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READY RECKONER FOR PAEDIATRIC PRACTICAL EXAM

MODULE 1 : GROWTH AND ANTHROPOMETRY

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METHODS OF ASSESSMENT OF GROWTH

A. Anthropometry
B. Bone age evaluation
C. Dental age assessment
D. Biochemical estimation
E. Histological method

A. ANTHROPOMETRY

The gold standard of nutritional assessment is anthropometry.
Simple, Cheap, Easy to learn and adapt, Noninvasive and Reliable

Equipment and Materials

1. Standard Growth charts
2. Weighing machines
3. Infantometer for length measurement
4. Stature meter or stadiometer for height measurement
5. Non - stretchable but flexible plastic tape
6. Harpenden skin fold caliper

Parameters

I. Weight
II. Length/Height
III. Weight for length/height
IV. Upper segment to Lower segment ratio
V. Head circumference
VI. Chest circumference
VII. Mid arm circumference
VIII. Skin-Fold thickness
IX. Arm span
X. Sexual maturity rating (SMR)

Age dependent criteria:

Weight, Height, Upper segment to lower segment ratio, Head circumference, Chest circumference, Arm span

Age Independent criteria:

Mid arm circumference, Skin fold thickness, Rao index, Dugdale index, Maclaren Index, Kanawati index, Bangle test, Shakir's tape, Quac stick.

Growth charts to assess child health

WHO 2006 growth chart
WHO 2006 and IAP 2015 combined growth chart

- Percentile distribution of observed value is plotted
- References are available for Weight for age, Height for age, Weight for Height Head circumference for age, BMI and waist circumference separately for boys and girls.
- Values < 3rd centile (- 2 SD) and > 97th centile (+ 2 SD) are abnormal.

WHO CLASSIFICATION OF MALNUTRITION

WHO has classified abnormal nutritional status of infants and children into:

1. OBESE

Weight-for-length/height or BMI-for-age > 3 standard deviations (SD) of the median

2. OVERWEIGHT

Weight-for-length/height or BMI-for-age > 2 SD and ≤ 3 SD of the median.

3. UNDERWEIGHT

- Moderately underweight - Weight-for-age <−2 SD and ≥−3 SD of the median
- Severely underweight - Weight-for-age <−3 SD of the median

4. ACUTE MALNUTRITION

- Moderate acute malnutrition- Weight-for-length/height or BMI-for-age ≤−2 SD and ≥−3 SD of the median, or mid-upper arm circumference ≥115 mm and <125 mm
- Severe acute malnutrition - Weight-for-length/height or BMI-for-age <− 3 SD of the median or mid-upper arm circumference <115 mm, or bilateral pitting oedema

5. STUNTING

- Moderately stunted (moderate chronic malnutrition)- Length/height-for-age ≤−2 SD and ≥−3 SD of the median
- Severely stunted (severe chronic malnutrition)- Length/height-for-age <−3 SD of the median

6. WASTING

- Moderately wasted- Weight-for-length/height ≤−2 SD and ≥−3 SD of the median
- Severely wasted- Weight-for-length/height <−3 SD of the median

NB:

Underweight ⏩ Acute Malnutrition

Stunting ⏩ Chronic Malnutrition

Wasting ⏩ Acute on Chronic malnutrition

I. WEIGHT

- **Types of weighing scales**
  1. Electronic weighing scale
  2. Beam type weighing scale
  3. Salter / Hanging scale

METHOD OF RECORDING THE WEIGHT:

- Weigh the child in bare minimum clothes and without shoes. Infants should be weighed naked (without diapers) and If a diaper is worn, its weight should be subtracted from the observed weight; because the reference data for infants is based on nude weight.

- Ensure that the scale is resting on a firm, stable, and even surface or uncarpeted floor. Check the zero of the scale before weighing.
- Ask them to stand in the center of the platform, with body weight evenly distributed on both feet. Ensure that the child is not holding on to anything
- Read the weight by standing in front of the scale and not from the side.
- Double weighing method – If the child is not cooperative, the parent can hold the child and the combined weight is recorded; afterwards weight of the parent may be subtracted.
- Normal Birth Weight – 2.5 kg to 4 kg

Low Birth weight (LBW)	- < 2500 gm (1500 – 2499g)
Very Low Birth Weight (VLBW)	- 1000 – 1499 gm
Extreme Low Birth Weight	(ELBW) - <1000 gm

- Average birth weight of normal Indian baby - 2800 gm (2.8 kg)

SGA (Small for gestational age)	- < 10th percentile
AGA (Appropriate for gestational age)	- between 10th and 90th centile
LGA (Large for gestational age)	- >90th percentile OR > 4000g

- **Weight increments in Infants & children**

A normal newborn loss 10% of the body weight in the first few days of life which is regained by day 10 of life.

