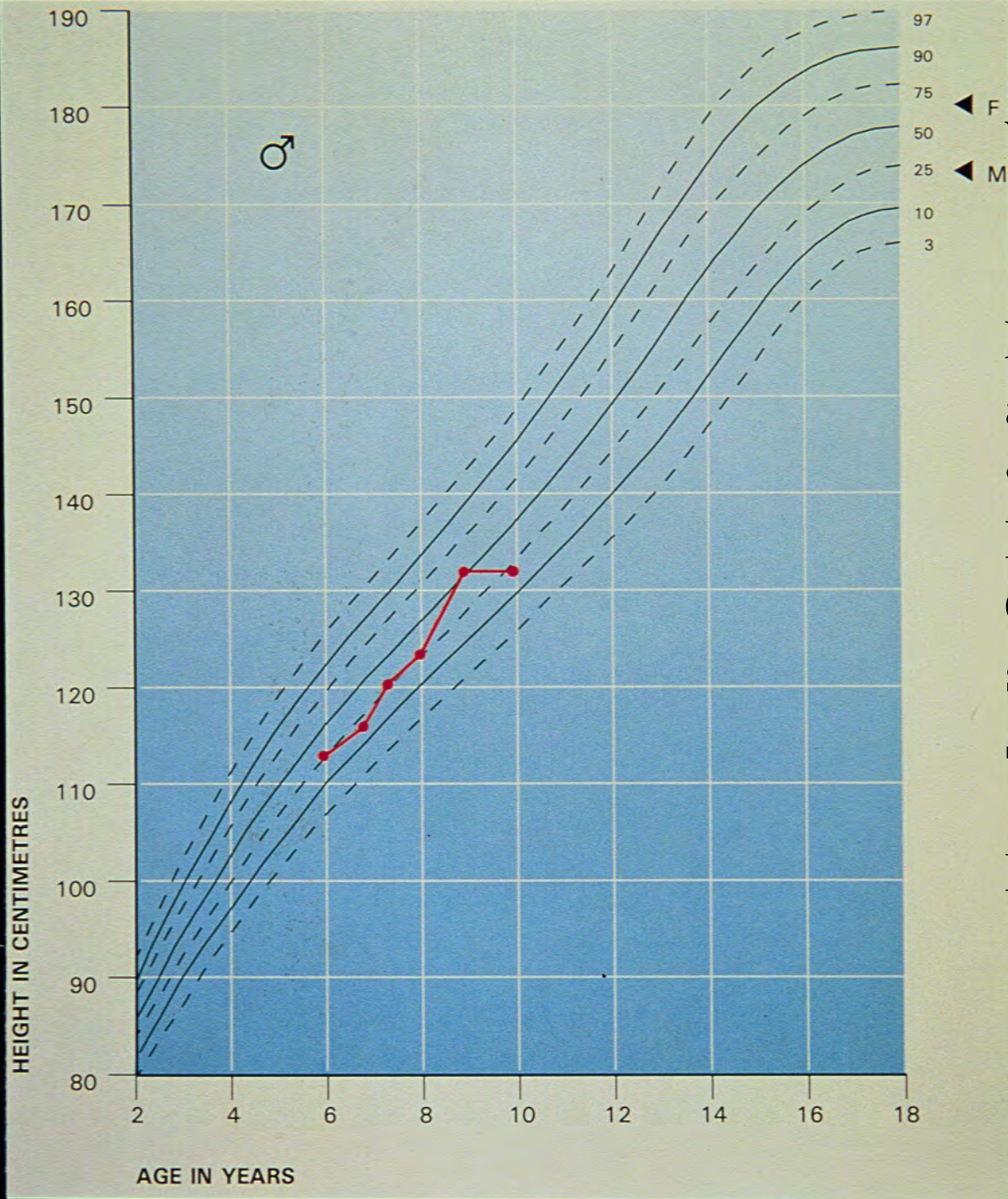


Looks worrying!

What about  
previous growth?

What about her  
parents heights?





What possibilities

Endocrine disorders  
affecting growth

- Any clinical evidence?

Hypothyroid?

Cushings/high dose  
steroids ?

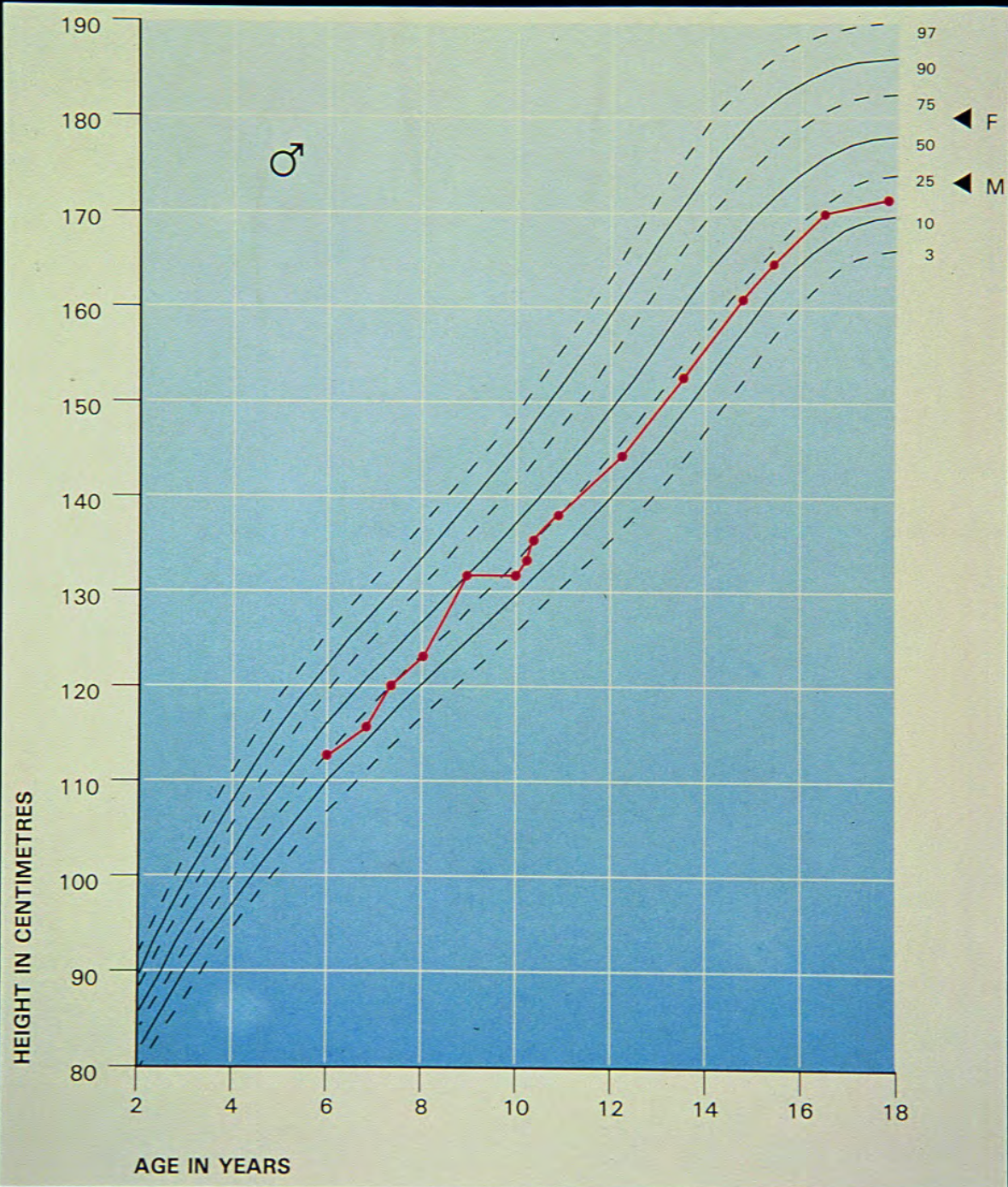
Severe illness (eg. ALL)

Investigations

# Case 6

- Investigations
  - FBE/ ESR
  - TFTs
  - U&Es
  - Bone Age = Chronological Age
- IS IT REAL??
- What happened

