MED439
KING SAUD UNIVERSITY

pediatric
439 Teamwork

Revised by The Academic Leader
Homoud Algadheb

Growth and Short Stature

objectives:

1. Describe the normal pattern of growth in children, highlighting variations in different age groups and the physiology of growth.
2. Demonstrate the ability to perform an assessment of growth using growth charts and growth parameters.
3. Define short stature in the context of pediatric medicine.
4. Develop a clinical approach for evaluating and diagnosing short stature in children, including relevant history-taking, physical examination, and necessary investigations to identify pathological causes of short stature.
5. Differentiate between familial and constitutional short stature.

Done by: Ibrahim Alabdulkarim

Revised by: Ibrahim Alabdulkarim - Saud Alrsheed

Team Leader: Saud Alrsheed

Special thanks to team 437 & Faisal alsaif

Extra

Notes

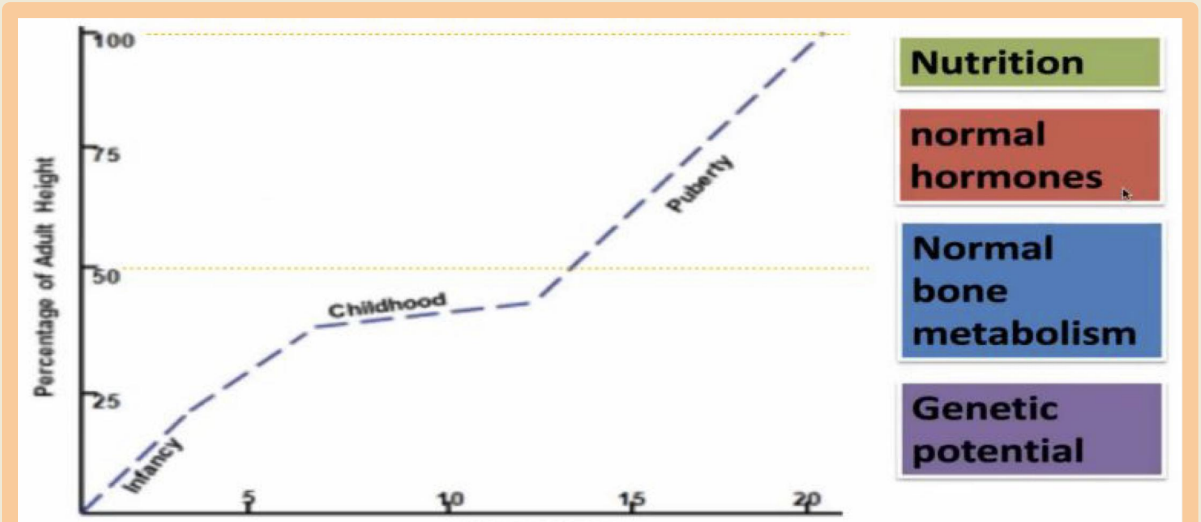
Important

Book

Why growth is important?

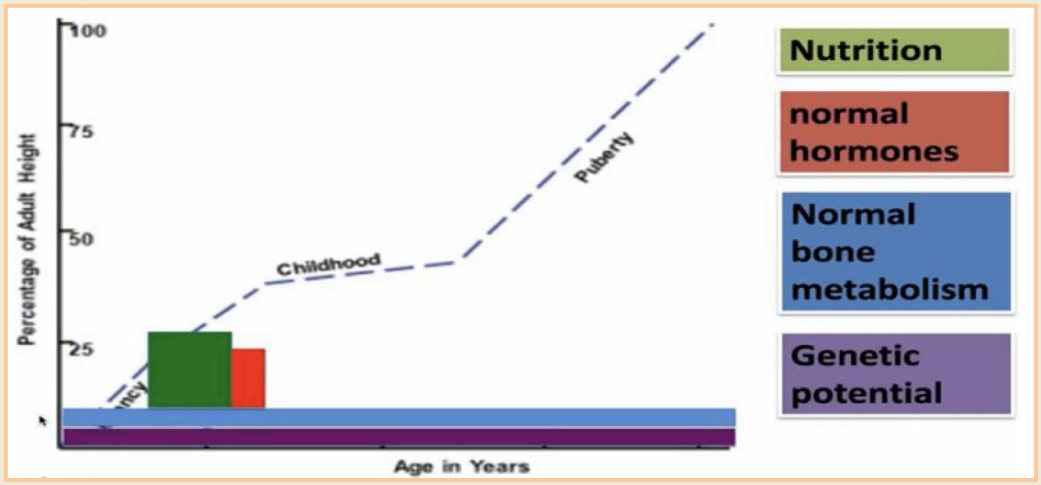
- Growth is a key element of child health and should be considered whenever children are seen.
- The growth of all children should be monitored regularly, especially during the first months of life, and recorded on the growth charts
- Knowledge about normal growth and pubertal development is required to recognize deviation from the norm
- Deviation of growth from expected percentiles or the normal sequence of pubertal development requires further assessment.

Normal Growth



- When person is born, He/she grows in terms of height gradually till they reach childhood when the growth somehow plateaus and then they go through growth spurt during puberty. So, the majority of the attained adult height is attained during puberty.
- If you drew a line, you would find almost 50% of adult height is attained during puberty.
- Almost 10% of adult height is attained during childhood..
- And the rest is attained during early infancy.

Normal Growth

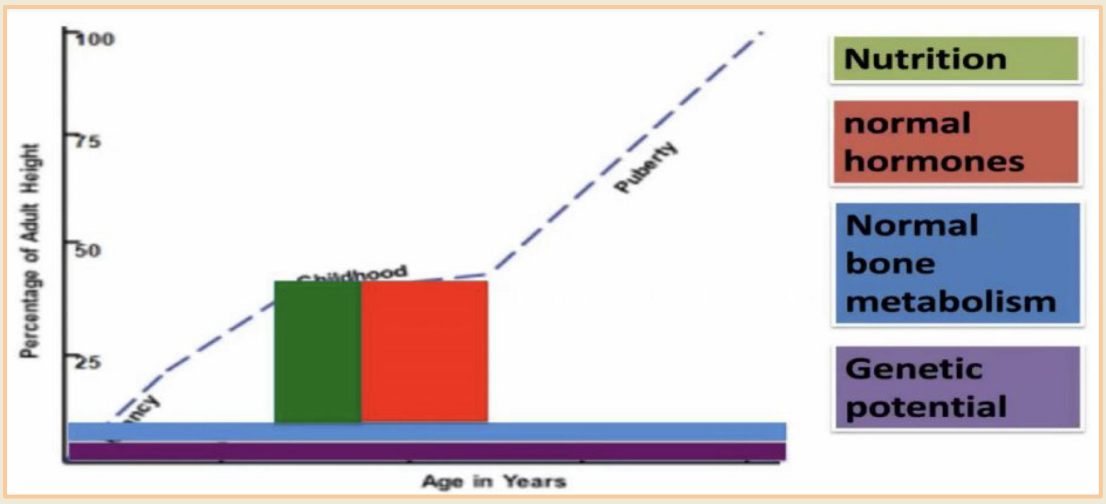


- What are the factors that contribute to growth?
  - Nutrition
  - Normal hormones (including Growth hormone)
  - Normal bone metabolism
  - Family history (genetic potentials)

- Which factor out of these 4 is the greatest contributor to growth during early infancy? **Nutrition**.

Genetics is the second factor.

Genetics and normal bone metabolism play major role during the whole life, but nutrition take the main bulk in early infancy, and normal hormones plays a role but not major role like nutrition in the early 2 years of life.



- Then, both nutrition and normal hormones play almost an equal role during childhood and puberty.
- This is important to understand because we receive lots of questions about children who are born short, children who are born short are usually not short because of growth hormone deficiency. growth hormone deficiency play a major role on height after the first 2 years of life. Rarely it leads to severe short stature in early infantile age.

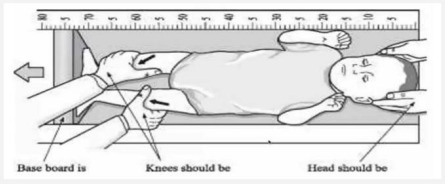
Growth Assessment

Infantometer for children who are < 2 years of age

Stadiometer for children who are > 2 years

Infantometer

- This measures the child's length; we call it length because children are measured while they are lying down. The word Height is used when children are measured while standing.
- It requires 2 people to help in assessing child length. The first person holds the head against the headboard which is at the zero level, and make sure that the child does not move their head. The second person holds the legs and straighten the knees.
- You cannot just stretch one leg alone when you do so the hip will be tilted, and the child would be measured falsely taller. After stretching both legs and straightening the knees, push the baseboard against the feet. And take the measurement in centimeters.
- Usually, children don't like this position and they will scream cry and kick. Repeat it 3 times and then take the average.



Stadiometer

- Another device is stadiometer that measures the height while child is standing. After age of 2 years.
- It can be done by one person but sometimes it is better done by two.
- You have to make sure you align all three points against the wall the heel the hip the shoulder and the head all against The wall and the child must be barefoot. The child should not bend their knees or be standing on tiptoes.
- The person taking the measurement should hold the head stabilizing the chin and child should be looking straight forward without looking up or down. Then, take the head bar slide till you reach child's head and then you read the measurement on the side of the wall.
- You take three reading and then you take the average of these readings.

Target Height

Target height of the child — Mid parental height

Boys:

$$\frac{[\text{Father's height (cm)} + \text{Mother's height (cm)}] + 13}{2} \quad \text{+/- 8 cm}$$

Girls:

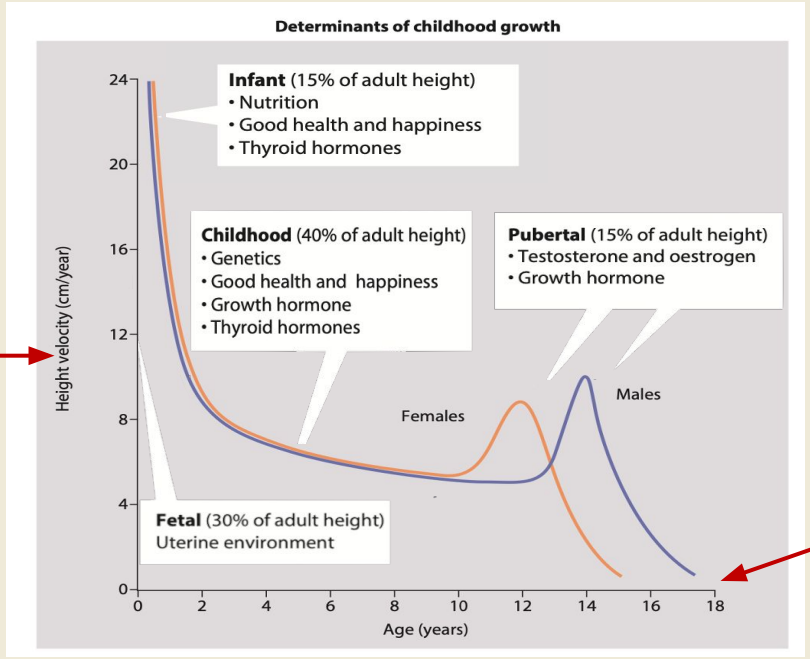
$$\frac{[\text{Father's height (cm)} + \text{Mother's height (cm)}] - 13}{2} \quad \text{+/- 8 cm}$$

- Target height or mid parental height is estimating the final adult height for the child knowing the mother's height and father's height.
- The difference between boy and girls' formula is that we add 13 in boys' formula while we subtract 13 in girls'.
- The outcome is the average height. For every mean there is standard deviation, If we want to know the normal range for that height we add and subtract 8 from the result. Add/subtract 13 before you divide by 2.

Normal phases of growth in children

Male and female height velocity charts (50th percentile) showing the determinants of childhood growth.

The **fetal** and **infantile** phases are mainly dependent on **adequate nutrition**



Height gain (Cm/year)

Age of child

The **childhood** and **pubertal** phases are dependent on **general health, growth hormone, and other hormones**

Why Adult males are **taller** than female?

Males have

- **Longer** childhood growth phase
- **Higher** peak height velocity
- Their growth ceases later.