Age group	Weight gain
Birth to 3 month	30 gms /day
3 mo to 6 month	20 gms/day
4 mo to 1yr	400 gms /month

WEECH'S FORMULA for expected weight for normal infants and children

Weight	Kilograms
3 – 12 months	$\frac{\text{Age (mo)} + 9}{2}$
1 – 6 years	Age (yr) X 2 + 8
7 – 12 years	$\frac{\text{Age (yr)} \times 7 - 5}{2}$

BIRTH WEIGHT	
Doubles by	5 months
Triples by	1 year
Quadruples by	2 years

INTERPRETATION OF WEIGHT

WEIGHT FOR AGE

1) IAP classification
2) Wellcome Trust classification
3) WHO classification

1. IAP (INDIAN ACADEMY OF PEDIATRICS) CLASSIFICATION

Grade of Nutrition	Weight for Age (% of expected*)
Normal	> 80%
Grade I	71 - 80%
Grade II	61- 70%
Grade III	51- 60%
Grade IV	£ 50%

Postfix “k” to the grade if the patient has nutritional edema

(*NCHS reference)

2. WELLCOME TRUST CLASSIFICATION

- **More than 80 % of expected weight* - Normal**
- **60 - 80 % of expected weight**

Without edema	Underweight
With edema	Kwashiorkor

- **Less than 60 % of expected weight**

Without edema	Marasmus
With edema	Marasmic kwashiorkor

* 50th percentile of Boston standard

3. WHO CLASSIFICATION

Refer Pg No :

NB :

- 1st percentile on growth chart is equivalent to – 3 SD from the mean.
- One SD for weight is 12.5% of the expected weight for the age

II. LENGTH / HEIGHT

Below the age of 2 yrs ⏩ **Length** ⏩ **Measured using Infantometer**

Above the age of 2 yrs ⏩ **Height** ⏩ **Measured using Stadiometer**

METHOD OF MEASURING LENGTH

1. Place the child on his back on clean length board of the infantometer (use a clean cloth to make the board comfortable)
2. Ensure that the head is in firm contact with the headboard
3. Position the head such that the child is looking straight up such that the line joining the external auditory meatus and the lower border of the eyeball is perpendicular to the board.
4. The shoulders and the spine should be in touch with the board and the knees should be gently straightened.
5. The footboard should be moved to ensure that the feet are firmly against it.
6. Measure the length in this position.

METHOD OF MEASURING HEIGHT

1. The child's footwear and any hair tie-up should be removed.
2. The child should stand on the height board with the back of the head, shoulders, buttocks, calves, and heels touching the vertical board/wall.
3. Position the head such that the child is looking straight ahead the line joining the external auditory meatus and the lower border of the eyeball (FRANKFURT PLANE) should be parallel to the floor)
4. With the child still in this position, the headboard is gently pulled down to rest firmly on the head.
5. Measure the height in this position.

Length/Height increments

Age	Length (cm)
At birth	48 - 50 cm
1-3mo	3cm/mo
4-6mo	2cm/mo
7-12mo	1.6cm/mo
13-24 mo	1cm/mo

2 to 12years **[Weech's formula]** ⏩ Ht. in cm = (Age in years x 6 +77)

Average Height Velocity

⏩ 25 cm/yr in first year

⏩ 4 – 6 cm/year in prepubertal children

⏩ 8 – 12 cm/year during puberty

Length/Height	
Birth	50 cm
3mo	60 cm
6mo	65 cm
9mo	70 cm
1 year	75 cm
2 years	87.5 cm
4 years	100 cm
4 1/2 yrs to 10yrs	6 cm/year

Length/Height
- Doubles at 4 yrs
- Triples at 12yrs

INTERPRETATION OF LENGTH/HEIGHT

HEIGHT FOR AGE :