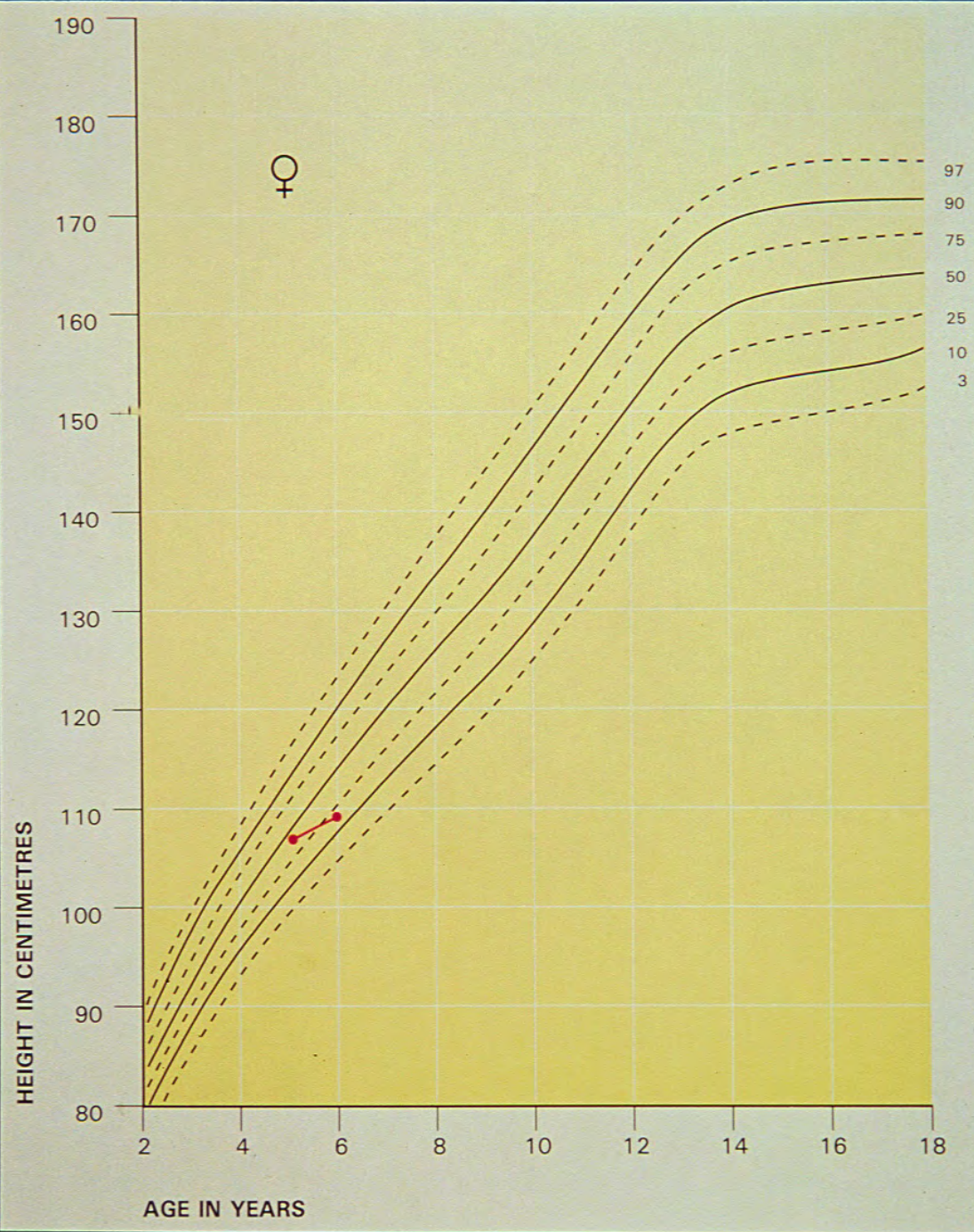




## Case 6

- 6 yr old girl
- Slow growth
- Quiet and gaining weight
- Hands cool and wearing more clothes than family

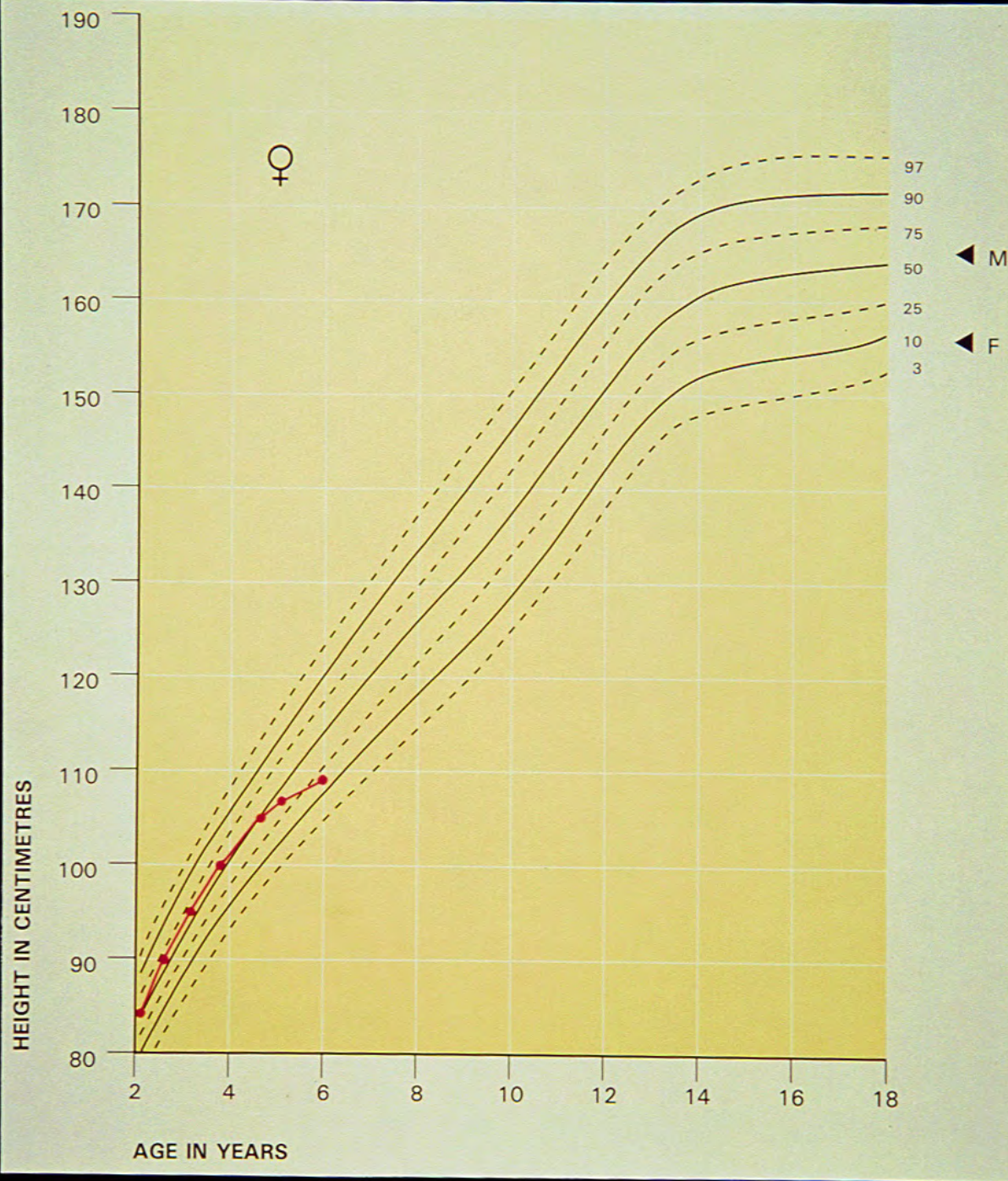




What about previous growth?

How tall are parents?





Looks suspicious

Any thoughts???

