TUTORIAL 2

ANTHROPOMETRY AND NUTRITION

OVERALL OBJECTIVES

At the end of this module the student should be able to:

a) Take a dietary history and growth history of children
b) Use growth parameters to assess nutritional status (normal or abnormal)
c) Describe the clinical features of malnutrition
d) Recognise by appropriate history taking and examination, common and life threatening complications of nutritional deficiencies in infants and children and investigate and manage these complications.
e) Use and impart the significance of Road to Health Booklet to parents.

ANTHROPOMETRIC MEASUREMENTS

A normal distribution pattern for weight, length and head circumference has been established for every month of age in the first 2 years of life and for every 2 months untill the age of 12 years. This was done by measuring hundreds of normal children in each group. From the above range of normal measurement Z-score charts have been developed for weight, length/height, BMI and head circumference.

Weight:

The most rapid period of growth after intrauterine period is during the first 2 years of life. Average birth weight doubles by 5-6 months and tripples by 1 year. Ideally the weight of every child seen at the clinic or hospital should be plotted on a Z-score chart than trying to rely on memory. Weight is easy to measure than height and shows rapid changes. Remember that weight, but not height, can be lost therefore weight is considered to be a more sensitive measure. Idealy children should be undressed when weighed but light clothing need not to be removed and weighing scale should be checked regulary.

Average weight values at certain age groups

Age	Weight in Kg
Birth	3.5
5-6 months	7
1 Year	10
2 yrs	12

Formula to calculate an average weight from 1 year therefater: Age (in years) + 4 x 2 = Kg

For example: approximate weight of a 2 years old child: 2 + 4 x 2 = 12 kg

Length:

Length is measured by infantometer and height by stadiometer and it follows the similar pattern of weight.

Average length/height in certain age groups

Age	Length/height in cm
Birth	50
6 months	65
1 year	75
2 years	87
3 years	95
4 years	100

Approximate height of a child at the age of 4 years is considered as 100 cm and therafter every year should add 6 cm per year till the age of 15 years. For example a 5 years old child's estimated height will be calculated as follows: 100+6 = 106 cm

Head Circumference or Occipito-Frontal Circumference (OFC):

Head circumference is of importance as increase in head size is almost entirely dependent on brain growth. The most rapid period of brain growth is before birth and during the first into the second year of life. More brain growth occurs during the first year after birth than in the total period from 1 year of age untill addulthood. In fact most growth occurs during the first 6 months of life. If severe nutritional insult or prolonged illness occurs during this very vulnerable period "catch up" brain growth may be insufficient for the potential of that individual ever to be achieved. Measurement of OFC is also useful if some chronic brain abnormality or abnormal growth of head is suspected.

Average head circumference in certain age groups

Age	OFC in cm
Birth	35
3 months	40
6 months	44
1 year	47
2 years	50
5 yrs	52
Adult	56+

PHYSICAL GROWTH

Children grow, and if they don't, there is a problem. Their growth depends on *varuis factors*, the most important being the heriditary, genetic, environmental, emotional health, chronic diseases, endocrine and timing of puberty .

1. **Heriditary and constitutional factors:** this refers to the type of body build inherited from the parents. If both parents are small and short, the children are likely to be small whereas tall parents tend to have tall children. However, temperament, manifested as the behavioural style of the child, is influenced by child-rearing practices as well as by the continuous interaction between partents and children.

2. **Intrauterine period:** During intra-uterine life, maternal influences play an important part in the growth of the fetus. Foetal growth may be affected by maternal nutritional, socioeconomic status, habbits and medical problem.
3. **Postnatal period:** The major part of infancy is cheratcterized by a rapid growth rate, which becomes increasingly related to the genetic background. This period of rapid growth is largely determined by nutritional rather than endocrine factors.
4. **Nutrition:** Growth is profoundly affecetd by nutrition. Linear growth, expressed as length or height measurement, is a sensitive indicator of the physical health of a child.
5. **Health status:** physical health and emotional status of a child or of his family may have direct or indirect effect on his growth and development. Chronic illness often leads to disability.
6. **Socioeconomic status:** Poverty, poor education, and social adversity increases the possibility of having complications from pregnancy, birth, infancy and childhood.
7. **Cultural factors:** Child-rearing beliefs and practices vary markedly from one culture to another and have profound effect on growth and development of children.
8. **Environmental:** this includes our surroundings, and factors that can influence our life and growth. A diet which is poor in quantity or quality will prevent normal growth. This is what can often be detected on properly completed growth charts.