❖ **Fetal phase** is the fastest period of growth. It is stimulated by raised maternal glucose resulting in raised glucose and increased IGF-1 in the fetus.

- Growth in fetal phase is restricted by pre-existing or pregnancy related maternal disease, maternal drugs, smoking or starvation or uteroplacental insufficiency and congenital infection and other disorders of the fetus

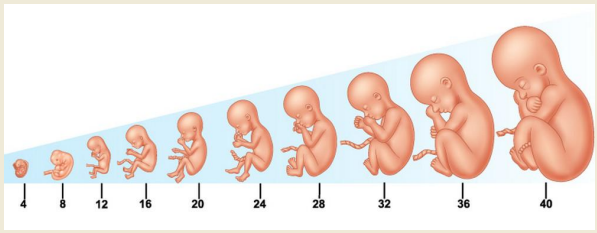
❖ **Infantile phase** is characterized by rapid but decelerating growth rate. An inadequate rate of weight gain during this period is called ‘faltering growth (FTT)’

❖ **Childhood phase** is a steady and prolonged period. Thyroid hormone, vitamin D and steroids also affect cartilage cell division and bone formation

❖ **Pubertal growth spurt:** height acceleration. Sex steroids cause fusion of the epiphyseal growth plates and cessation of growth

Phases of normal growth

Fetal phase:



- The **fastest period** of growth
- Accounting for about **30% of eventual height**.

Size at birth is determined by:

- The **size of the mother**
- **Adequate maternal diet** (Optimal placental nutrient supply is dependent on mother)
- **Placental nutrient supply** which in turn modulates
- **Fetal growth factors** [insulin- like growth factor 2 (IGF-2), human placental lactogen, and insulin].

Size at birth is largely **in**dependent of the father's height and of growth hormone

- Severe **intrauterine growth restriction** and extreme **prematurity** when accompanied by **poor postnatal growth** can result in **permanent short stature.**
- Paradoxically, low birthweight increases the later metabolic risk of childhood obesity.

Infantile phase:

- Period of infancy to around 18 months of age
- **Rapid** but **decelerating** growth rate
- Accounts for about **15% of eventual height**.

By the end of this phase, children have changed from their fetal length, largely determined by the uterine environment, **to their genetically determined height**.

Largely dependent on **adequate nutrition**.
Other factors:

- Good health
- Normal thyroid function

- Prolonged/severe **inadequate rate of weight gain** during this period ('faltering growth' or 'failure to thrive') → will result in **reduction in height or length (stunting)** and reduction in head growth and may be associated with delayed development.

Phases of normal growth

Childhood phase:

- Slow, steady but prolonged period of growth
- Contributes **40% of final height**

Dependent on

1. Pituitary **GH secretion** acting to produce **IGF-1** at the epiphyses (the main determinant of a child's rate of growth)
2. Adequate nutrition
3. good health
4. Other hormones: Thyroid **hormone, vitamin D, and steroids** also affect cartilage cell division and bone formation.
5. Psychological factors: profound chronic unhappiness can decrease GH secretion and accounts for psychosocial short stature.

Pubertal growth spurt phase:

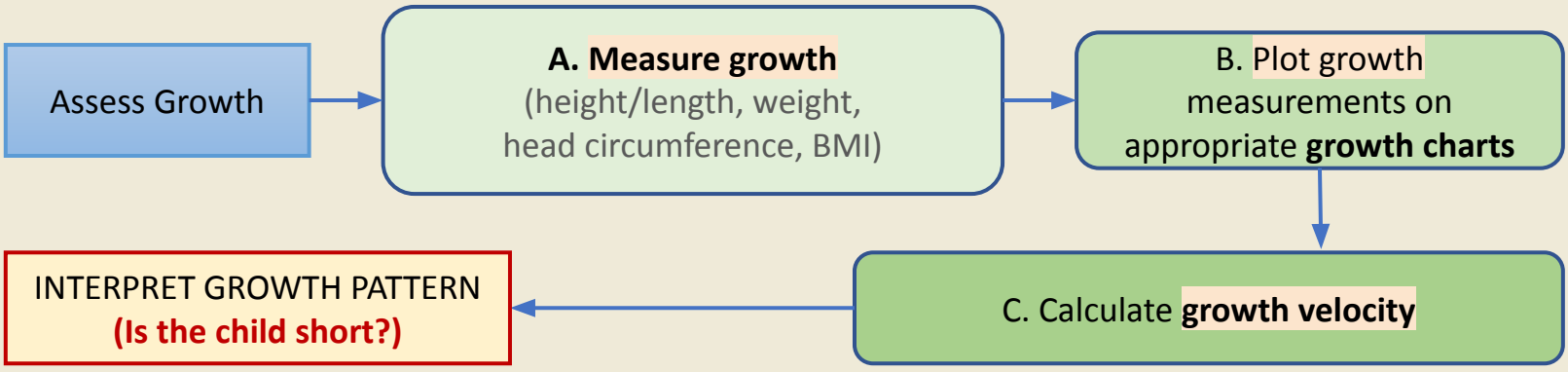
Adds 15% to final height.

Dependent on sex steroids

- ❖ Sex hormones (mainly testosterone and estradiol) causes;
  - the back to lengthen and boost GH secretion.
  - fusion of the epiphyseal growth plates and a cessation of growth.

If puberty is early (which is not uncommon in girls) the final height is reduced because of early fusion of the epiphyses.

Assessment of growth



A. Measure growth (height/length, weight, head circumference, BMI)

Pubertal growth spurt phase:

Growth must be measured accurately, with attention to correct technique and accurate plotting of the data

1. Weight

- Readily and accurately determined with electronic scales
- Must be performed on a naked infant or a child dressed only in underclothing.
  - (an entire month's or year's weight gain can be represented by a wet diaper or heavy jeans, respectively)

2. Height

- Accurate measurement (stadiometer)
  - Recumbent length (from birth to 3 years old) • Standing height (from 2 to 20 years old)
  - Accurate length measurement in infants can be difficult to obtain, as the legs need to be held straight and infants often dislike being held still.
- The equipment must be regularly calibrated and maintained.

3. Head circumference

- The occipitofrontal circumference is a measure of head and hence brain growth.
- Plot the maximum of three measurements.
- It is of particular importance in developmental delay or suspected hydrocephalus

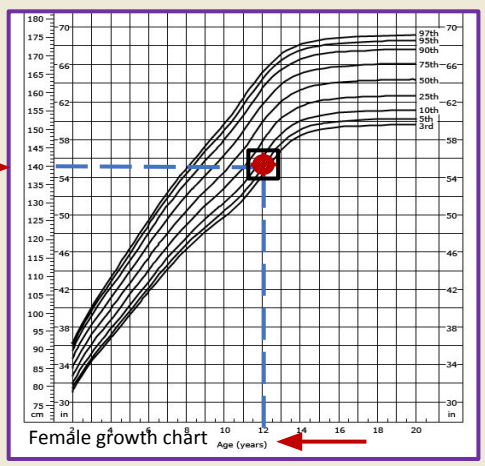
4. Body mass index (BMI)

- Calculate this using height in square meters/weight in kilogram
- Plot on a sex-specific body mass index centile chart to assess underweight or obese children.

B. Plotting Growth measurement (growth charts)

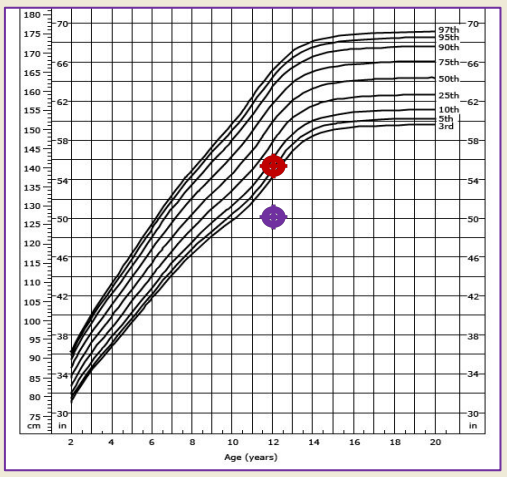
EXAMPLE →

Age: 12 yo girl
Height: 140 cm

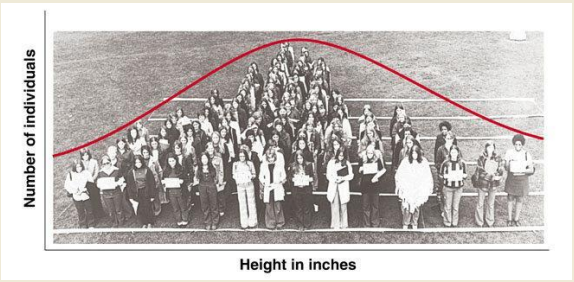


Female growth chart ←

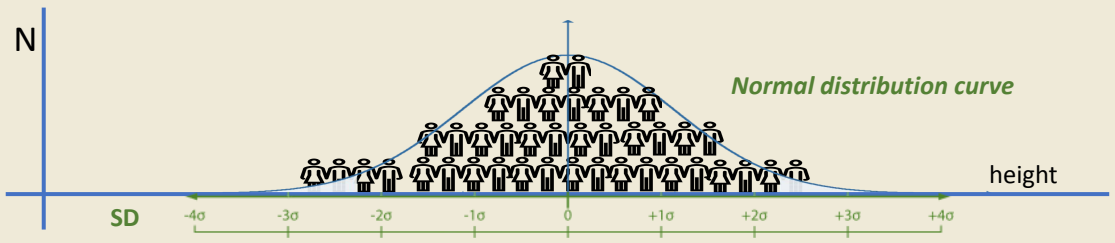
What do dots on the growth chart represent?



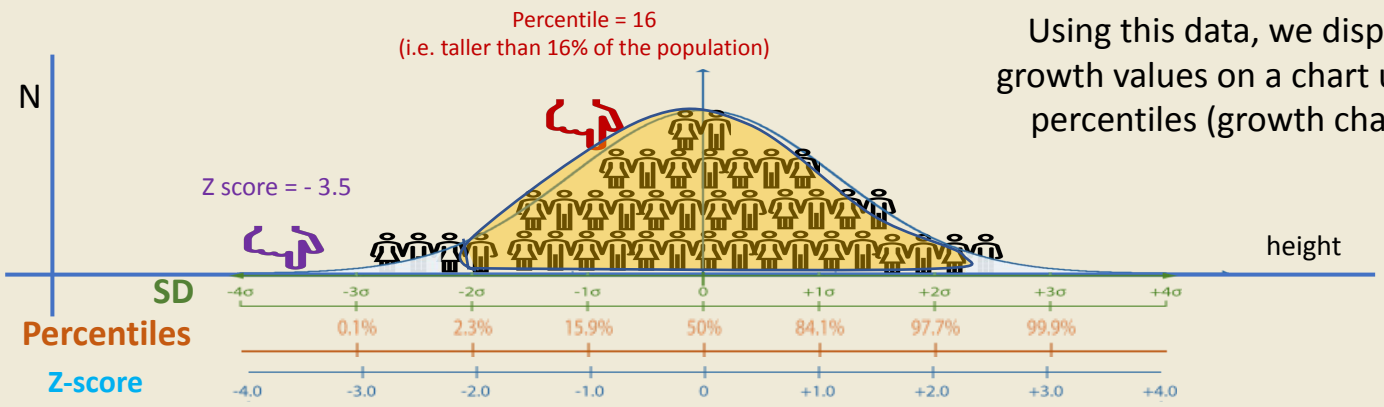
B. Plotting Growth measurement (growth charts)



1. Let's say I gather a representative sample of girls who are 12 yrs old and measure their height
2. Then I plot the height compared to the total number of kids



1. The height differences at a certain age would be normally distributed (height girls who are 6 years old)
2. Children height will be distributed evenly around the mean
3. From this data, we can display and interpret growth measures
4. SD are plotted as percentiles



Using this data, we display growth values on a chart using percentiles (growth chart)

Measure that indicates the percentage of observations that fall below a certain value (cumulative percentage)
(the position of a child among a group of normal children ranked by height)

1. We assume that height differences at a certain age is normally distributed (height girls who are 6 years old)
2. Children height will be distributed evenly around the mean
3. Using this data, we displayed growth values on the growth chart
    1. for interpretation
    2. Define/interpret growth based on z score.
    3. at it from a SD are plotted as percentiles
4. Percentiles = indicates the percentage of observations that fall below a certain value (position of a child among a group of normal children ranked by size)

B. Plotting Growth measurement (growth charts)

Types of Growth charts

- Center for Disease Control (CDC, 2000)
- World Health Organization (WHO, 2006)
- Saudi Growth Chart (2007)

Which chart to use?