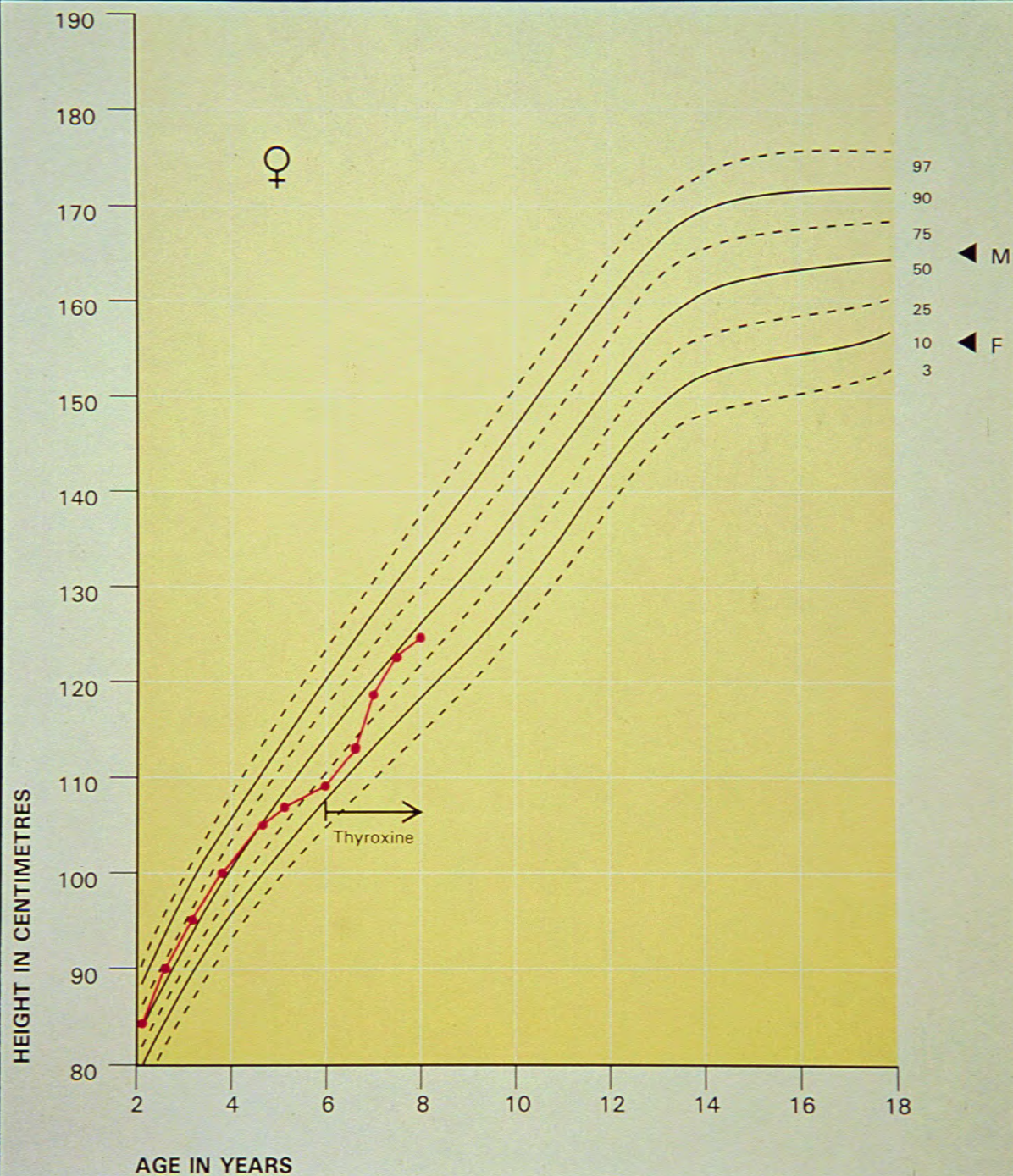
Examination findings

What tests??

TSH 160 mU/L

Free T<sub>4</sub> 7pmol/L

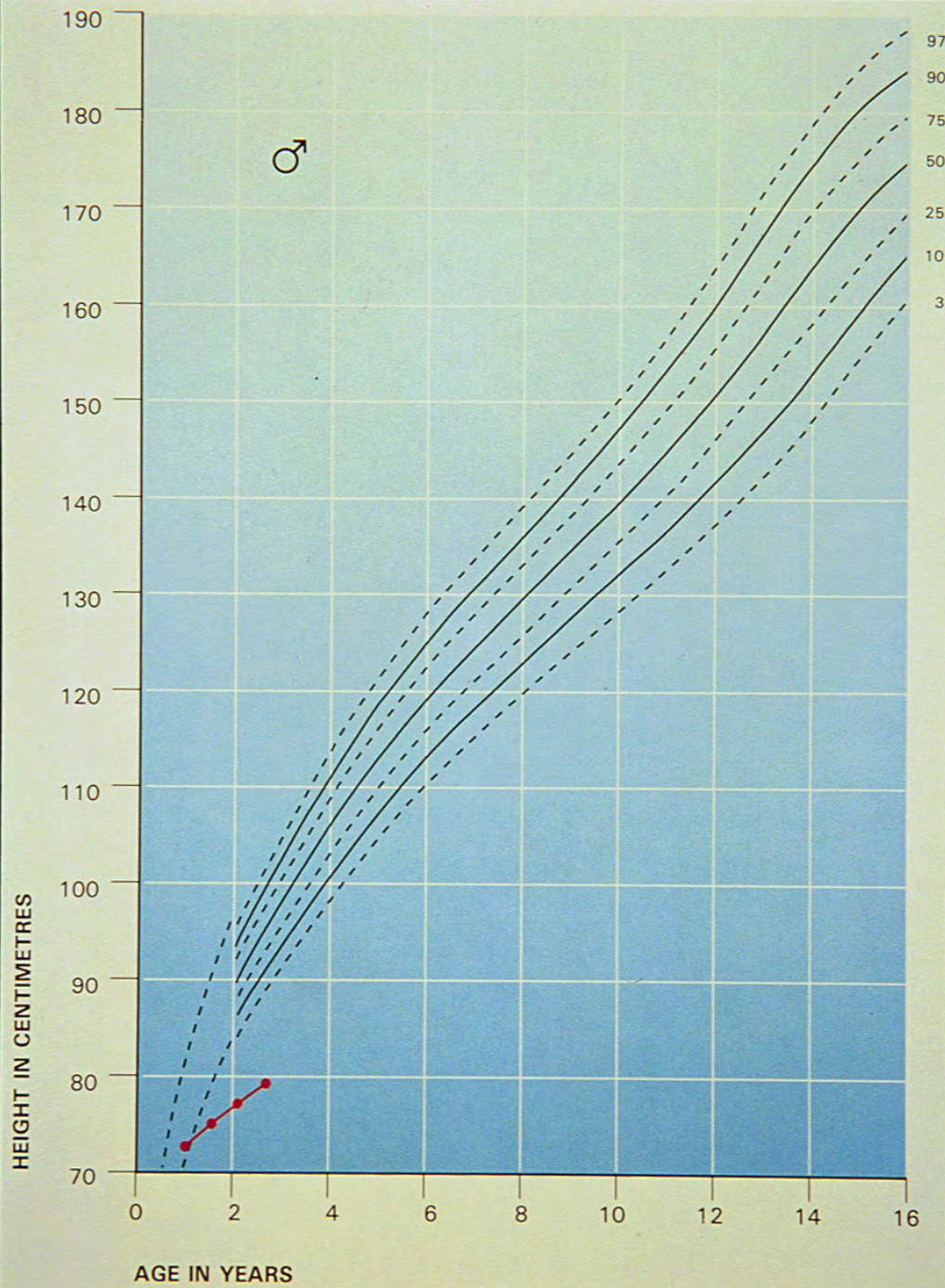




# Case 7 - Charles

- 3 yrs old
- Poor growth in the last year
- Some hypoglycaemia as a neonate which resolved