1. WATERLOW'S CLASSIFICATION

Degree of stunting	Height for age (% of expected)*
Nil	>95
I	90-95
II	85-89
III	<85
*50th centile NCHS	

2. WHO CLASSIFICATION

Refer page no:

NB :
- **Short stature** ≤ 3rd centile / ≤ **−2 SD**
- **Tall stature** ≥ 97th centile / ≥ **+ 2SD**

- One SD for height is 4 % of the expected normal value for the age.
  Eg: A 4-year-old child whose height is less than 92 cm has short stature

CAUSES OF SHORT STATURE :

Physiological – Familial, Constitutional
Pathological – Undernutrition, Chronic systemic illness (cerebral palsy, congenital heart disease, cystic fibrosis, malabsorption, chronic renal failure), Endocrine causes (growth hormone deficiency, hypothyroidism, cushing syndrome, pseudohypoparathyroidism, delayed puberty), Psychosocial dwarfism, Skeletal dysplasia, Genetic syndrome (Down, Turner)

CAUSES OF TALL STATURE:
Familial, Obesity, Syndromes (Klinefelter, Marfan, Soto), Endocrine (Growth hormone excess, Hyperthyroidism, Precocious puberty)

III. WEIGHT FOR LENGTH/HEIGHT (WASTING)

CALCULATING WEIGHT FOR LENGTH/HEIGHT

$$\frac{\text{(WEIGHT OF THE CHILD)}}{\text{(EXPECTED WEIGHT OF A CHILD WITH SAME HEIGHT)}} \times 100$$

Eg-
1 year old girl with 6 kg and 60 cm

STEPS:

1. Keep measured weight of the child as numerator
2. Calculate the height age
3. Find the 50th percentile weight for height age (denominator)

So in this scenario,
Measured weight = 6 kg
Height age for 60 cm = 3 months
50th percentile weight for 3 months = 6 kg

So weight for length / height = $\frac{6}{6} \times 100 = 100$

Hence in this scenario, even though the child's weight and length is below 3 rd centile (underweight & stunted), there is no wasting.

1. WATERLOW'S CLASSIFICATION

Weight for height	Grade of wasting
>110%	Overweight
Normal	90 – 110%
I0 wasting	80 – 90%
II0 wasting	70 – 80%
III0 wasting	< 70%

2. WHO CLASSIFICATION

Refer Page No :

IV. UPPER SEGMENT TO LOWER SEGMENT RATIO

- Short stature (Ht for age <-2 SD) can be proportionate or disproportionate. The proportionality is assessed by the upper segment (US): lower segment ratio.

- LS can be measured by taking the length from the upper border of the pubic symphysis to the ground while the child stands erect. US can be obtained by subtracting the LS from height.

- Alternatively, the child is made to sit on a square stool against the stadiometer's vertical rod. The headboard is brought down to the vertex, similarly to taking height. The height of the stool is subtracted from the reading to get the sitting height. LS can be obtained by subtracting the US from height.

Normal US : LS ratio :

At Birth	1.7:1
6mo	1.6:1
1 yr	1.5:1
2yrs	1.4:1
3yrs	1.3:1
4yrs	1.2:1
7-10 years	1:1
Adult	0.9 : 1

NB:

- Increased US : LS ratio (Infantile for age / Short limb dwarfism) – Precocious puberty, Achondroplasia, Hypothyroidism, Chondrodystrophy

- Decreased US : LS ratio (Advanced for age/ Short trunk dwarfism) – Mucopolysaccharidoses, Hypogonadism, Spondyloepiphyseal dysplasia

MID PARENTAL HEIGHT (MPH)

Reveals whether the child's linear growth is in accordance with parental height
To differentiate between genetic and pathologic causes of short and tall stature.

$$\text{MPH Boys (cm)} = \frac{(\text{Mothers Ht} + \text{Fathers Ht}) + 13}{2}$$

$$\text{MPH Girls (cm)} = \frac{(\text{Fathers Ht} + \text{Mothers Ht}) - 13}{2}$$