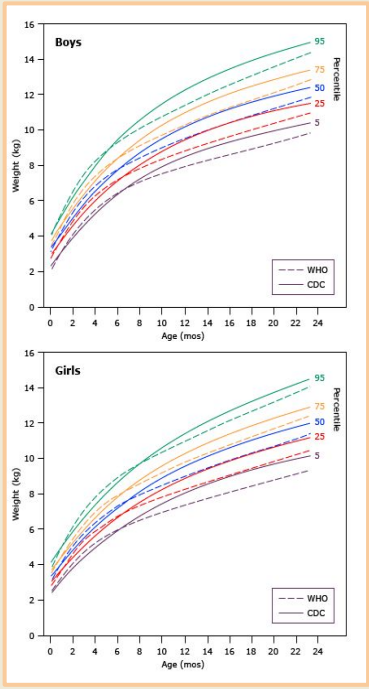
	CDC (2000)	WHO (2006)	Saudi (2007)
Population (intended use when developed)	**Reference** chart (observationally describe how children **grow** in the united states population)	**Standard** chart (describe how healthy children **should** grow in **ideal conditions)**	**Reference** chart (observationally describe how children **grow** in the Saudi population)
		Excluded: • Low socioeconomic status • Birth at altitude >1500 m • Birth at <37 wk or >42 wk • Multiple birth • Perinatal morbidity • Health condition • Maternal smoking • Breastfeeding <12 mos • Weight-for-length > +/-3 SD	Excluded: • Birth < 8 months • Low BW < 2.5 kg • Unhealthy children (determined based on interviews and clinical examination done by measurers (doctors and nurses)) • Non-Saudi nationality
Data	**Cross-sectional data (birth to 20yrs)** • **4697 observations on 4697 distinct children** • **Uses five national health examination surveys and five supplementary data sources.**	**Longitudinal data (**birth to 24 months) cross-sectional data (2 to 5 yrs) • **18973 observations on 882 distinct children** • **Racial/ethnic diversity →** • **Brazil** • **Ghana** • **India** • **Norway** • **Oman** • **California**	**Cross-sectional data** • **15,516 observations on 15,516 distinct children** • **Family interviews, and physical examinations (birth to 19 years of age)**

This recommendation reflects the opinion that the WHO charts represent a healthier standard for children younger than two years of age because they are based on longitudinal measurements in a breastfed population. Use of the WHO charts is less likely to lead to miscategorization of a breastfed baby as being underweight

CDC - normal range is generally defined as between the 5th and 95th percentiles WHO -2 SD and +2 SD (ie, Z-scores between -2.0 and +2.0), which corresponds to approximately the 2nd and 98th percentiles.

B. Plotting Growth measurement (growth charts)

WHO vs. CDC charts



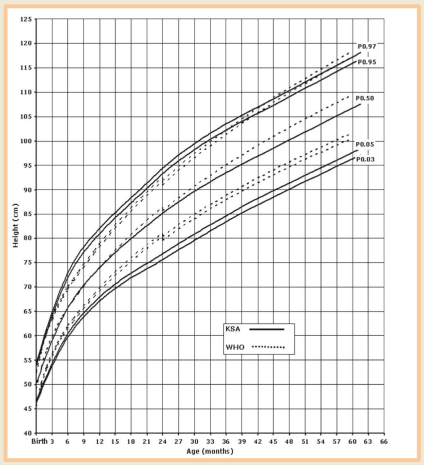
WHO represent a healthier standard for children younger than two years of age

- Because they are based on longitudinal measurements in a breastfed population.
- Less likely to miscategorize breastfed baby as being underweight

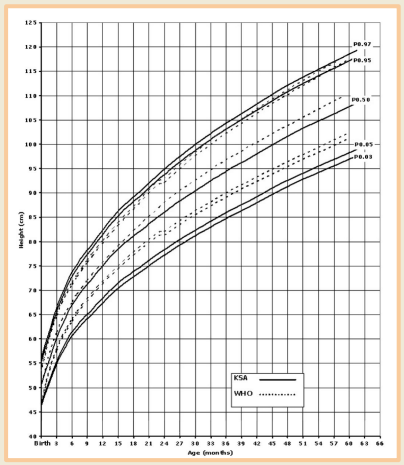
Both AAP and CDC recommends using WHO to monitor growth in children aged <24 months, and the CDC to monitor children > 2yrs of age

Saudi vs. WHO charts

- The WHO's lower percentiles (third and fifth) are shifted upward.
- Children are more likely to be classified as stunted (short) if the WHO vs. the Saudi growth chart was used.



girls



boys

Saudi vs. CDC charts

- The CDC's lower percentiles (third and fifth) are shifted upward.
- Children are more likely to be classified as stunted (short) if the CDC vs. the Saudi growth chart was used.

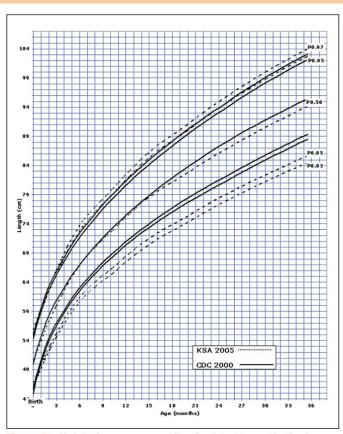


Figure 2a. Height for age percentiles for 0 to 36 months for boys.

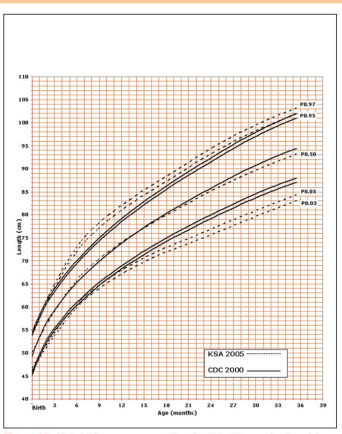


Figure 2b. Height for age percentiles for 0 to 36 months for girls.

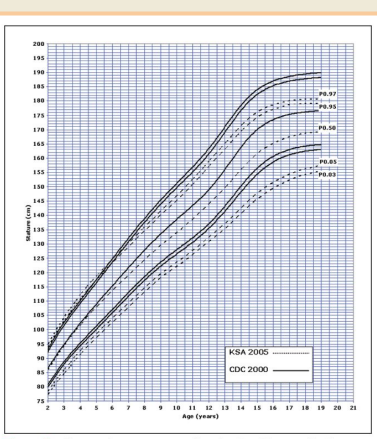


Figure 5a. Stature for age percentiles for 2 to 19 years for boys.

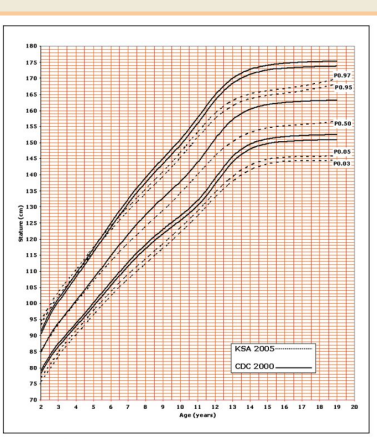


Figure 5b. Stature for age percentiles for 2 to 19 years for girls.

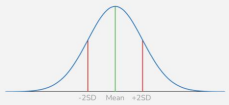
B. Plotting Growth measurement (growth charts)

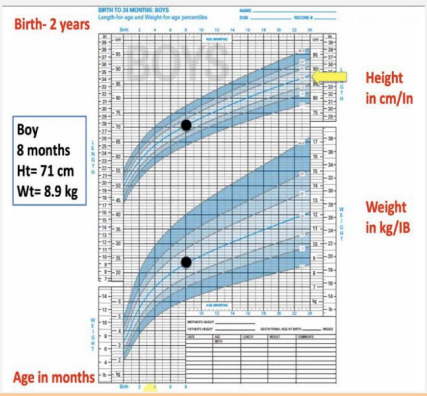
Boys:

This is WHO growth curve for boys from birth – 2 years.

These are the percentile, so we can compare the child to children in same age and gender.

- If we take any measurement, it should follow the normal distribution of the "Bell curve".
- Where the 0 represents the mean, plus 2 standard deviation (+2SD) and minus 2 standard deviation (- 2SD).
- The growth curve idea was adopted from this. Where the mean represents 50th percentile + 2 SD represents 99th percentile -2 SD represents 3rd percentile.

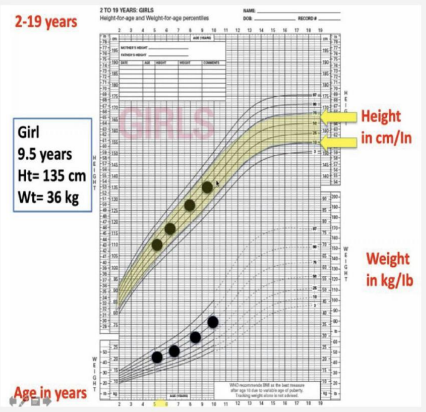




How to plot height / weight data of a baby who is 8 months old his height is 71cm and weight is 8.9?
Draw imaginary line starting from the age going down till you reach the height of 71 cm, the intersection between age and height is where you can plot this child.
The same for weight draw imaginary line from age going up until it meets the child's weight.

Girls:

This is WHO growth curve for girls 2 – 19 years.



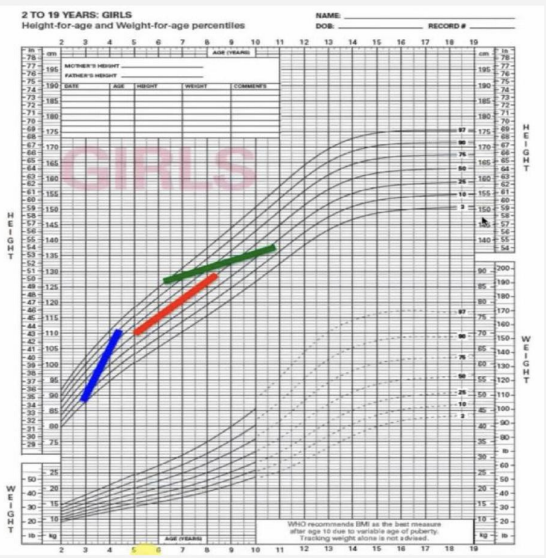
- Plotting height data of 9.5-year-old girl the same principle applied/
- Other dots means previous growth measurement.
- **Why is it important to look at previous growth data?** Because it tells you about the pattern of growth.
- **What does the yellow arrows represent?** The standard deviation of mid parental height calculated using the formula.
- That means the normal mid parental height of this child is between the 10th percentile and 55th percentile.
- We can also plot the average after calculating the mid parental height instead of putting 2 arrows of the normal range (putting the result of the equation without adding/subtracting 8).
- All these values lie within the range of mid parental height. That means the child is following their genetic potential.

We learned three things:

1. The value needs to be normal within normal population we have the comparison to other children in the same age and gender.
2. Child growth pattern follows the same tracking of the same line that he started since birth and growth velocity is normal.
3. These values are lying within mid parental height, so the child is following the same distant genetic potentials.

- If these 3 information are normal so most likely the child growth is normal.
- The average weight gain for children after 2 years of life is 1-2 Kg/ year. **Why does weight curve plotting disappear?** Because it is not important to follow the weight, we should follow the BMI instead, so we don't miss children with obesity.