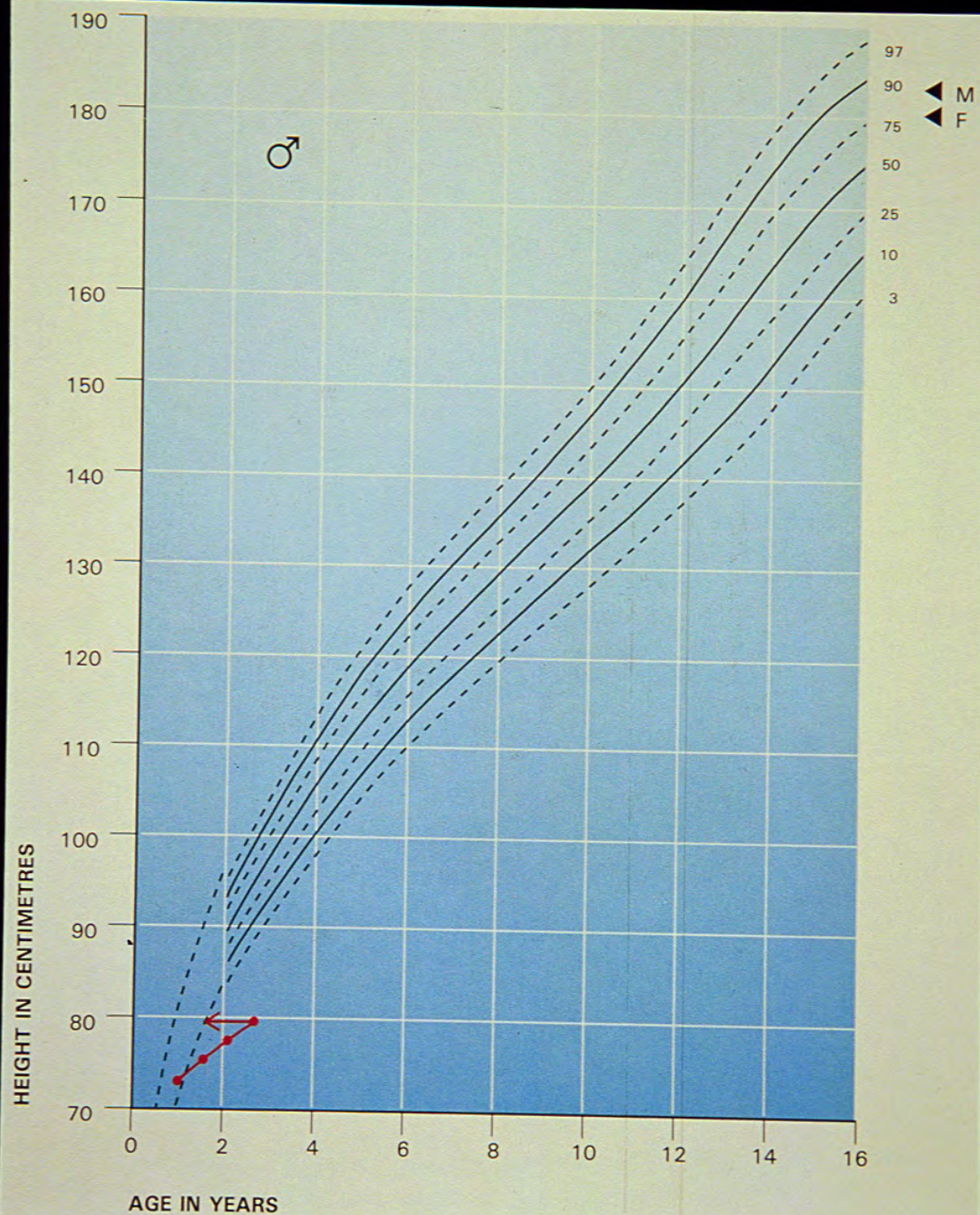




Parents Heights??

Bone Age





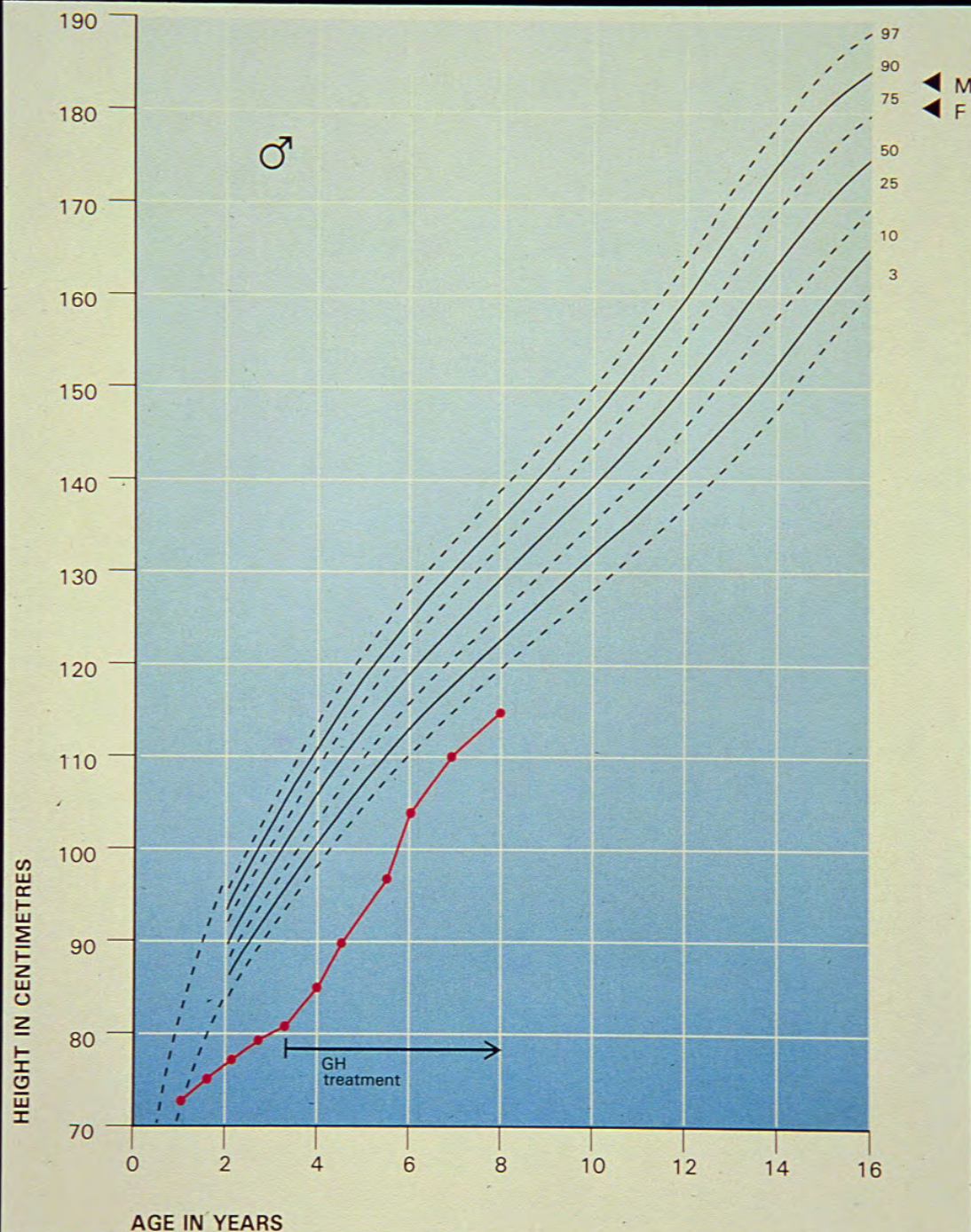


# Where to from here?

- Examination
  - Looks much younger than a 3 year old
  - Penile length is small (2.5cm)
- Tests
  - Thyroid, FBE, IGF-1, IGF-BP3
- Growth hormone testing
  - Peak overnight and Arginine stim result 7mIU
  - Most normally exceed 20 and all should be >10

# Treatment

- Growth Hormone
- Regular monitoring for emergence of other hormone deficiencies



Pituitary hormone deficiencies may develop progressively over time.