Poor health includes infections, as well as any serious disturbances of physiological function such as heart disease or severe congenital abnormalities. If the vital organs will not function properly, the child will not grow normally. Health and nutrition influence each other. In turn, unhealthy child may become malnourished and the poorly nourished child suffers with more frequent infections. Thus a serious cycle is set in motion, the one factor aggravating the other.

Sprcific factors may be affecting at specific age groups:

- Infancy (upto two years): Food, nutrition and chronic diseases
- Childhood: Genes, growth hormones and chronic diseases
- Puberty: Sex hormones

Types of growth charts

- Road-to-Health Booklet growth charts: contains Weight for age & Height for age
- Longitudinal growth charts: Percentile graphs & Z-Score graphs
- BMI charts
- Weight for length/height charts
- Growth velocity Charts
- Combined prenatal and postnatal growth charts
- Growth charts for special populations: Down syndrome, Turner syndroms
- WHO Anthro: for personal computers – software for assessning growth and developemnt of world's children. www.who.int/growth

Uses and advantages of growth charts

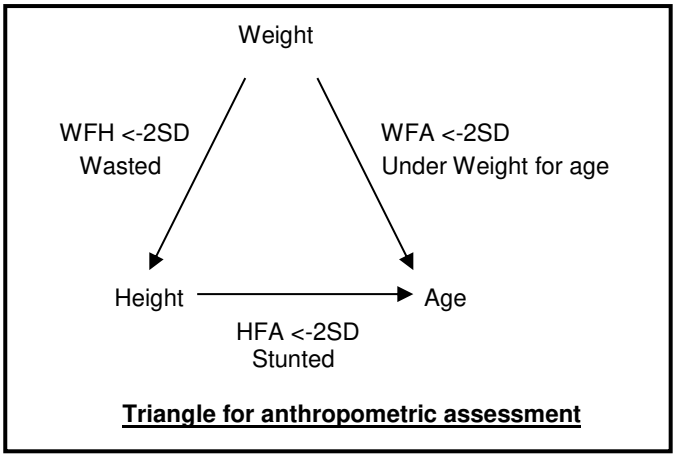
1. **To check whether the child falls into the normal range** for his age. Many children are found whose weight falls below -2SD line. They do not necessarily look ill or obviously malnourished. They are just small for their ages and if their weights were not plotted on growth charts, they would have not been noticed. These children are underweight for age (UFA) and represent the largest group of undernutrition. Steps must be taken to improve their nutrition because they are more likely to develop infections and obvious malnutrition.
2. **Recording growth repeatedly at intervals**, gives the most valuable information as to whether the rate of growth is satisfactory. The child's charted weight graph should run parallel to one of the normal growth lines given on the graph i.e parallel growth = good (normal) growth.

Z-SCORE GROWTH CHARTS

Measurement is the only way to recognise whether growth is normal or not. In order to record child's growth and physical development, special Z-Score growth charts are used in South Africa.