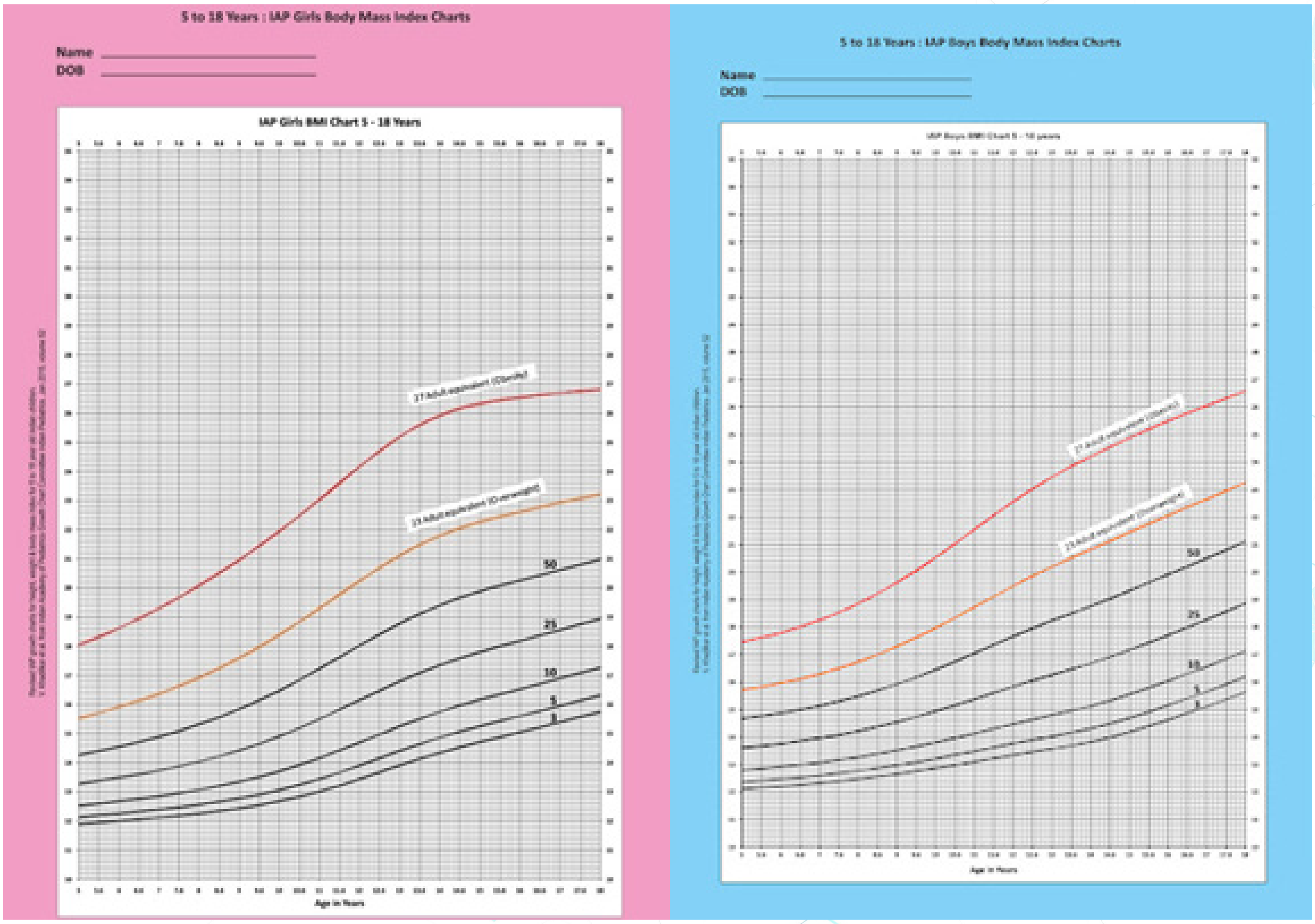
TARGET HEIGHT

It is marked as 6 cm above and below the MPH. It denotes the range of predicted adult height.