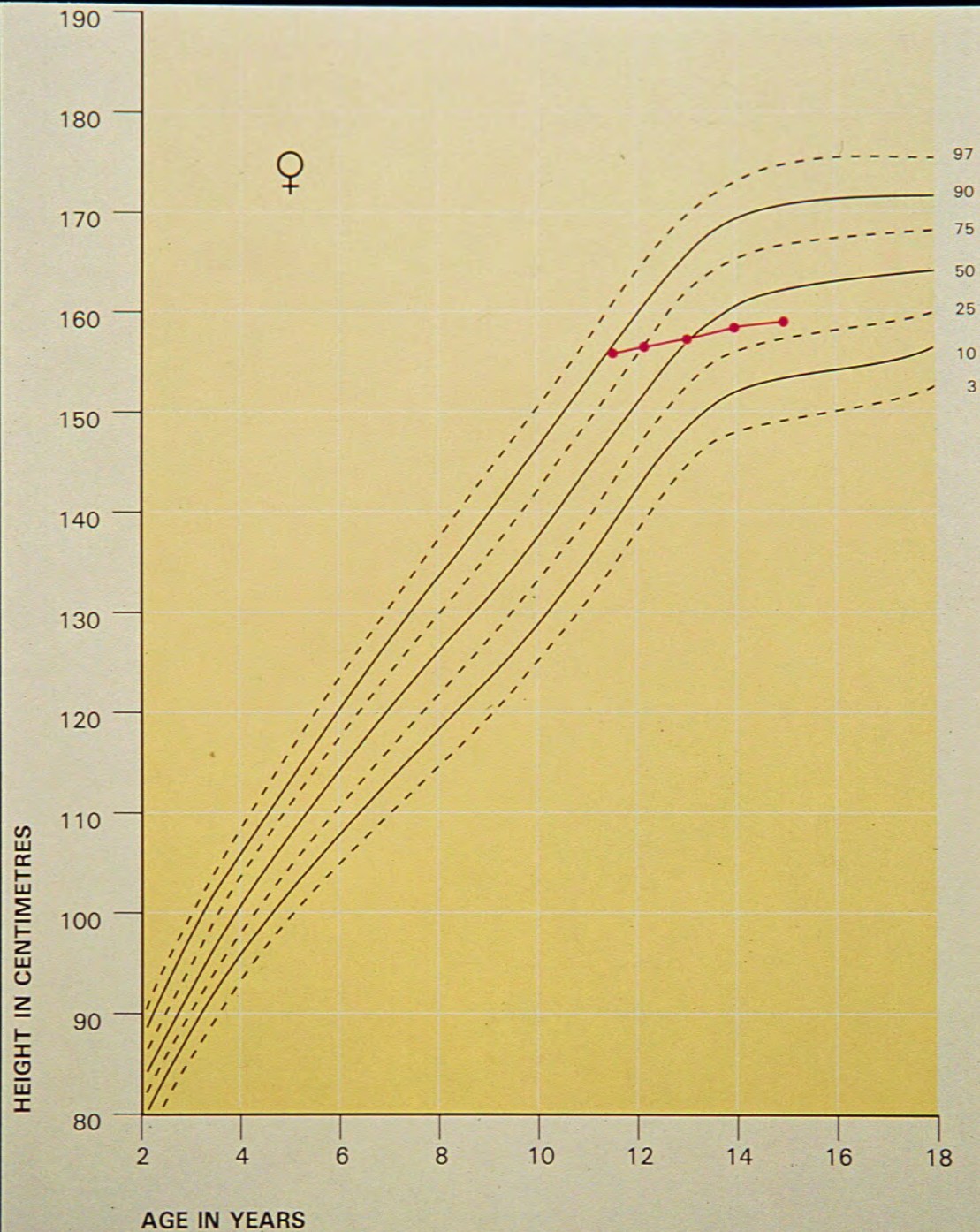
If catchup slows, check hasn't developed central hypothyroidism

With full replacement, should achieve expected height potential provided start early.

## Case 8 - Mary

- 15 yrs old
- Puberty began with breast budding at 10 yrs of age but still no periods
- 3kg Weight gain last year
- Has been bumping into things at night





Tests?