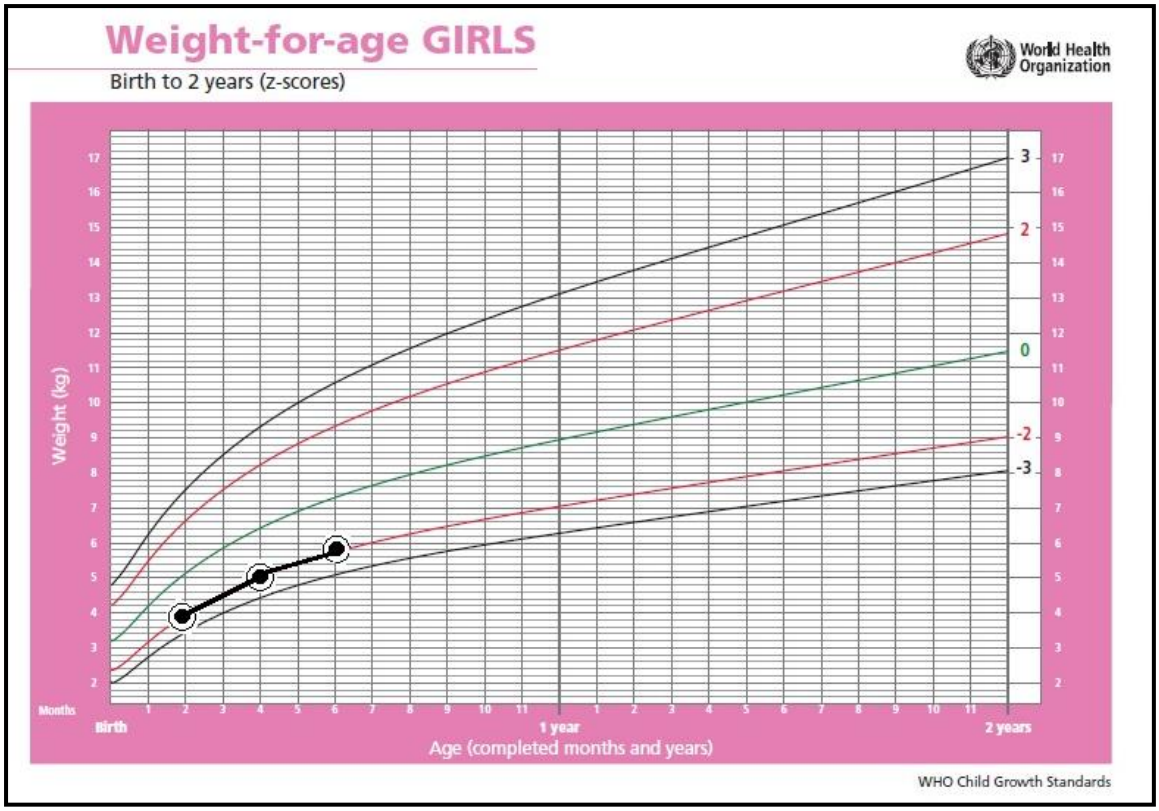
In a graph one factor is plotted against another but related factor e.g. wight for age, weight for height and height for age. Repeated observations are recorded at regular intervals. Following triangle for anthropometric measurements is helpful tool for plotting the variables on the growth charts.

- Weight for age (WFA Z score)
- Weight for height (WFH Z score)
- Height for age (HFA Z score)



Triangle for anthropometric assessment

Increasing age should be accompanied by increase in weight. Following graph shows this and the rate at which it occurs. Increase in weight by itself is not enough as the time period over which it occurred must also be taken into account.



Explanation of above graph:

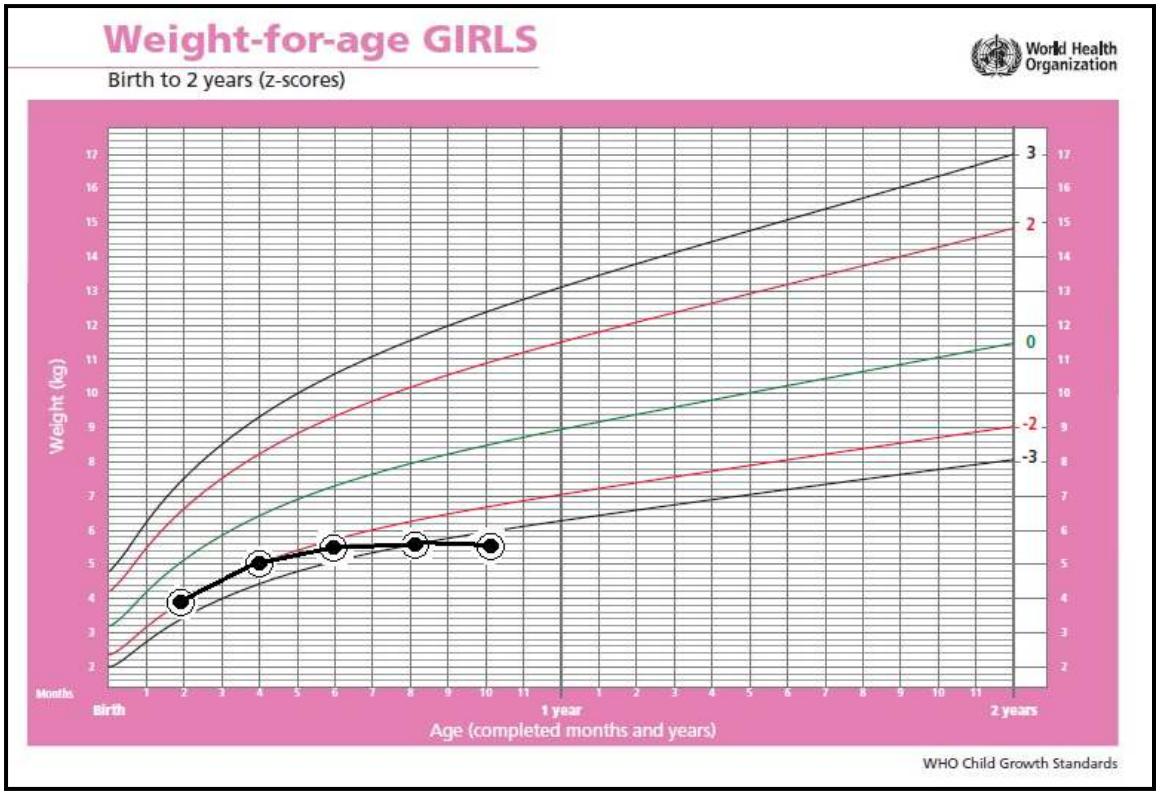
A graph is made indicating the baby's growth.
When seen at 2 months female baby is found to have a weight of 4kg. Following a straight line up from 2 months and across from 4 kg a point can be plotted.