Ibra: I think it's important to understand

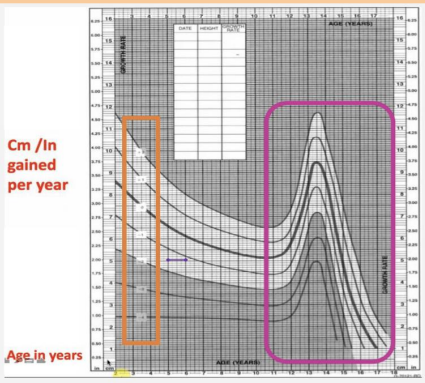


These are growth patterns of three children:

- The first one (in BLUE) started to grow in height in 3rd percentile and through years progressively gained height till she reach 90th percentile.
- The second child (in RED) started at 50th and continued at 50th.
- The third child (in GREEN) started at the 97th percentile and then reached 25th percentile.

Which one is normal?

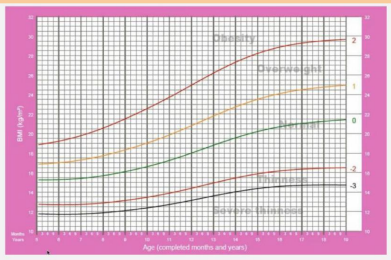
- The one in RED because the child started at 50th percentile and continued at 50th percentile. Even if she started at 10th percentile and continued at 10th percentile, she is considered normal as long as she continued at the same pattern.
- The blue line means the child was short and suddenly she became taller (Abnormal).
- The green line means the child was tall and then she progressively became shorter (Abnormal).



- This is growth velocity curve where x-axis represents ages in years and Y-axis represents the cm gained per year.
- This is marked by Z score as you can see -4, -3, -2, -1, 0, +1, +2.
- Some of growth curves are marked similarly using -3,-2,- 1,0,+1,+2 not translated in percentiles.
- **If you want to translate it to percentiles:**
  - -2 = 3rd percentile
  - -1 = 25th percentile
  - 0 = 50th percentile
  - +1 = 75th percentile
  - +2 = 95th percentile
- **To plot a child in growth velocity curve:**

If we have child who grew 5cm between 5 & 6 years of age, we drew a line from 5-6 years at the level of 5cm.

- There is peak and decline that represents the puberty (growth spurt), and then you complete your growth while growth velocity declines. once you reach the final adult height you don't grow anymore therefore your growth velocity becomes zero.

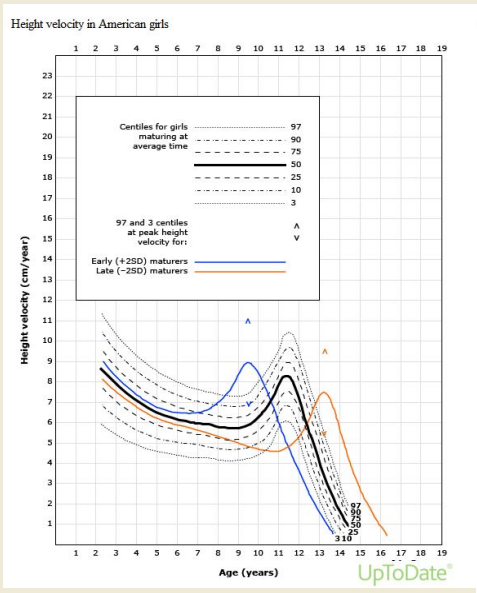


- This the BMI growth curve age in the x-axis and BMI in y-axis.
- Numbers are in Z score.
- Zero is the zone for normal (-2 to +1).
- **BMI curve give a little information about nutritional status:**
  - Those who are less than -2 standard deviation, are thin.
  - Those who are less than -3 are severely thin or malnourished.
  - Those who are between +1 and +2 standard deviation are overweight.
  - Those who are more than +2 are obese.
- Some BMI curves shows percentile where +1 standard deviation equals to 85th percentile.
- It is important in counselling children with obesity. We have to catch them before they reach the obesity zone. And to work on children who are severely thin.

C. Growth velocity

- Consider "**growth velocity**" as a **vital sign** for children
- Accurate calculation **require at least 4-6 months** interval between measurements
- calculated in **cm/year**

Height Velocity Chart



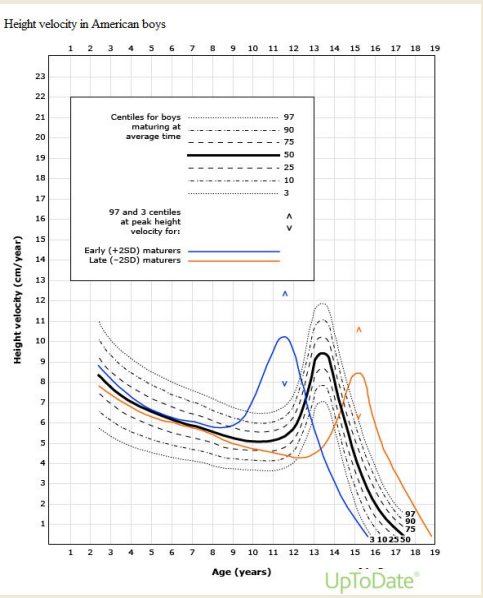


Table 9.1 Normal Growth Rates in Children

Age	Growth Rate (Per Year)	
	Inches	Centimeters
Birth to 1 year old	7 to 10	18 to 25
1 to 2 years old	4 to 5	10 to 13
2 years old to puberty	2 to 2.5	5 to 6
Pubertal growth spurt: Girls	2.5 to 4.5	6 to 11
Pubertal growth spurt: Boys	3 to 5	7 to 13

determine the HV percentile (or SD [Z-score]) for the child's age and gender (note that this is different from the height-for-age percentile). In general, HV between the 10th and 25th percentile should raise concern for possible growth failure and an HV below the 10th percentile warrants a thorough evaluation for growth failure.

INTERPRET GROWTH PATTERN

3 question steps that will help you decide if further evaluation is needed!

1- Is the child short?

Short stature Definition
Length or Height

- more than **2 standard deviations (SD) below the mean** for age and sex
- (i.e., a **Z-score < -2**)
- which corresponds to **<2.3rd percentile**

INTERPRET GROWTH PATTERN

2- Is growth velocity impaired?

Growth failure

- Defined as a **subnormal linear growth velocity** for age and sex (if persistent, **eventually results in short stature**)

Either

- Deviated downward **across two major height percentile curves**
- A GV:
  - Between 10th and 25th percentile-possible growth failure
  - < 10th percentile- growth failure
- child is growing **slower than the following rates**:
  - 2-4 years – HV < 5.5 cm/year
  - 4-6 years – HV < 5 cm/year
  - 6 years to puberty: HV < 4 cm/year for boys. HV < 4.5 cm/year for girls

3- Is the predicted adult height fall within the target height range?

- Adult height is **determined by a combination** of **genetic** potential and **many other factors** that **influence somatic growth and biologic maturation**
- **No method accurately predicts adult height**, and there is wide variation in predicted adult height among the different methods.

Practical method

1- Calculate Mid-Parental height (MPH)

- **Girls**

- [Paternal height (cm) **– 13 cm** + maternal height (cm)] ÷ 2
- or [Paternal height (in) – 5 in + maternal height (in)] ÷ 2

- **Boys**

- [Paternal height (cm) **+ 13 cm** + maternal height (cm)] ÷ 2
- or [Paternal height (in) + 5 in + maternal height (in)] ÷ 2

Practical method

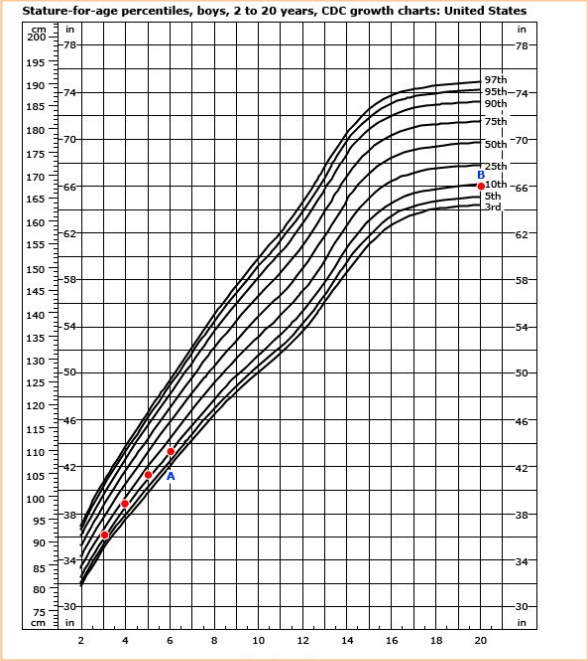
2- Target height

MPH **± 2 SD**

- Girls **±8.5 cm**
- Boys **±10 cm**

3- Projected height

extrapolating the child's height along the growth percentile curve



Does projected height fall in the target height range?

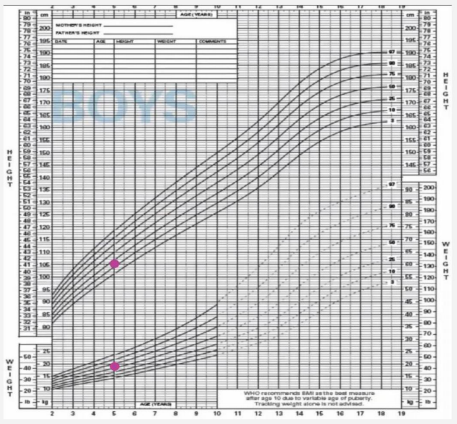
infant stadiometer – chin up. Head and extended feet held against both ends of the stadiometer. Need at least 2 persons
Child stadiometer – shoeless, feet together, back straight, looking strait ahead.

- ***the recumbent length*** was measured while the child was lying on the back over a flat surface, by a measuring rod (Seca, Germany) with a fixed head end, and a sliding feet end perpendicular to this surface. An observer holds the head in contact with the head end board, and another straightens the legs and turns the feet upward to be at right angle with the legs and bring the sliding feet end board in contact with the heel of the child.

1.

- 5 year old boy
- Height: 105 cm
- Weight: 18 Kg
- BMI
- Father height: 170 cm
- Mother height: 160 cm

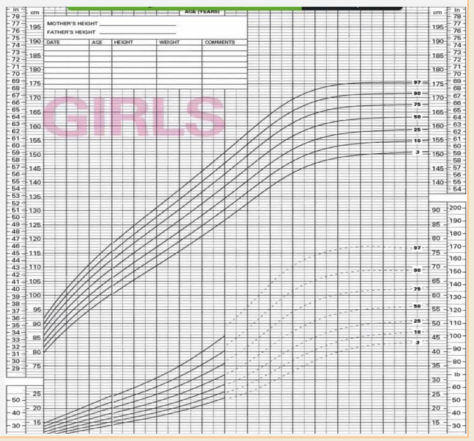
- Mid parental height = ((170+160) + 13 / 2) +/-8 = 171.5 +/- 8



2.

- 5 year old girl
- Father height: 170 cm
- Mother height: 160 cm

Age	5	6	7	8
Ht	105	106	107	108
Wt	18	18	19	20

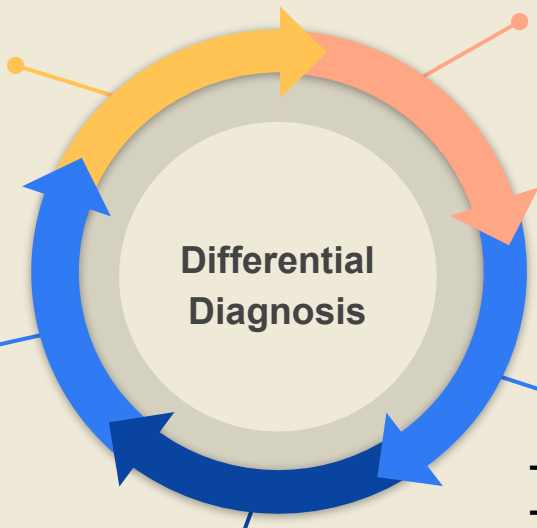


Short stature

Psychological burden of short stature

- Most short children are psychologically well adjusted to their size.
- However, there may be problems from being teased or bullied at school, poor self-esteem, and they are likely to be at a considerable disadvantage in most competitive sport.
- They are also assumed by adults to be younger than their true age and may be treated inappropriately.