FBE/ESR

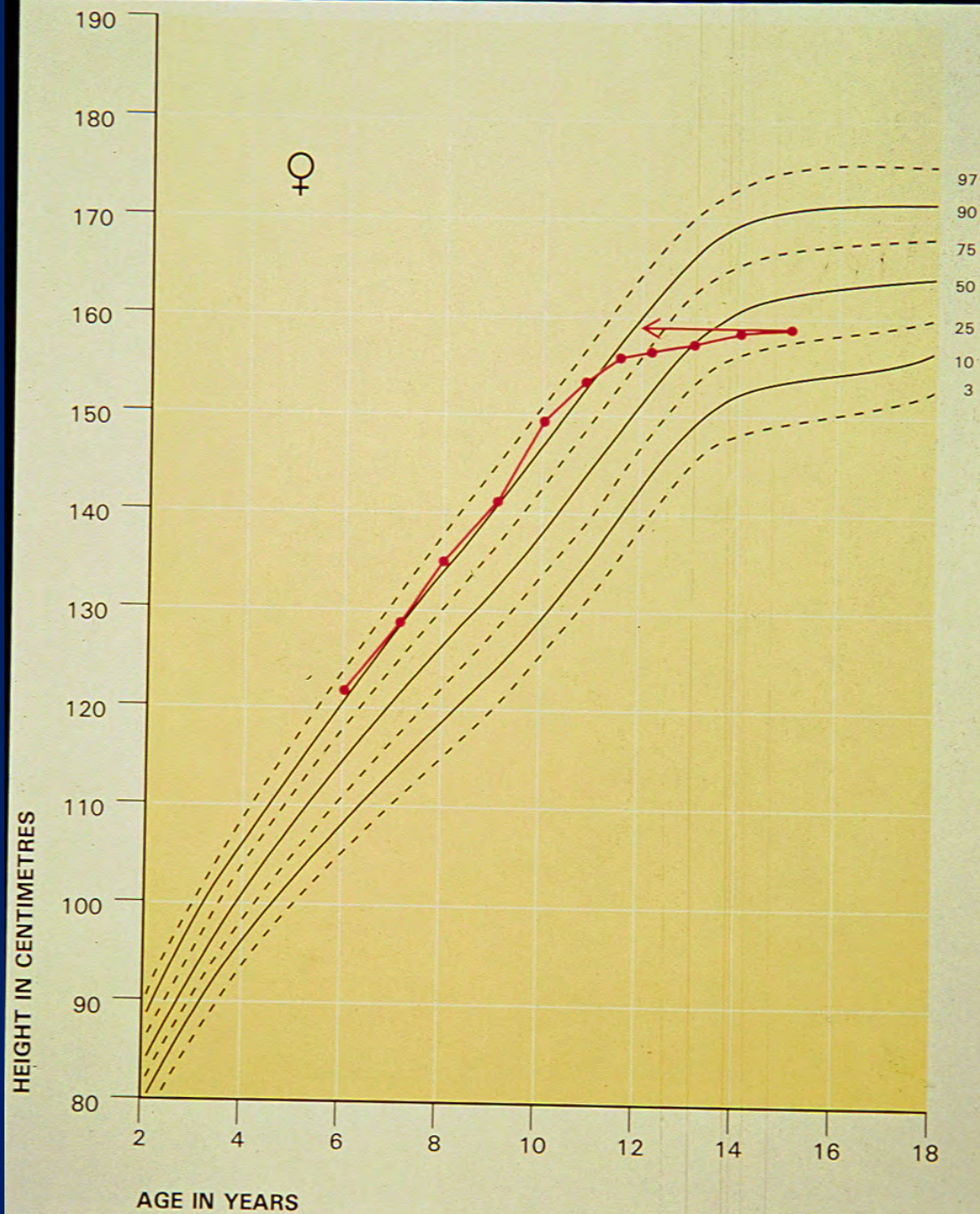
TFTs/ Prolactin

FSH/LH

? Androgens

Bone Age



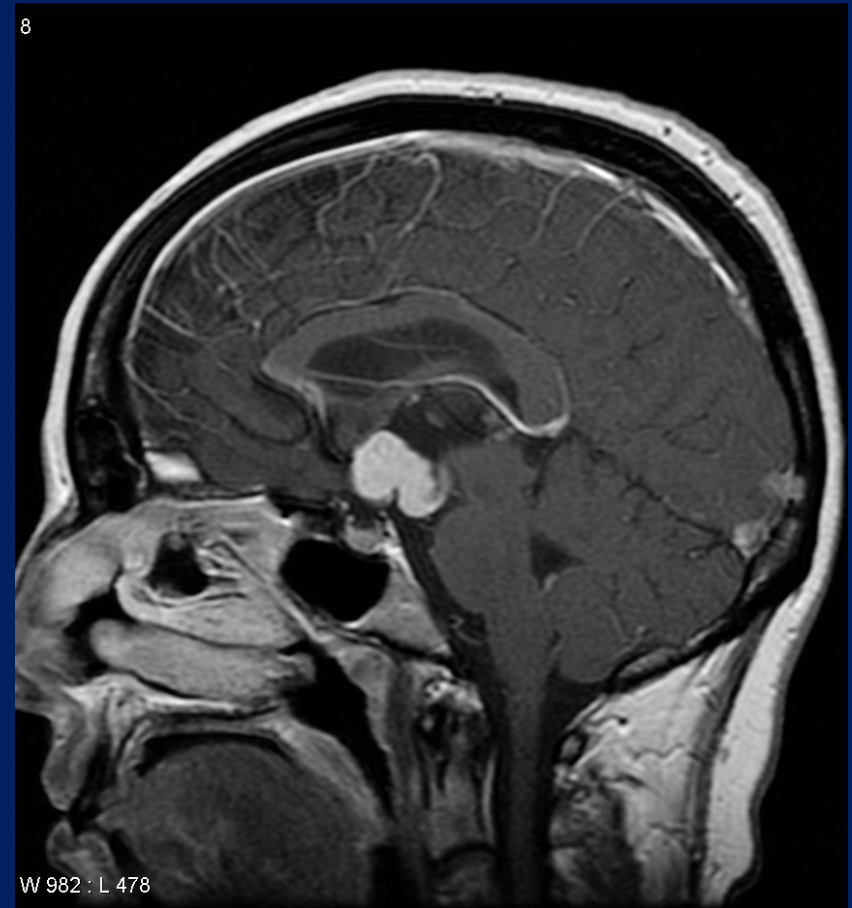


## Case 8 - Mary

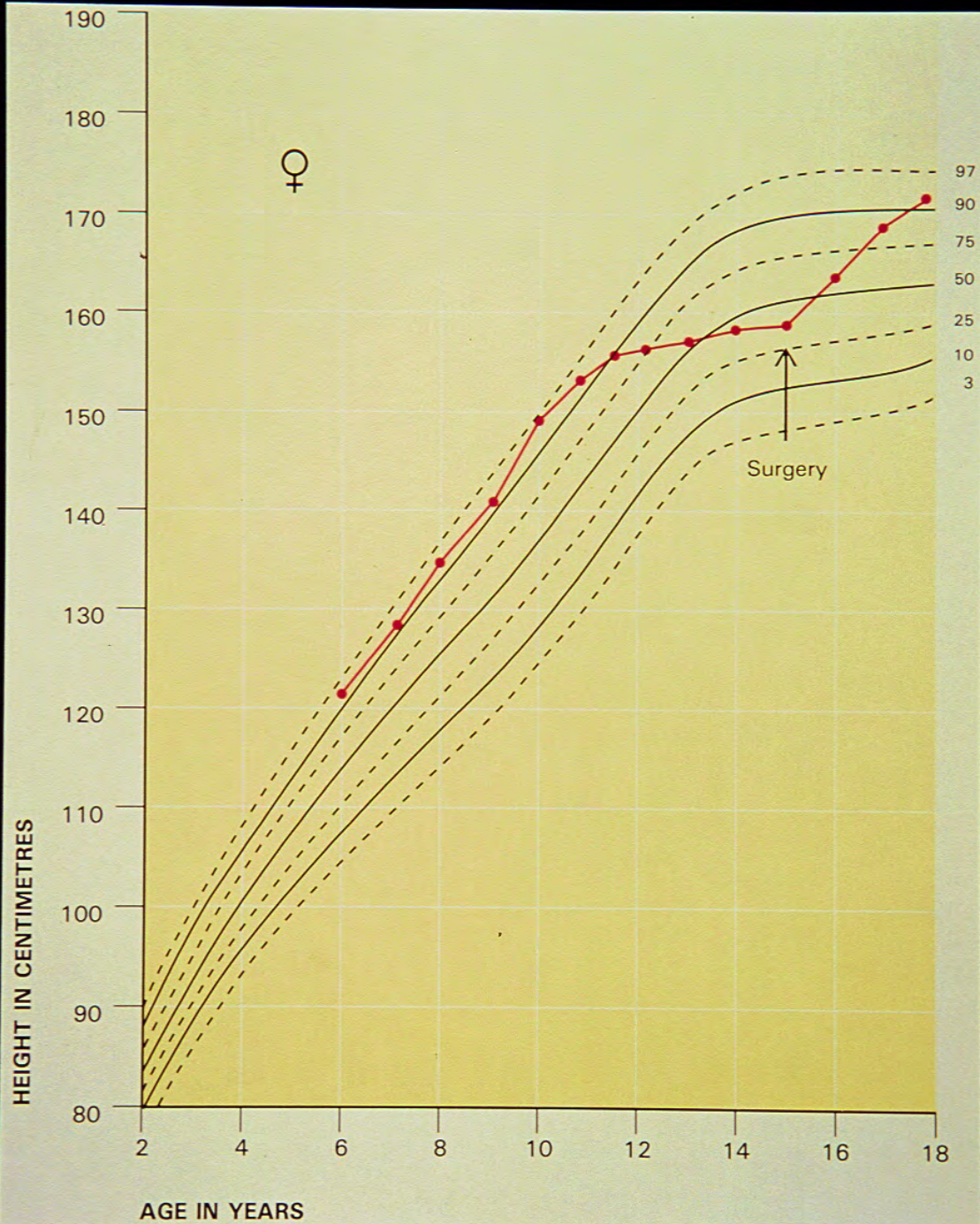
- Free T4 7.8 pmol/L (10-19), TSH 2 (0.4-4)
- FSH 0.5/ LH < 0.1
- Oestrogen 50 pmol/L
- Prolactin mildly elevated ~ 500nmol/L
- What now?

# Mary

- MRI
- Suprasellar  
Craniopharyngioma







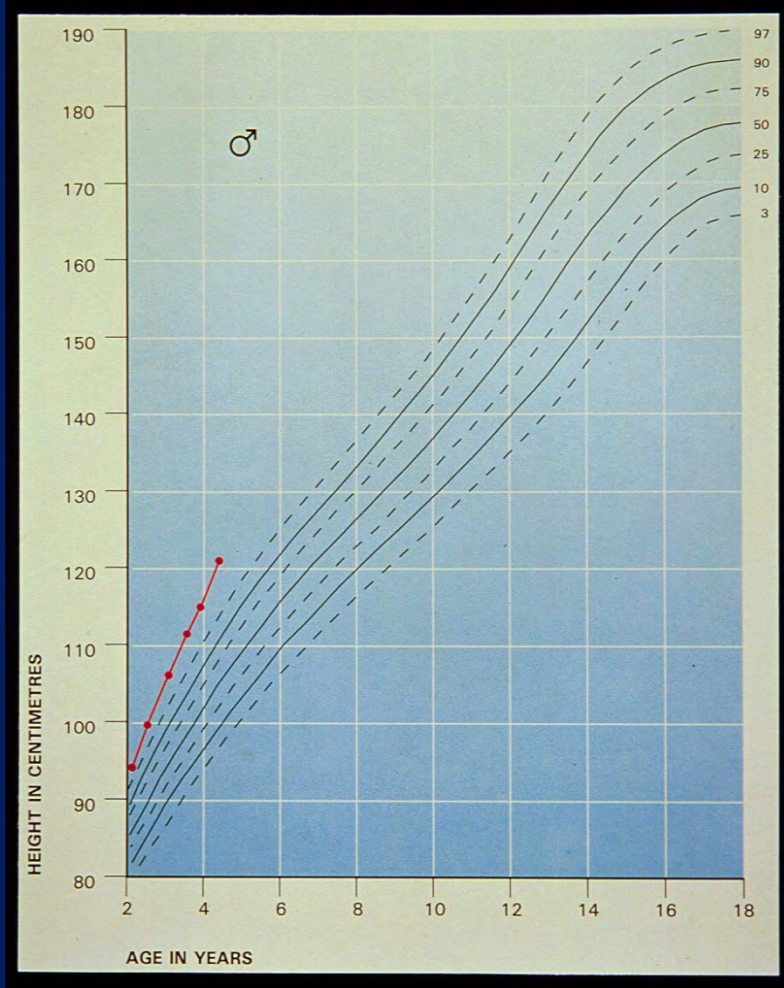


## Case 8 - Mary

- Now has hypopituitarism
- Needs replacement of
  - Thyroxine
  - Growth hormone
  - Oestrogen to complete pubertal development and then ongoing
- Risk of hypothalamic obesity...
- Trade off invasive surgery vs. radiating

# Martin - Case 9

- 4.5 yrs old
- Big strong boy
- ? puberty



Growing quickly!