(Various textbooks states values between 6 cm to 8.5 cm for target height. But keeping the range narrow, ie; ± 6 cm improve the chances of identification and evaluation of short stature)

BODY MASS INDEX

Weight in kg / Height in m2



NB :

3rd centile – 23rd adult equivalent - Normal

> **23rd** adult equivalent – **Overweight**

> **27th** adult equivalent – **Obesity**

PONDERAL INDEX (PI)

Ponderal index is calculated in SGA babies, by the following formula

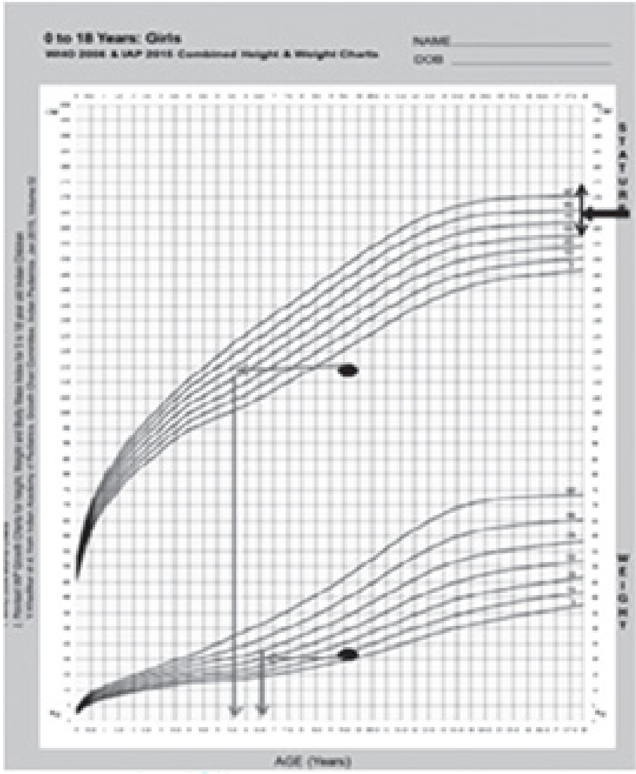
$$\textbf{PI} = \frac{\text{(WEIGHT IN GRAMS)}}{\text{([LENGTH IN CM]3)}}$$

> 2 - Symmetric IUGR

<2 - Asymmetric IUGR

CALCULATION OF HEIGHT AGE AND WEIGHT AGE

The appropriate anthropometric measurement is plotted on the corresponding growth chart. A line is drawn horizontally from the plotted point to the 50th percentile line and then vertically downwards from the 50th percentile line to touch the X-axis which is the corresponding height age and weight age as depicted in the figure.



a. CA = HA = WA : Normal child

b. CA > HA > WA : Malnutrition / Chronic illness

c. CA > WA > HA : Endocrine disease

d. HA > WA > CA : Precocious puberty

e. WA > CA > HA : Endocrine Obesity

f. WA > HA > CA : Nutritional Obesity

V. HEAD CIRCUMFERENCE

- Head circumference: Hair ornaments are removed and braids undone. Using a non-stretchable tape, the maximum circumference of the head from the occipital protuberance to the supraorbital ridges on the forehead is recorded.

- Average head circumference of a term healthy newborn at birth is 35 cm (Normal range 33 cm – 38 cm)

INCREASE IN HEAD CIRCUMFERENCE FROM BIRTH TO 1 YEAR OF AGE

Age	Rate
0 - 3 mo	2 cm/mo
3 - 6 mo	1 cm/mo
6 – 12 mo	0.5 cm/mo
2nd year	2 cm /year
>2 year	0.5 cm/year till the adult value of 54-56 is attained

DINE'S FORMULA

- It is applicable in children upto 400 days of life.
- To express the relationship between length and head circumference

DINE'S FORMULA

$$\frac{\text{LENGTH}}{2} + 9.5 \pm 2.5$$

INTERPRETATION OF HEAD CIRCUMFERENCE

Microcephaly < 3rd percentile / < - 2 SD
(< - 3 SD ⏩ Severe Microcephaly)

(NB: There is no standardized definition for microcephaly. Some textbooks defines microcephaly as HC < - 3 SD)

Macrocephaly > 97th percentile / > +2 SD

One S.D = 2.5% of expected value

CAUSES OF MICROCEPHALY

Trisomies- (21,18,13), Syndromes (William, Cri-du-chat, Seckel, Angelman), Neural tube defects (Anencephaly, Holoprosencephaly), Lissencephaly.
Metabolic disorders (Phenylketonuria), Maternal TORCH infection, Meningitis.
Teratogen (Alcohol, Tobacco, Anticonvulsants)
Endocrine (Hypothyroidism, Hypopituitarism, Adrenal insufficiency)

CAUSES OF MACROCEPHALY

Benign familial megalencephaly, Neurocutaneous syndromes (Neurofibromatosis, Tuberous sclerosis, Sturge-Weber syndrome)
Leukodystrophies (Alexander, Canavan)
Lysosomal storage disease (Tay-sachs,Mucopolysaccharidosis)
Fragile-X-syndrome,Hydrocephalus, AV malformation, Bone disease (Achondroplasia, Osteogenesis imperfecta)
Intracranial mass (cyst,abscess), Raised ICT (pseudotumor cerebri, lead poisoning.