Causes of short stature



Normal variants of growth

- **Constitutional delay of growth and puberty**
- **Familial short stature**
- **Idiopathic short stature**

Chronic diseases

Assuming they are relatively uncontrolled

- **Anemia**
- **Celiac disease**
- **Chronic renal insufficiency**
- **Inflammatory bowel disease**
- **Malnutrition**

Endocrine disorders

- **Skeletal dysplasia**
- **Rickets**
- **Hypothyroidism**
- **GH deficiency**
- **Hypopituitarism**
- **Cushing's Syndrome**

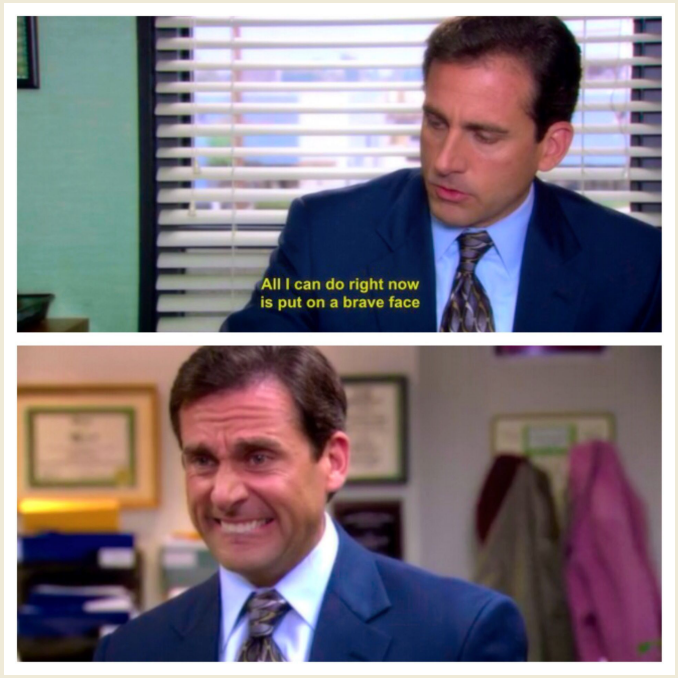
Prenatal/genetic causes

- **IUGR/SGA**
- **Chromosomal disorders (turner)**
- **Noonan syndrome**
- **Dysmorphic/genetic syndromes**

Psychosocial/other

- **Psychosocial dwarfism**
- **ADHD**

Almost done , don't give up



Short stature

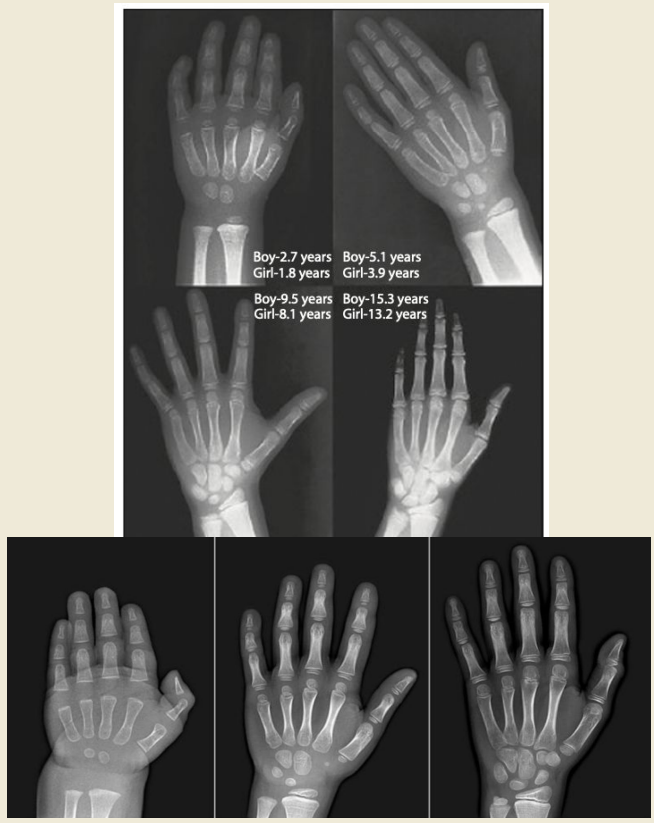
What is the best next step to evaluate a child short stature/growth failure?

Bone Age Greulich & Pyle Atlas

- Indicator to skeletal maturation
- Bone age should be compared with chronologic age to narrow the differential diagnosis
- Children with normal variations of growth may have advanced or delayed bone age
- BUT a bone age that is more than two standard deviations away from the mean for age is likely due to a pathologic condition

- The first investigation we should order is Bone age.
- We have an atlas for bone age that looks at bone maturity across all age groups, which is taken through an x-ray of the left hand and wrist. You look at maturation of all growth plates.
- This is hand of female who is 1 year old and female who is 11 years old.
- You can observe the difference female 11 y: all carpal bones achieved major part of their maturation compared to 1 year old. And even all growth plates here are more mature while in 1yr old there is no growth plates that start maturation.

Epiphysis and metaphysis ossification and union
Changes an number and size of carpal bones
Radius and ulna ossification



The traditional method compares a plain radiograph of the left wrist and hand to a database of norms

Short stature

Other investigations to consider

- Celiac screening
- Thyroid screening (Free T4 and TSH)
- Growth markers (IGF1/IGFBP3)
- Karyotype in girls
- For chronic diseases:
  - CBC and inflammatory markers (ESR, CRP)
  - CMP, urinalysis

Of note

- Controversy about the **extent of testing** that should be performed for short stature in **otherwise healthy children**.
- The yield of testing is extremely low.

Investigation	Significance
X-ray of the left hand and wrist for bone age	Some delay in constitutional delay of growth and puberty. Marked delay for hypothyroidism or growth hormone deficiency
Full blood count	Anemia in celiac or Crohn's disease
Creatinine and electrolytes	Creatinine raised in chronic kidney disease
Calcium, phosphate, alkaline phosphatase	Renal and bone disorders
Thyroid-stimulating hormone	Raised in primary hypothyroidism
Karyotype	Turner syndrome shows 45,XO, other chromosomal disorders
Anti-endomysial (EMA) and anti-tissue transglutaminase (anti-TTGa) immunoglobulin A antibodies	Usually present in coeliac disease
C-reactive protein (acute-phase reactant) and erythrocyte sedimentation rate	Raised in Crohn's disease
IGF-1	Disorders of the growth hormone axis, including IGF-1 deficiency
Limited skeletal survey	Skeletal dysplasia, scoliosis
Growth hormone provocation tests (using insulin, glucagon, clonidine, or arginine in specialist centres)	Growth hormone deficiency
0900 h cortisol and dexamethasone suppression test	Cushing syndrome
MRI scan if neurological symptoms/signs	Craniopharyngioma or intracranial tumor

Cases of short stature

Follow this approach:

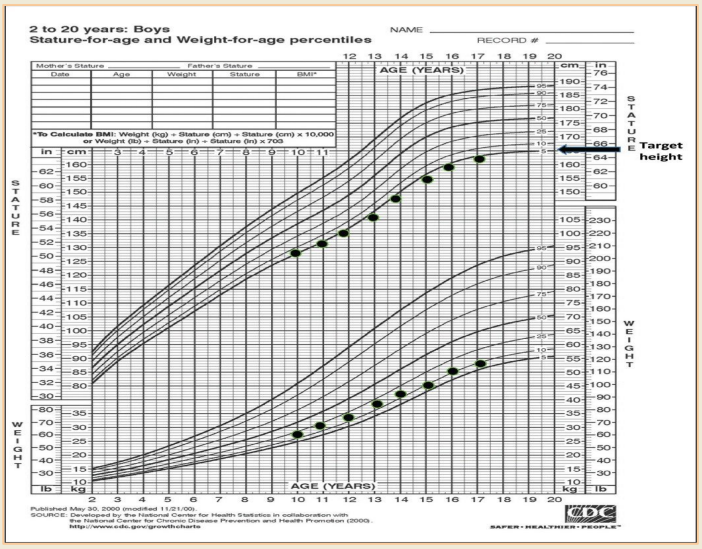
1. Is the patient short by definition?
2. How is the growth velocity?
3. What is the MPH
4. What is the bone age?

Case 1

17-year-old boy.Parents are concerned about his stature (tanner 5 on exam)

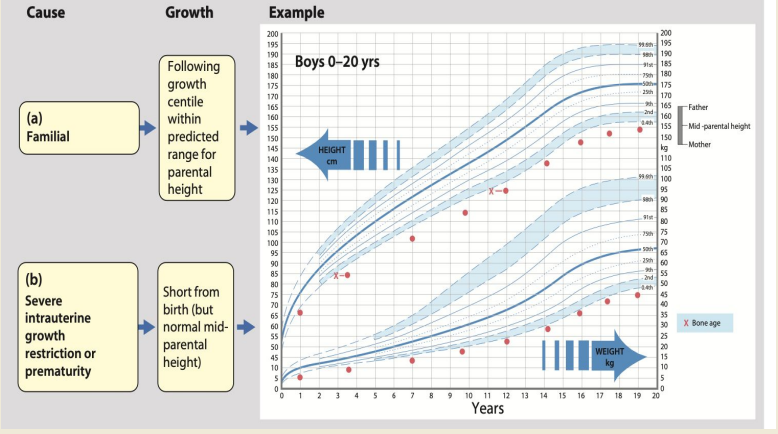
What's your diagnosis?

1. Constitutional short stature
2. Familial short stature
3. Malnutrition
4. GH deficiency
5. Genetic disorder



Familial Short Stature

- Most short children have short parents and fall within the centile target range allowing for midparental height.
- No gender preference
- Birth length normal
- FH of SS
- GV normal
- Puberty normal
- Bone age = Chronological age
- Final height - short



Care needs to be taken, though, that both the child and a parent do not have an inherited growth disorder, such as a skeletal dysplasia.

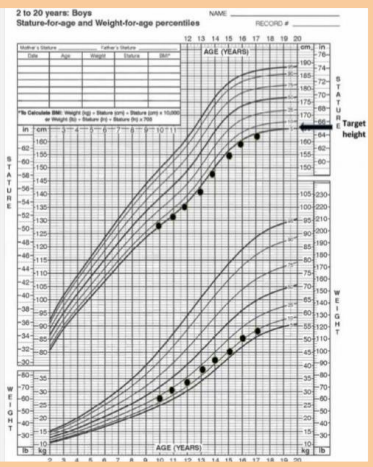
Small for gestational age and extreme prematurity

- About 10% of children born small for gestational age or who were extremely premature remain short.
- GH treatment may be indicated if there is insufficient catch-up growth by 2-4 years of age.

Familial Short Stature

- Short family (MPH)
- No chronic illness
- Normal growth velocity
- Normal physical exam
- No dysmorphic features
- Normal puberty
- Normal bone age

Here the child growth pattern follows the 5th percentile and falls in the normal range of mid parental height and did not cross percentile and this is normal familial short stature. Which is normal variant of height, if the parents are short then the child is destined to be short.



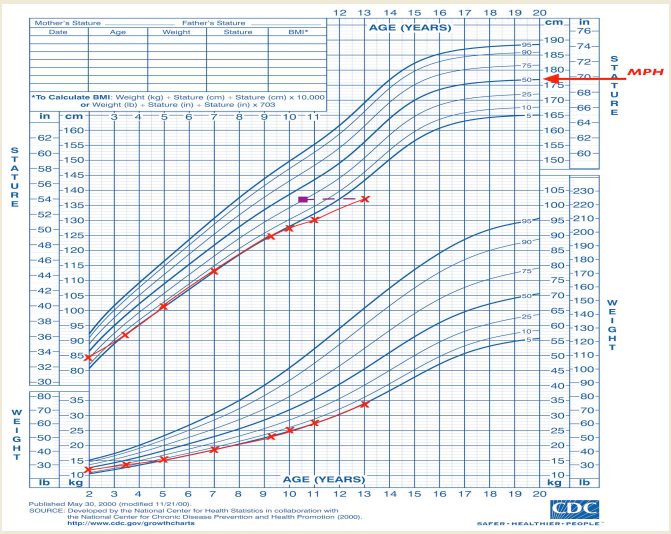
Cases of short stature

Case 2:

13-year-old healthy boy.
Parents are concerned about his stature

What's your diagnosis?