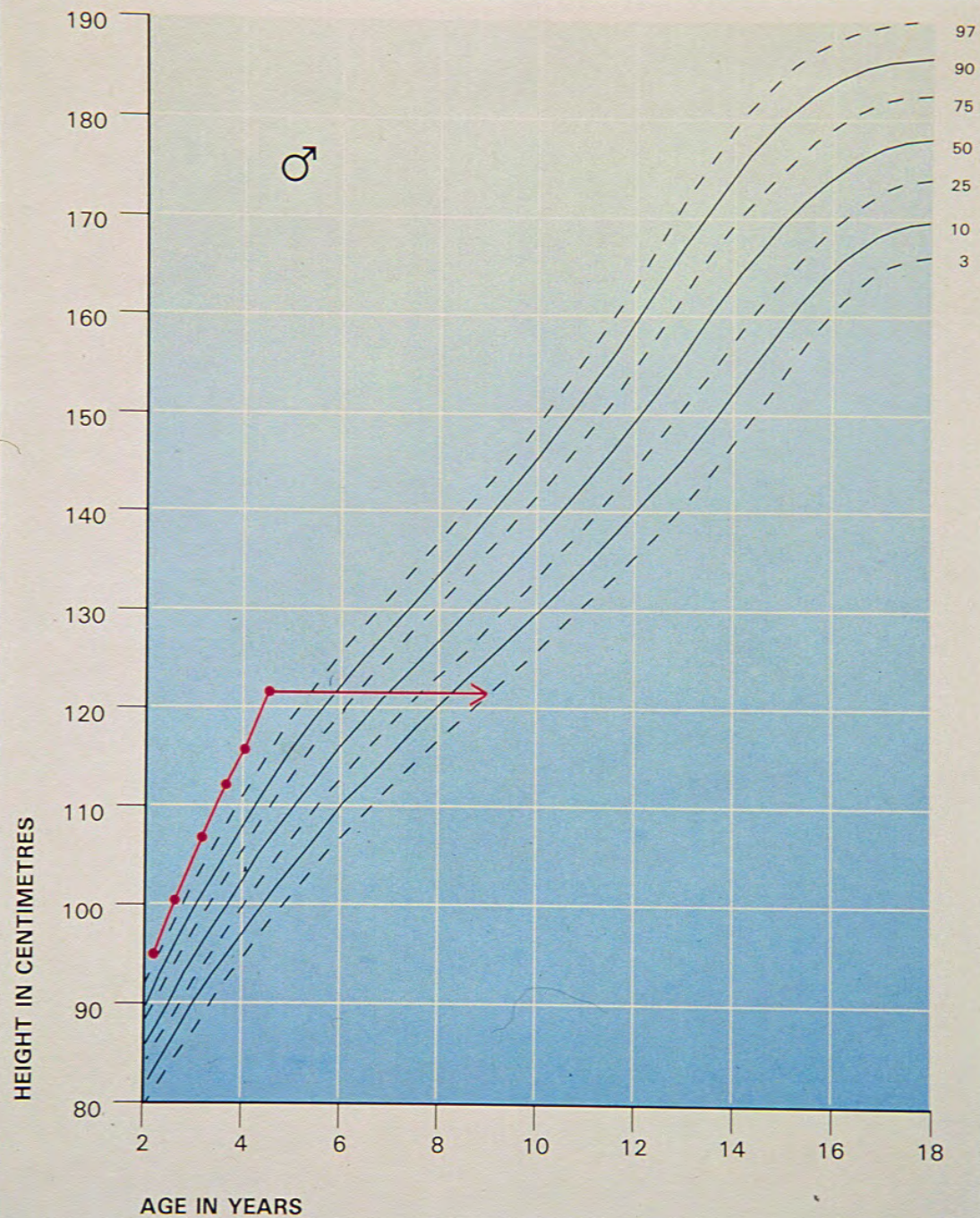
Enlarged penis with Tanner Stage 3 pubic hair but small Testes

Too much androgen but where from?

# Case 9 - Martin

- ? Tumour of testicle or adrenal
- ? CAH
- Initial assessment
  - Low FSH/LH
  - 17 OH Progesterone 104 nmol/L (< 4.5 nmol/L)
  - Renin 80 (normal < 42)
- Bone age 9yrs!!!

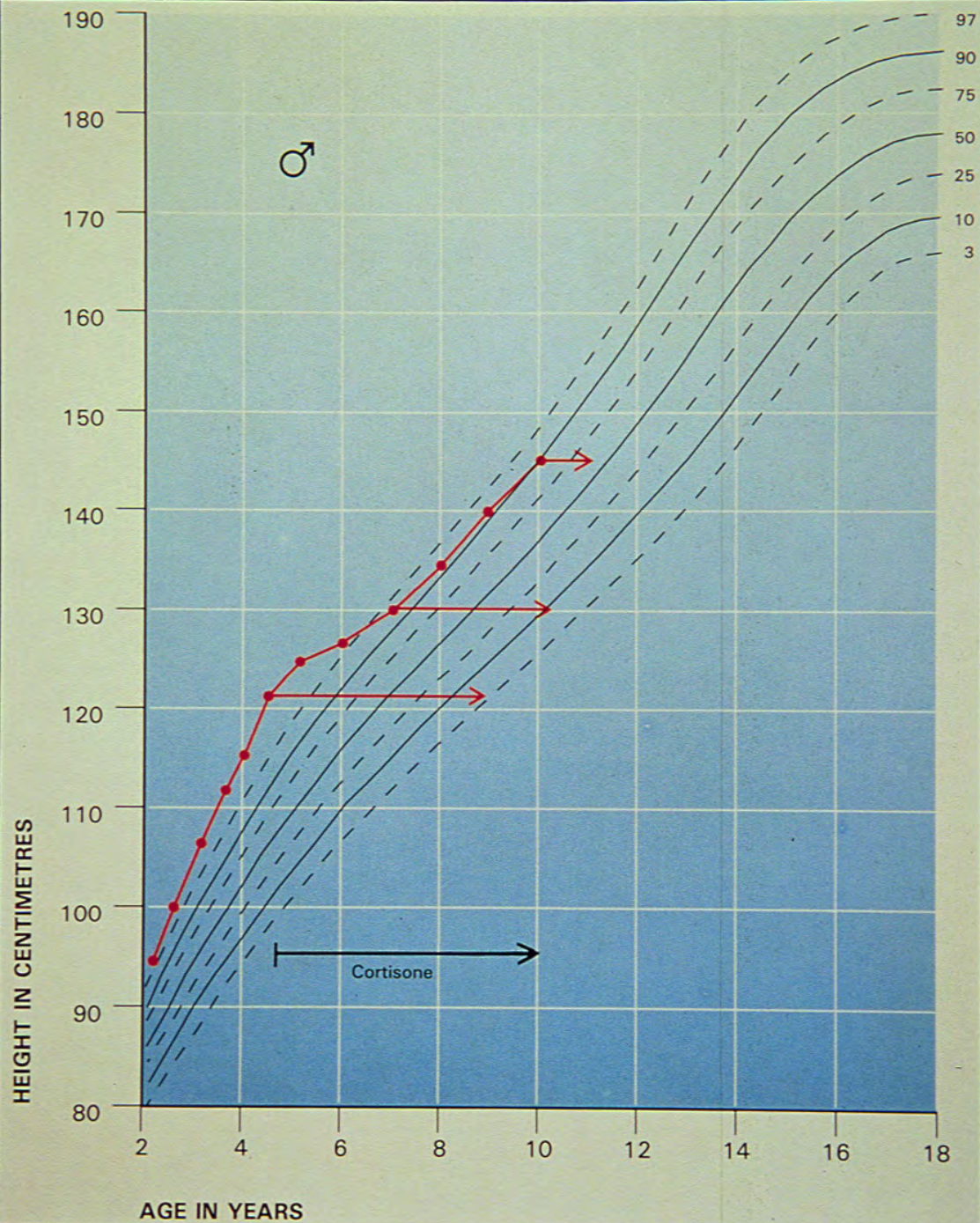




## Case 9 - Martin

- CAH due to  $21\alpha$  hydroxylase deficiency
  - Secondary central precocious puberty may develop once treatment is started