VI. CHEST CIRCUMFERENCE (CC)

The chest circumference is measured at the level of the nipples, midway between inspiration and expiration.

At birth	CC 3 cm less than HC
9m – 1 yr	CC equals HC
After 1 yr	CC > HC

Catch up growth

In a preterm baby we use corrected chronological age for some time to give them time for catch up growth.

Expected time for catch up growth

Head circumference	by 18 months
Weight	by 24 months
Height	by 40 months

VII. MID ARM CIRCUMFERENCE (MAC)

To measure the mid arm circumference (MAC), first mark a point midway between the tip of the acromion process of the scapula and the olecranon of the ulna on the left side. Take the measurement while the child keeps the arm by his side, straight at the elbow. Ensure the tape is tight enough to avoid any gap and compression of soft tissues.

- Age independent anthropometric parameter.
- Relatively constant between 6 months - 5yrs (normal range is 15 – 17cm)
  (As a child moves from infancy to toddlerhood, their body composition changes in a way that the adipose tissue is replaced by muscle mass which balance each other so that the mid arm circumference remains fairly constant)

1. ARNOLD'S CLASSIFICATION

ARNOLD'S CLASSIFICATION	
No PEM	> 13.5 cm
Mild - Moderate PEM	12.5 – 13.5 cm
Severe PEM	< 12.5 cm

2. WHO CLASSIFICATION

WHO CLASSIFICATION

MAC 11.5 – 12.5 cm- Moderate Acute Malnutrition (MAM)

MAC < 11.5 cm - Severe Acute Malnutrition (SAM)

3. SHAKIR TAPE

GREEN	– > 12.5	– NORMAL
YELLOW	– 11.5 – 12.5 CM	– MODERATE MALNUTRITION
RED	– <11.5 CM- RED	– SEVERE MALNUTRITION

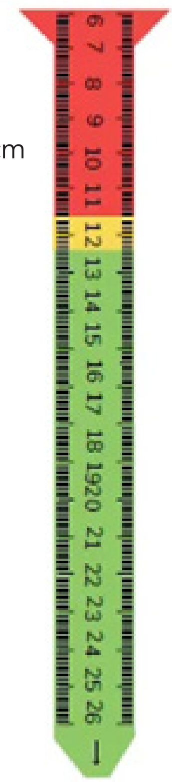
SHAKIR TAPE METHOD

New (WHO)

Green = MUAC > 12.5 cm

Yellow = MUAC 11.5 - 12.5 cm

Red = MUAC < 11.5 cm



● BANGLE TEST

Simple, community-based screening method for malnutrition that uses a 4-centimeter diameter bangle or bracelet to estimate a child's Mid-Upper Arm Circumference (MUAC). If the bangle can be slipped up and over the child's elbow, it suggests a reduced arm circumference and potential malnutrition.

● QUAC STICK

The MAC expected for a specific height can be calculated using this method.

>80 % of expected	– normal
70 – 80 %	– borderline malnutrition
<70 %	– Malnutrition

VIII. SKIN-FOLD THICKNESS

- Not done in routine clinical examination
- To be done when PEM is suspected
- Measured using Harpenden calipers over triceps on mid left arm (arm hanging loose by the side)
- 11 mm or more is normal

IX. ARM SPAN

- For measuring arm span, the child is asked to stand straight with both arms extended outwards parallel to the ground. The length between the tips of the middle finger of the outstretched hands is the arm span.