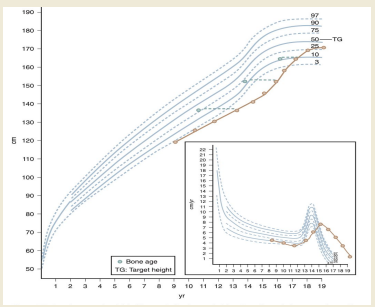
1. Familial growth delay
2. Constitutional growth delay
3. GH deficiency
4. IUGR/SGA

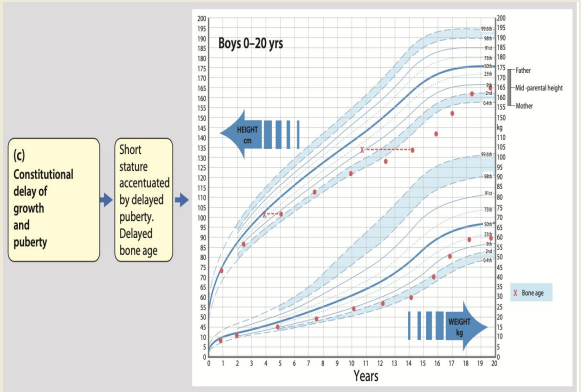


Here we see the **bone age** following the MPH.
Suggesting Constitutional growth delay

Constitutional Delay in growth and puberty

- Male preference
- Birth length normal
- Falls <5% in years 1-3
- FH of delayed puberty
- GV normal
- Puberty delayed
- Chronological age > Bone age
- Final height normal





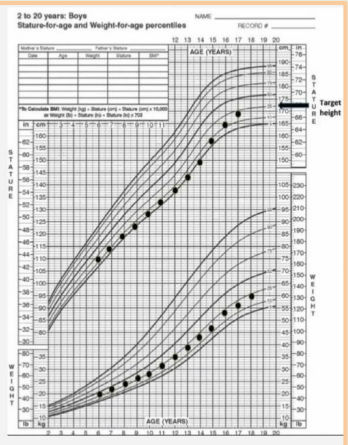
Constitutional delay in growth and puberty

- Constitutional delay in growth and puberty is a variation of normal growth, which presents with short stature in teenage years because of a delay in the onset of puberty.
- Growth during childhood is usually within the lower limits of normal, bone age is somewhat delayed, and onset of secondary sexual development is delayed but final height is normal.
- There is usually a family history of delayed growth and puberty but normal height as adults

Constitutional Short Stature

- Family history of delayed puberty
- Appropriate height for MPH
- Normal growth velocity
- Delayed puberty
- Delayed bone age

- This is a bit difficult to get because most of the clues you get through the history and small clues in the growth chart.
- They usually have a family member who had delayed puberty and was the short and once they go through puberty, they stretched out and they became the tallest in the family.
- The height although it lies at the 5th percentile it is still within the normal mid parental height.
- If you take an x-ray of the hand, it will show delayed bone age.
- No treatment needed only reassurance and follow up, because they are going to have delayed puberty just like their family and they will grow and be the tallest in their family.

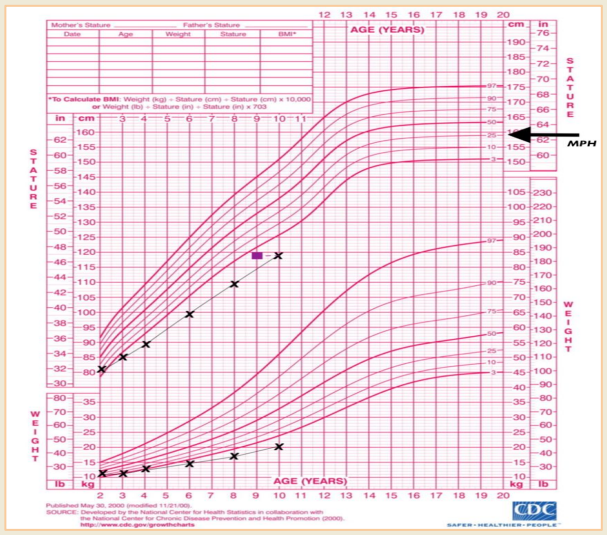


Cases of short stature

Case 3

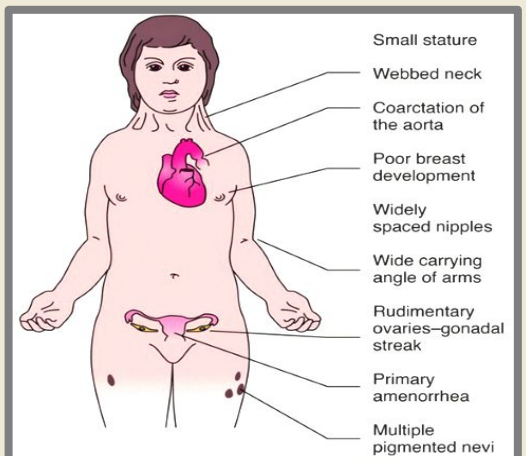
10-year-old healthy girl, Parents are concerned about her stature (pre-pubertal on exam)

1. Constitutional short stature
2. Familial short stature
3. Chromosomal abnormality
4. Malnutrition



Chromosomal disorder/syndromes

- Many chromosomal disorders and syndromes are associated with short stature.
- Trisomy 21 (Down syndrome) is usually diagnosed at birth
- Turner syndrome
  - May be particularly difficult to diagnose clinically and should be considered in all short females.
- Noonan syndrome
- Russell–Silver syndrome



Turner Syndrome

- Growth Pattern:
  - Mild IUGR
  - Poor childhood growth
  - Growth failure in childhood
  - Absent pubertal growth spurt
- Other:
  - Short stature, webbed neck
  - short metacarpals
  - broad chest with widely spaced nipples
  - hyperconvex fingernails and toenails
  - **may be normal appearing**

Case history 12.1

Turner syndrome

This girl (Fig. 12.10), presented when 10 years old with short stature. She had a history of recurrent ear infections, but was otherwise well. She had always been very short, and her height was 126.4 cm, well below the 0.4th centile on the standard growth chart. Her chromosomes were checked, which confirmed Turner syndrome 45,XO. She was started on growth hormone injections and on ethinyl oestradiol (oestrogens) for pubertal induction at 14 years of age. At 15 years of age her height was 150 cm.

Figure 12.10 At 15 years, she has few clinical features of Turner syndrome, demonstrating the need to check the karyotype of females with marked short stature.

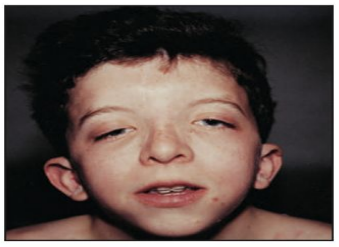


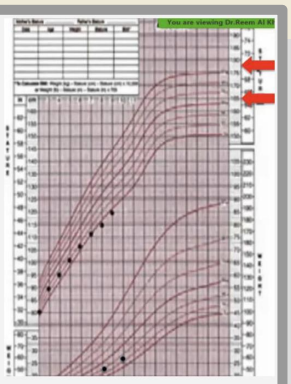
Figure 9.17 Noonan syndrome affects both males and females. There are some similarities to the phenotype in Turner syndrome, but it is caused by mutation in an autosomal dominant gene and the karyotype is normal.

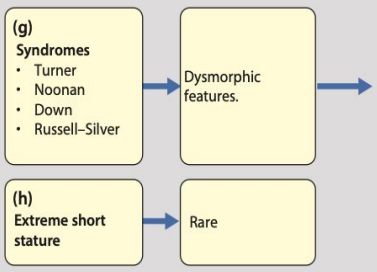
Box 9.11 Clinical features of Noonan syndrome

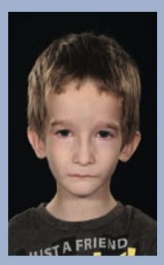
- Characteristic facies
- Occasional mild learning difficulties
- Short webbed neck with trident hair line
- Pectus excavatum
- Short stature
- Congenital heart disease (especially pulmonary stenosis, atrial septal defect)

Syndromic Causes

- Not appropriate for MPH
- Dysmorphic features
- Child crosses the percentiles in height. He is at the 3rd percentile which is very far from MPH. This pattern is syndromic.







Russell-Silver syndrome

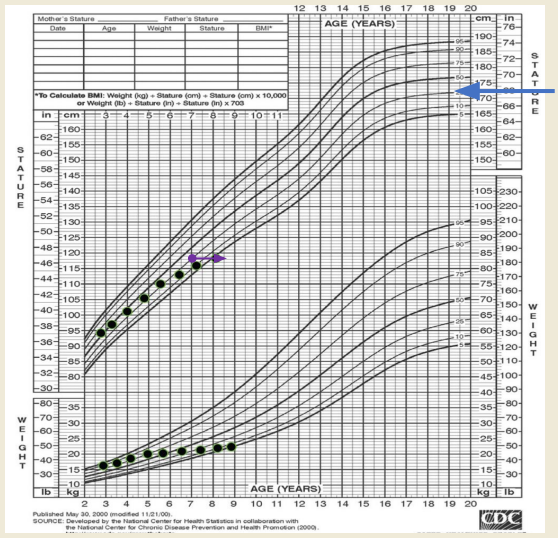
Cases of short stature

Case 4

9-year-old boy. Parents are concerned about her stature (pre-pubertal on exam)

What's your diagnosis?

1. Celiac disease
2. GH deficiency
3. Constitutional short stature
4. Genetic syndrome
5. Familial short stature



MPH

In malnutrition, weight plateaus first

Nutritional/long-term illness

- This is a relatively **common cause of abnormal growth**.
- These children are usually short and underweight, i.e. their weight is on the same or a lower centile than their height.
- Inadequate nutrition **may be due to** insufficient food, restricted diets or poor appetite associated with a long-term illness, or from the increased nutritional requirement from a raised metabolic rate.

Chronic diseases

★ Weight deficit > height deficit

❖ **Celiac disease**:
- prevalence of up to 1% of children
- may have an insidious onset in children and lead to short stature (34% reported growth failure as the sole presenting sign)

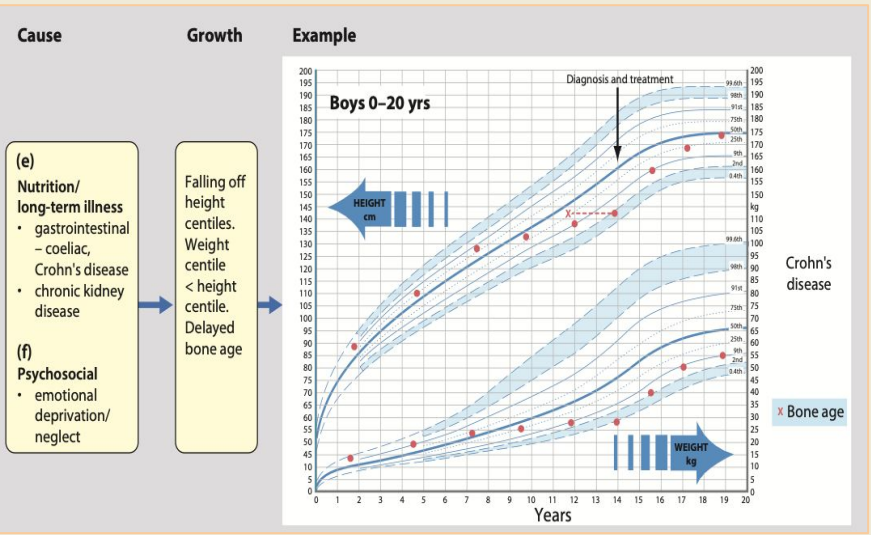
❖ **IBD**:
- in Crohn disease, 30% has growth failure (often reversible with optimal treatment)

❖ **Chronic kidney disease**
- may have growth failure as the presenting sign, which can be profound and multifactorial.

❖ **Childhood malignancies, pulmonary disease, and immunologic disease** are all associated with growth failure, **and therapies** with CNS radiation, chemotherapy, and corticosteroids can further contribute to growth deceleration.
- cystic fibrosis – malabsorption, recurrent infections, increased work of breathing, and reduced appetite
- congenital heart disease – increased work of breathing.