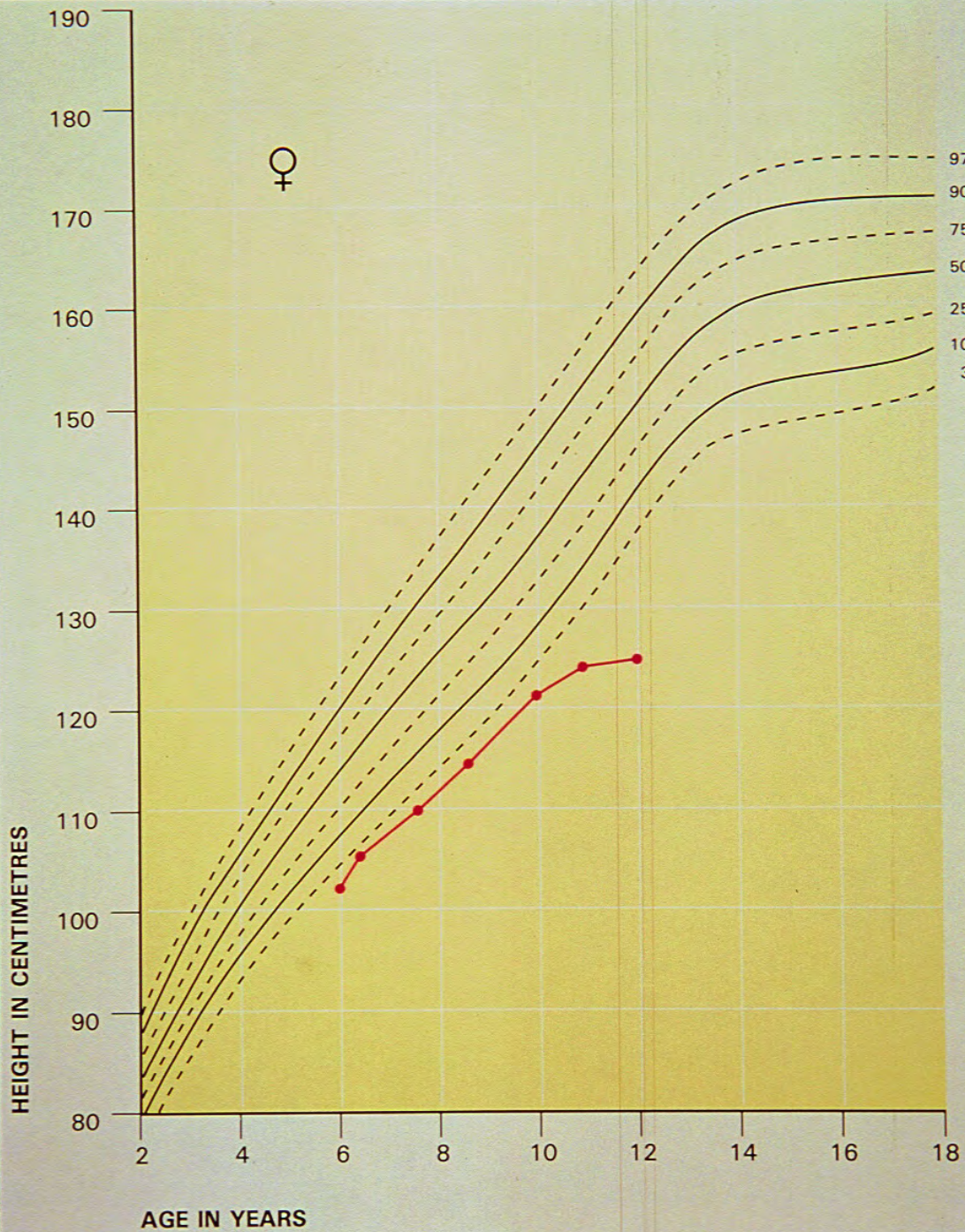




# Case 10

- Lucy 13yrs
- Followed at clinic for genetic short stature
- New school recently with no friends
- 6 months of abdominal pain and 3kg weight loss

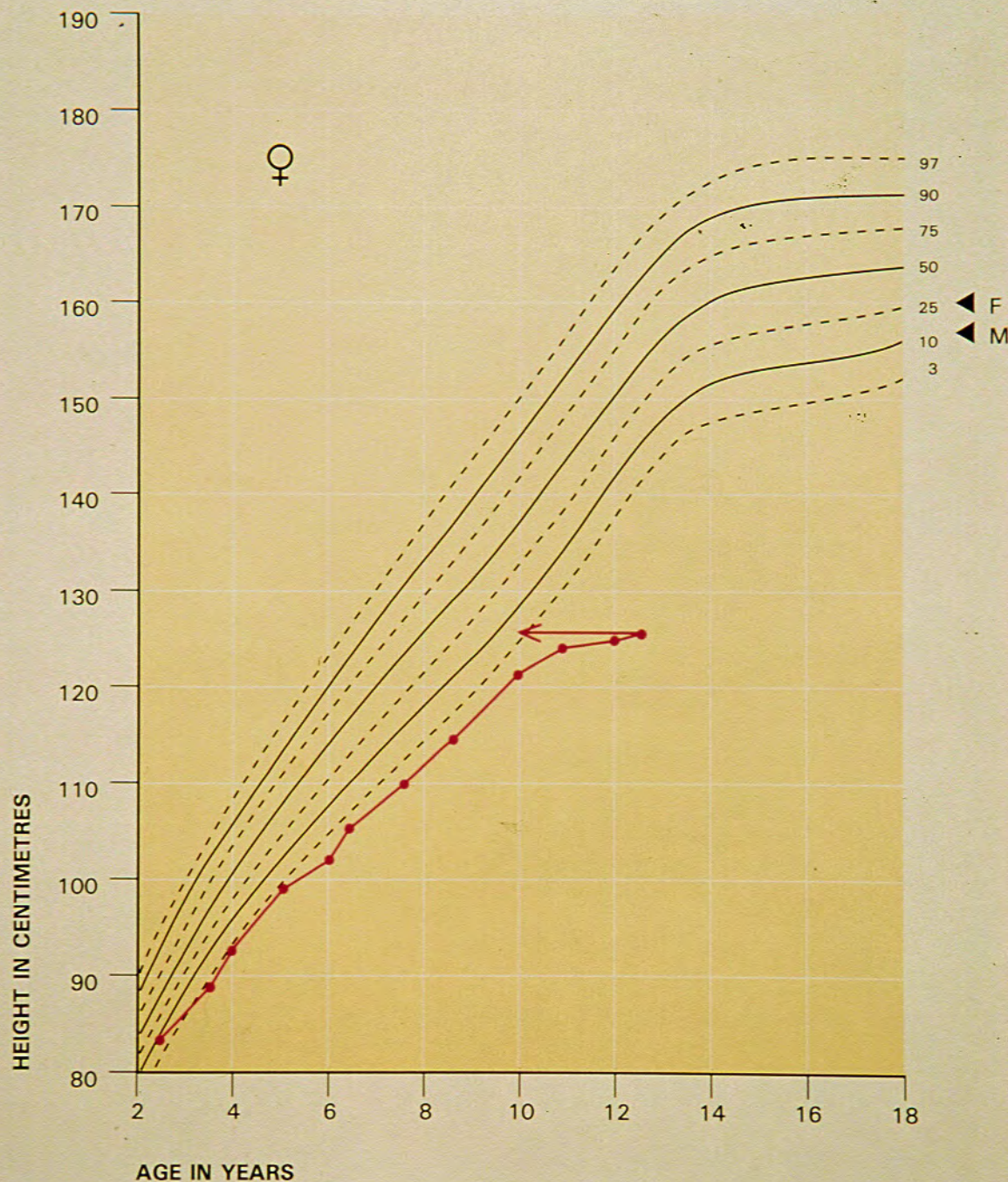




Parent heights?

Bone Age??





Is this related to the trauma of moving schools and no friends?

What other tests?

FBE/ ESR

TFTs

CD screen

U&E

# Case 10 - Lucy

- CD Screen Normal
- TFT, U&E Prolactin normal
- FBE/ESR
  - Hb 99 g/L
  - Platelets 560
  - ESR 50

# Lucy

- Gastroscopy/ Colonoscopy
- Small Bowel biopsy
- Diagnosed with CROHN's Disease
- Dietetic Input – elemental diet
- Mesalazine and steroids
- Started Biologic agent



# Lucy

- Minimise steroids for bone health
- Also optimising nutrition with resumption of growth and puberty

## Case 12 - James age 14

- Referred because of gynaecomastia
- History of undescended testis treated with orchidopexy
- Always a shy boy
- Socially awkward and a loner
- Thought to have some ASD features

## James age 14

- Weight 54kg
- Height 172 with long legs
- 2-3 cm of breast tissue with pectus excavatum
- Tanner stage 4 Genitalia and pubic hair
- Testes are 6 mL
- What investigations would help?

# James - Age 14

- LH, FSH – 10/ 56
- FBE – normal
- Chromosomes
  - 47XXY



# Growth as a marker of health

- Variations of growth can be a clue to the presence of an underlying health problem
- Regular growth measurements are an essential part of seeing children
- Understanding common variations and distinguishing from those needing more evaluation will enable more targeted referrals and investigation