< 5 yrs	arm span 2cm less than the height
5 -10 years	arm span 1 cm less than the height
10 – 11 years	arm span = height
Adults	arm span 1cm more than the height

Eg : Increased arm span seen in Marfan syndrome, Homocystinuria

X. SEXUAL MATURITY RATING

TANNER STAGING - SMR IN BOYS

SMR Stage	Pubic hair	Penis	Testes
1	None	Preadolescent	Preadolescent Length<2.5cm
2	Scanty, long, slightly pigmented at the base of penis	Slight enlargement	Enlarged scrotum, pink, texture altered Length >2.5cm
3	Darker, starts to curl, small amount	Longer	Larger Length 3.3-4cm
4	Resembles adult type, but less in quantity, coarse, curly	Longer, glands and breadth increase in size	Larger, scrotum dark Length 4-4.5cm
5	Adult distribution spreads to medial surface of thighs	Adult size	Adult size Length >4.5

TANNER STAGING - SMR IN GIRLS

SMR STAGE	PUBLIC STAGE	BREASTS
1	Preadolescent	Preadolescent
2	Sparse, lightly pigmented, straight, medial border of labia	Breast and papilla elevated as small mound, areola diameter increased
3	Darker, beginning to curl, increased amount over mons	Breast and areola enlarged, no contour separation
4	Coarse, curly, abundant but amount less than in adult	Areola and papilla form secondary mound, contour of breast well defined
5	Adult feminine triangle, spread to medial surface of thighs	Mature, nipple projects, areola recedes into general contour

B. BONE AGE

- Bone age is typically assessed on the radiograph of left hand and wrist using

1. Atlases (Greulich and Pyle or Tanner and Whitehouse)
2. Software - BoneXpert.

NB: In newborns we use Xray of lower end of femur.

Relationship between height age (HA), bone age (BA) and chronological age (CA)

HA = BA < CA ⏩ CONSTITUTIONAL SHORT STATURE
HA < BA = CA ⏩ FAMILIAL
BA < HA < CA ⏩ GH DEFICIENCY
BA > HA < CA ⏩ PRECOCIOUS PUBERTY, CUSHING SYNDROME

C. DENTAL AGE

PRIMARY DENTITION:

- Temporary teeth (primary teeth) 20 in number
- Starts at 5 – 8 mo and is complete before 30 mo of age
  (8 by 1 year, 16 by 2 years, 20 by 2.5 years)
- No of primary teeth = Age in months - 6 (for age more than 1 year)
- Delayed dental eruption ⏩ no eruption by 13 mo of age

PERMANENT DENTITION:

- **SEQUENCE**

Central Incisor and Lateral Incisor	– 6 – 9 years
Canine	– 9 – 12 years
Pre-molars	– 10 – 12 years
1st molar	– 6 years
2nd molar	– 12 years
3rd molar	– 18 years

FREQUENTLY ASKED QUESTIONS

1. How does WHO classify nutritional status of infants and children?
2. What is the range of normal birth weight? How is low birth weight classified?
3. Explain increment in weight from birth to the age of 1 year.
4. What is Weech's formula for calculating expected weight of infants and children?
5. Name 3 classifications of malnutrition based on weight for age. Explain each one of them?
6. Describe the procedure for measuring length and height
7. What is the average height velocity of pre-pubertal and pubertal age group?
8. Explain degrees of stunting based on Waterlow's classification?
9. How does WHO classify stunting?
10. What is short stature & tall stature?
11. Explain the increment in head circumference from birth up to the age of 1 year
12. What is Dine's formula for calculation of head circumference?
13. Define microcephaly and macrocephaly
14. Describe the procedure for measuring MAC (mid arm circumference)
15. Explain Arnold's classification of malnutrition based on MAC
16. What is the difference between MAM and SAM?
17. How do you calculate weight for length/height using a growth chart? What is Waterlow's classification of wasting?
18. How does WHO classify wasting?
19. How do you measure upper segment to lower segment ratio? What is the importance of this in a child with short stature?
20. What is the relation between chest circumference and head circumference?
21. What is the relation between arm span and height?

22. How do you calculate mid parental height?
23. What is target height?
24. How does IAP classify malnutrition based on BMI?
25. How do you calculate height age and weight age using growth chart?
26. What is the sequence of permanent dentition?
27. Which radiograph is used for assessing bone age in a child? Name atlases used.
28. Explain Tanner staging for SMR in boys and girls.
29. Name conditions associated with short stature and tall stature
30. Enumerate causes of microcephaly and macrocephaly

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