Cases of short stature

Chronic diseases



Chronic Illness Undernutrition

- Weight affected more than height
- Celiac disease
- Malabsorption
- Cystic fibrosis
- Renal failure
- Crohn's disease

- Child crosses the percentiles in both height and weight, but the weight was first. he was malnourished and that what affects their height.
- So, in this pattern the weight is more affected than height. The weight is first to be affected and the height after that.
- The differential diagnosis could include all GI diseases.

Psychosocial deprivation

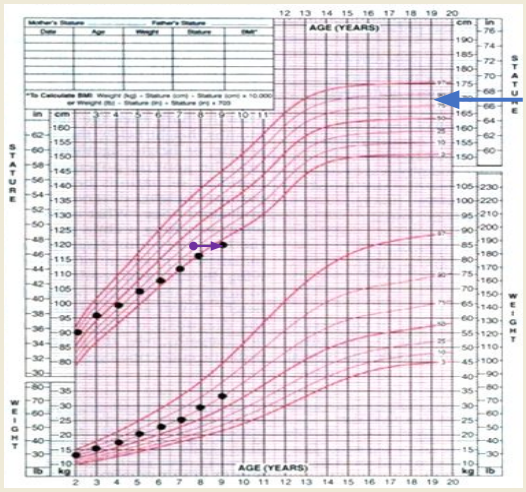
- Children subjected to **physical and emotional deprivation** may be short and underweight and show delayed puberty.
- This condition may be extremely difficult to identify, but affected children show catch-up growth if placed in a nurturing environment.

Case 5:

9-year-old healthy girl.
Parents are concerned about her stature (pre-pubertal on exam)

What's your diagnosis?

1. Celiac disease
2. GH deficiency
3. Constitutional short stature
4. Familial short stature
5. Genetic syndrome



MPH

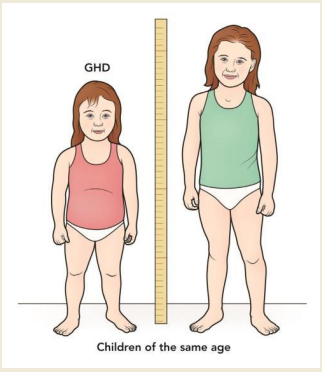
Cases of short stature

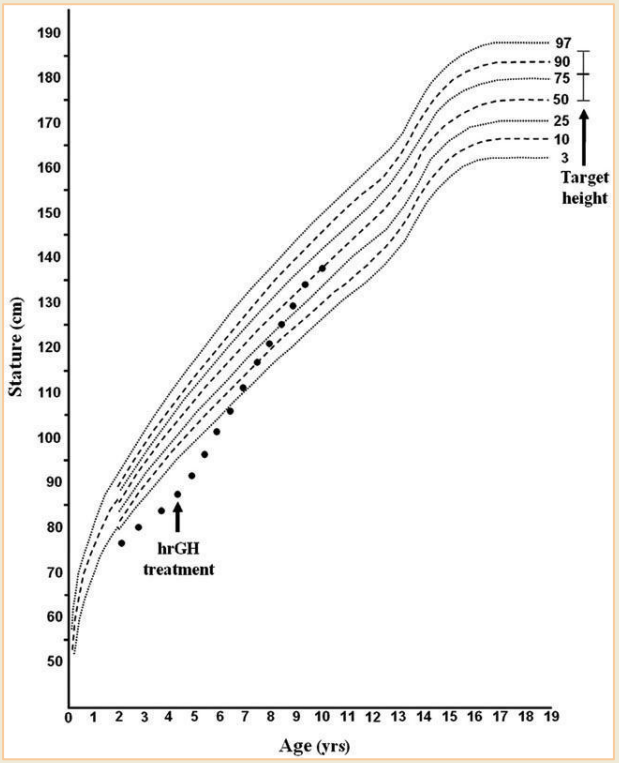
Endocrine causes of short stature

- **Hypothyroidism, GH deficiency, IGF-1 deficiency, and steroid excess** are uncommon causes of short stature.
- They are associated with **children being relatively overweight**, i.e. **their weight on a higher centile than their height**.
- By contrast, children with nutritional obesity tend to be relatively tall compared with midparental height range.

Growth Hormone Deficiency

- 70% patients - isolated hormone deficiency
- Congenital, acquired, or idiopathic
- Short stature and Poor growth
- Delayed bone age (delayed dentition)
- Mid-facial hypoplasia
    - “doll like” facies
- Increased skinfolds
- Small hands and feet
- Micropenis
- Hypoglycemia as neonate





- GH deficiency is treated with biosynthetic GH, which is given by subcutaneous injection, usually daily.
- It is expensive and the management of GH deficiency is undertaken at specialist centers.
- The best response is seen in children with the most severe hormone deficiency.
- **Other indications:**
    - **Turner syndrome**
    - **Prader–Willi syndrome**
    - **chronic kidney disease**
    - **SHOX deficiency**
    - **intrauterine growth restriction or small for gestational age with failure of catch-up growth.**
- **Recombinant IGF-1** has been used to treat children with GH resistance (e.g. Laron syndrome) and IGF-1 deficiency who would have previously not responded to GH treatment. Recombinant IGF-1 therapy is still very expensive and is confined to a few specialized centers

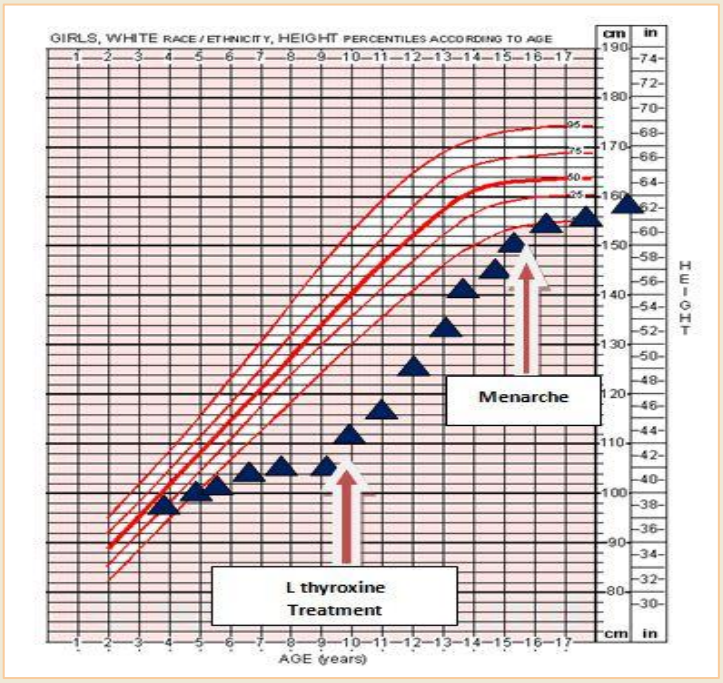
Cases of short stature

Growth Pearl about endocrine causes

- ❖ in endocrine disorders, **height is more affected** than weight
- ❖ Majority **bone age is delayed** (unless precocious puberty/Cushing's)

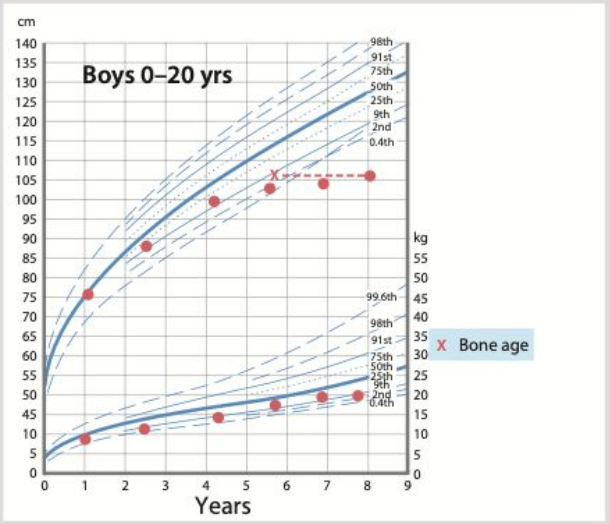
Hypothyroidism

- Delayed bone age
- Catch up growth with treatment
- usually caused by **autoimmune thyroiditis** during childhood.
- growth failure, usually with excess weight gain. It may go undiagnosed for many years and lead to short stature.
- When treated, catch-up growth rapidly occurs but often with a rapid entry into puberty that can limit final height.
- Congenital hypothyroidism is diagnosed soon after birth by neonatal biochemical screening and with treatment does not result in any abnormality of growth.



(d)
Endocrine
- hypothyroidism
- growth hormone deficiency
- steroid excess
  – iatrogenic
  – Cushing syndrome
- IGF-1 deficiency

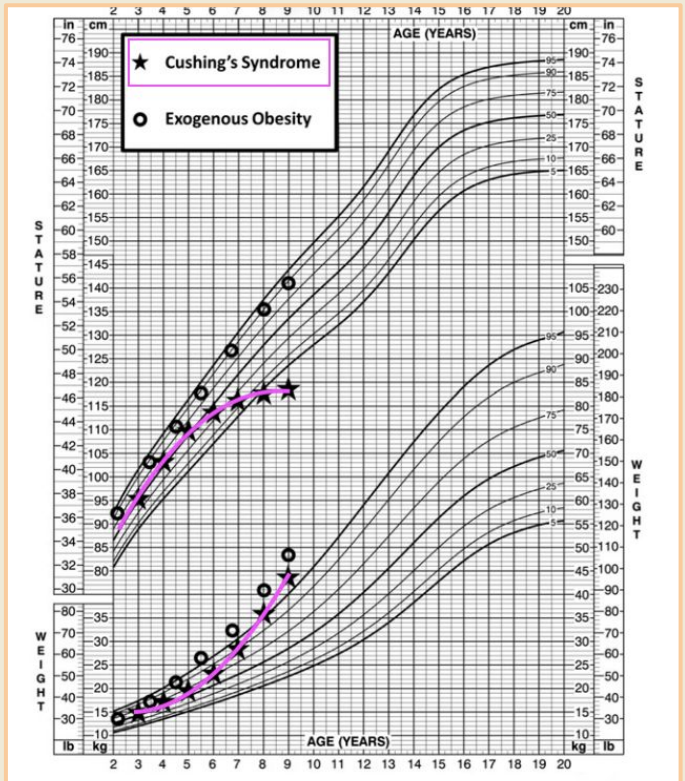
→ Falling off height centiles. Weight centile >height centile. i.e. short and overweight Markedly delayed bone age. →



Cases of short stature

Corticosteroid excess, Cushing syndrome

- This is usually **iatrogenic**, as corticosteroid therapy is a potent growth suppressor and several chronic conditions are treated with corticosteroids.
    - This effect is reduced by alternate day therapy, but some growth suppression may be seen even with relatively low doses of inhaled or topical steroids in susceptible individuals.
- **Non Iatrogenic Cushing syndrome** is **very rare** in childhood and may be caused by pituitary or adrenal pathology.
- Growth failure may be very severe, and is accompanied by excess weight gain, although normalization of body shape and height occurs on withdrawal of corticosteroid therapy or treatment of the underlying steroid excess.
- Cushing syndrome during puberty can result in permanent loss of height.



delay (★), precocious puberty (X), and familial short stature (o). B. Typical linear
obesity (O). Adapted from 2000 CDC growth charts for males ages 2 to 20 years. (2)

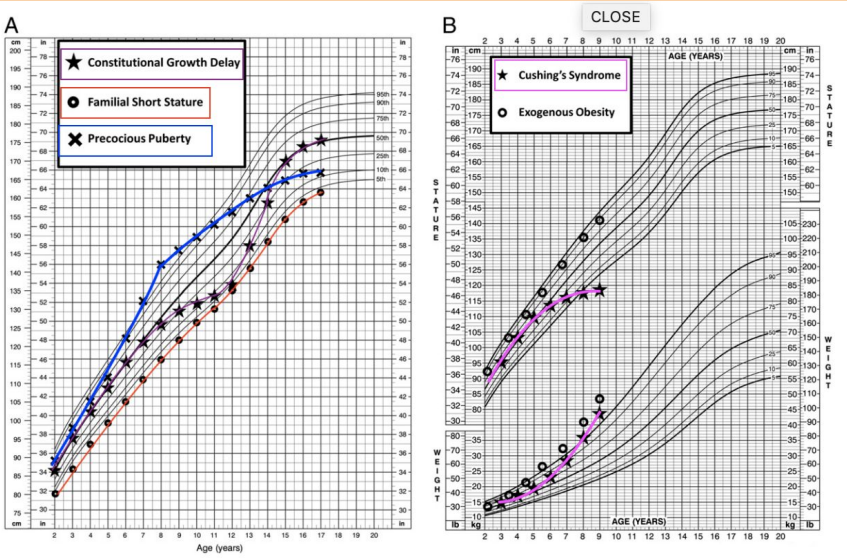


Figure 1. A. Typical linear growth pattern of a child with constitutional growth delay (★), precocious puberty (X), and familial short stature (o). B. Typical linear growth and weight pattern of a child with Cushing syndrome (★) and exogenous obesity (O). Adapted from 2000 CDC growth charts for males ages 2 to 20 years. (2)

Extreme short stature

- There are a few **rare conditions** that cause extreme short stature in children.
- **Idiopathic** short stature refers to short stature that does not have a **diagnostic explanation**.
- In addition, abnormalities in a gene called **short stature homeobox (SHOX) located on the X chromosome** lead to severe short stature with skeletal abnormalities when present on both copies of the gene.
    - Absence of one SHOX gene in Turner syndrome is thought to be the cause of short stature in this condition (and additional copies in Klinefelter syndrome produce taller than normal stature).
    - Polymorphisms in this gene probably account for a proportion of idiopathic short stature.

Disproportionate short stature

❖ This is confirmed by measuring:

sitting height – base of spine to top of head

subischial leg length – subtraction of sitting height from total height

limited radiographic skeletal survey to identify the skeletal abnormality.

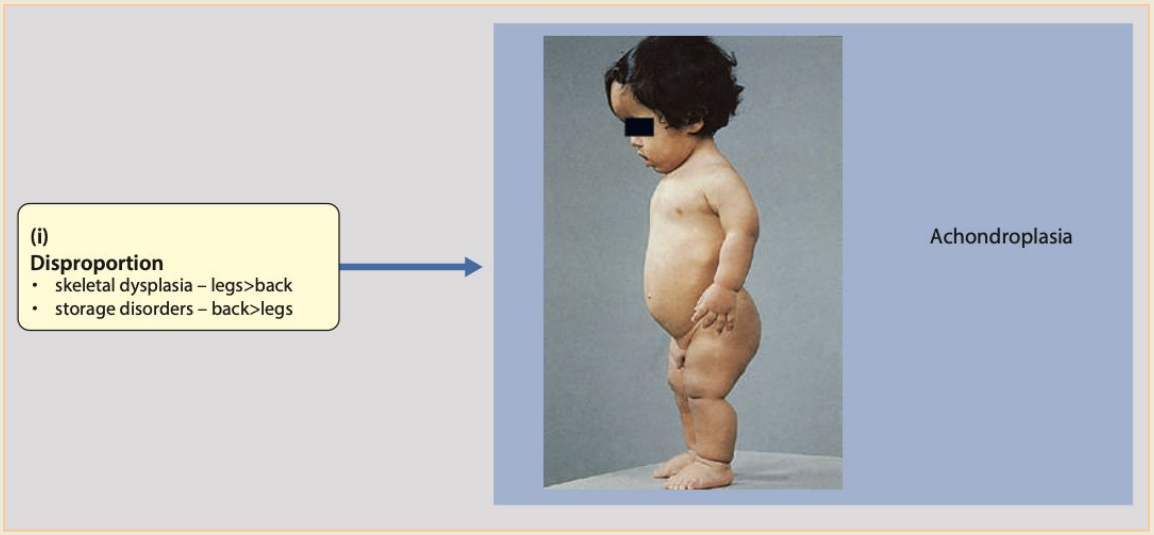
❖ Charts exist to assess the normality of body proportions.

❖ Conditions with **abnormal body proportions are rare** and may be caused by disorders of the **formation of bone (skeletal dysplasias).**

➢ They include achondroplasia and other short-limbed dysplasias.

➢ If the legs are extremely short, treatment by surgical leg lengthening may be appropriate.

➢ The back may be short from severe scoliosis or some storage disorders, such as the mucopolysaccharidoses.



Examination of the growth chart:

- Following growth centile lines for length/height, weight and head circumference?
- Consider familial, low birthweight, constitutional delay of growth and puberty, syndromes and skeletal dysplasias
- Faltering growth with crossing of centile lines?
  Consider endocrine (including therapeutic corticosteroids), nutrition/chronic illness, psychosocial deprivation

Determine the mid-parental height
- For genetic target range

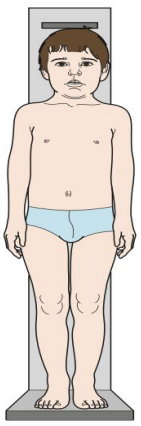
History

- Birth length, weight, head circumference and gestational age
- Pregnancy history: infection, intrauterine growth restriction, drug use, alcohol/smoking
- Feeding history
- Developmental milestones
- Family history of constitutional delay of growth and puberty or other diseases?
- Consanguinity pertaining to inherited conditions
- Features of chronic illness, endocrine causes, e.g. hypothyroidism, pituitary tumour, Cushing syndrome or psychosocial deprivation?
- Medications, e.g. corticosteroids?

Examination

- Dysmorphic features – chromosome/syndrome present? (But in Turner syndrome other stigmata may be absent)
- Chronic illness, e.g. Crohn's, cystic fibrosis, celiac disease?
- Evidence of endocrine causes?
- Disproportionate short stature from skeletal dysplasia?
- Pubertal stage?

Assessment of a child with short stature



Examination of the growth chart:
- Following growth centile lines for length/height, weight and head circumference?
  Consider familial, low birthweight, constitutional delay of growth and puberty, syndromes and skeletal dysplasias
- Faltering growth with crossing of centile lines?
  Consider endocrine (including therapeutic corticosteroids), nutrition/chronic illness, psychosocial deprivation

Determine the mid-parental height
- For genetic target range

History
- Birth length, weight, head circumference and gestational age
- Pregnancy history: infection, intrauterine growth restriction, drug use, alcohol/smoking
- Feeding history
- Developmental milestones
- Family history of constitutional delay of growth and puberty or other diseases?
- Consanguinity pertaining to inherited conditions
- Features of chronic illness, endocrine causes, e.g. hypothyroidism, pituitary tumour, Cushing syndrome or psychosocial deprivation?
- Medications, e.g. corticosteroids?

Examination
- Dysmorphic features – chromosome/syndrome present? (But in Turner syndrome other stigmata may be absent)
- Chronic illness, e.g. Crohn's, cystic fibrosis, coeliac disease?
- Evidence of endocrine causes?
- Disproportionate short stature from skeletal dysplasia?
- Pubertal stage?

Diagnosis
Cause can usually be determined from the above and no tests are required

EXTRA

Tall stature

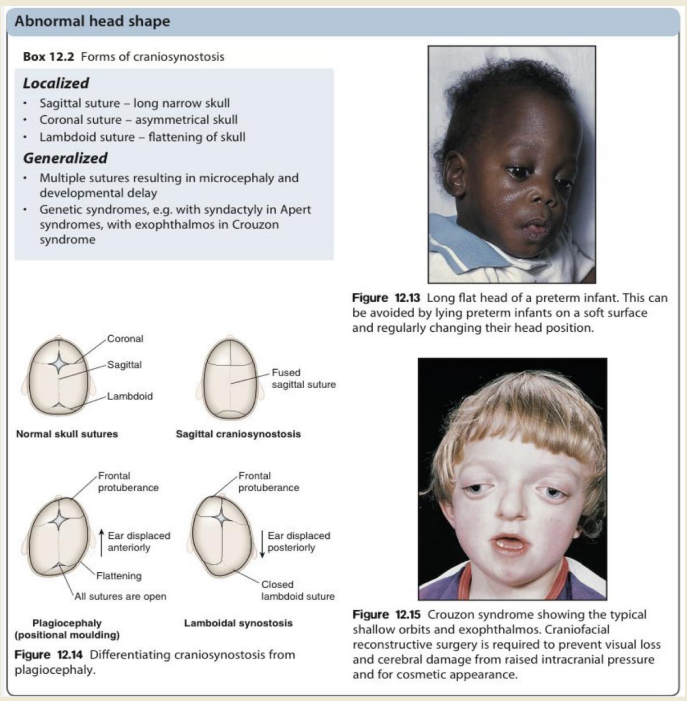
- Most tall stature inherited from tall parents
- Obesity causes tall stature in childhood but they will get their puberty earlier hence their final height doesn't increase
- In Marfan syndrome you need to screen for aortic root dilation

Causes of tall stature:

Genetic	Familial – most common cause Klinefelter syndrome (47,XXY karyotype) Marfan syndrome Homocystinuria Beckwith Wiedeman syndrome Sotos syndrome – associated with large head, characteristic facial features, and learning difficulties
Nutritional	Antenatal – maternal diabetes mellitus Obesity – puberty is advanced, so final height centile is less than in childhood
Hormonal	Hyperthyroidism Excess sex steroids – precocious puberty Excess adrenal androgen steroids – congenital adrenal hyperplasia Excess growth hormone secretion

Growth

- Most head growth occurs in the first 2 years of life and 80% of adult head size is achieved before the age of 5 years
- Sutures and fontanelle are open at birth. Posterior fontanelle normally closes by 8 weeks, and the anterior fontanelle by 12 months to 18 months
- Rapid increase in head circumference >> exclude increased intracranial pressure (hydrocephalus)(do US or CT scan)



Craniosynostosis: The condition can be treated surgically in specialist centres for craniofacial reconstructive surgery if there is raised intracranial pressure, or for cosmetic reasons

Box 12.1 Causes of a large head

- Familial macrocephaly
- Raised intracranial pressure (in an infant):
  - chronic subdural haematoma
  - brain tumour
  - neurofibromatosis
- Cerebral gigantism (Sotos syndrome)
- Central nervous system storage disorders, e.g. mucopolysaccharidosis (Hurler syndrome)

Questions

1- Janine, a 9-month-old female infant, is seen by her family doctor because of concern that she is not growing fast enough. She is only on the 5th centile for height and 2nd centile for weight.

What is the greatest influence on her growth rate
at her age?
Select one answer only.
A. Genes
B. Growth hormone
C. Nutrition
D. Oestrogen
E. Testosterone

2- Tom, a 7-year-old boy, is referred by his general practitioner with concerns about his growth. He is an adopted child and no details are available about his biological father although his biological mother was 'of average height'.
Physical examination reveals a happy and playful boy with no dysmorphic features. His height is 110 cm which is just below the 0.4th
centile. His weight is on the 0.4th centile.
He has a normal physical examination.
What is the most likely cause for his short stature?
Select one answer only.
A. Achondroplasia
B. Constitutional delay of growth and puberty
C. Familial short stature
D. Growth hormone deficiency
E. Vitamin D deficiency

3- Jake, a 5-year-old boy with Down syndrome has a check-up with his general practitioner. He is short but until 6 months ago was following
his growth centiles. You note that his height has dropped one centile line and his weight two centile lines. His mother reports that he has become very irritable and difficult to manage. On direct questioning, his appetite has deteriorated, with meal times becoming problematic.
From the following clinical scenarios **pick the investigation**
which is most likely lead to a correct diagnosis.
A. Bone age (wrist X-ray)
B. Coeliac screen
C. C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR)
D. Creatinine and electrolytes
E. Full blood count
D. Thyroid stimulating hormone (TSH)

Answers

1- **C.** Nutrition
Along with good health, happiness and thyroid hormones, infant growth (from birth to 12 months of age) is most dependent on good nutrition. Growth in the 1st year of life contributes about 15% to final adult height.

2- **C.** Familial short stature
Most short children have short parents and fall within the centile target range allowing for midparental height. Care needs to be taken, though, that both the child and a parent do not have an inherited growth disorder, such as a skeletal dysplasia.

3- **B.** Coeliac screen
Children with Down syndrome are at increased risk. He is also at increased risk of hypothyroidism, but his decreased appetite, irritability and weight loss are characteristic of coeliac disease.