At the age of 4 months the baby weighs 5 kg and at 6 months 6 kg. Find and mark these points on the graph and then join these points. In a similar way height and age or head circumference and age can be plotted.

Babies grow very rapidly in the first year of life. A normal infant should double its birth weight by 5-6 months and it should triple by the age of 1 year. In later childhood growth is generally slower but increases again markedly at puberty.

Human beings of any given age are not all the same size even though they may be perfectly normal and healthy. It can therefore not be said that a normal newborn should weigh 3.5 kg. There is always a range of normal and in this case, it is from 2.5 to 4 kg.

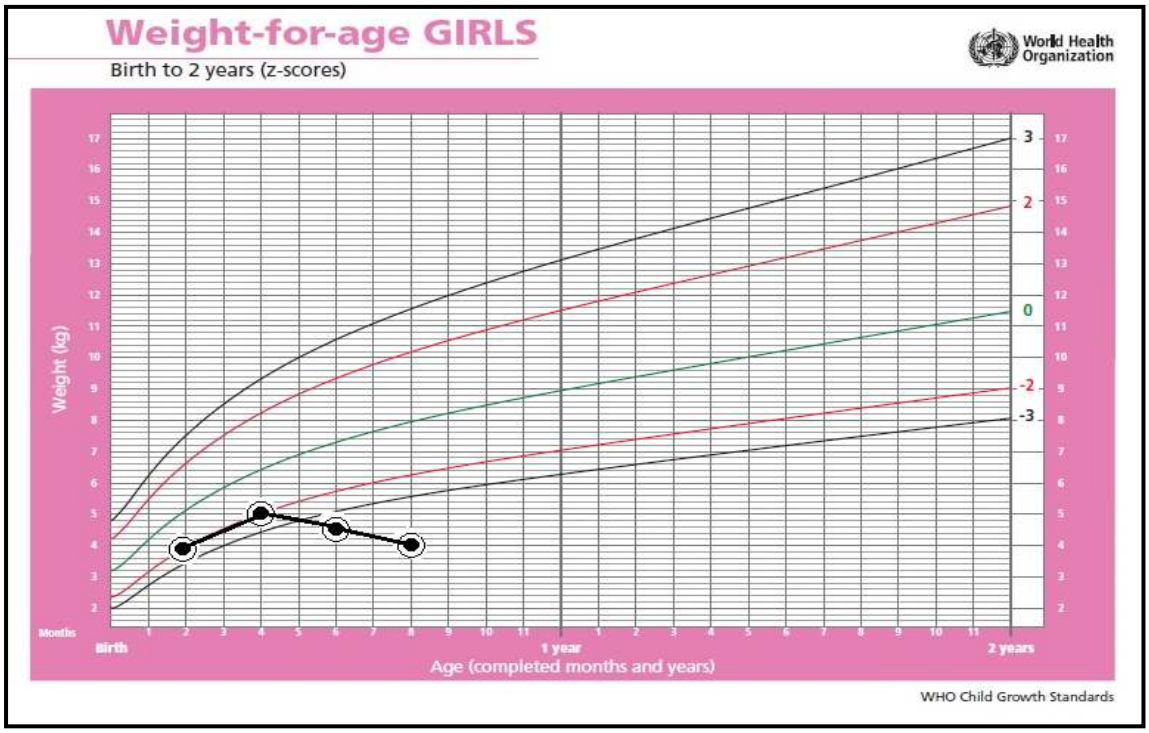
It is difficult to remember all these normal variations for all ages; therefore, growth charts are used with normal lines showing both the normal range and the rate of growth.



Graph above showing abnormal growth pattern

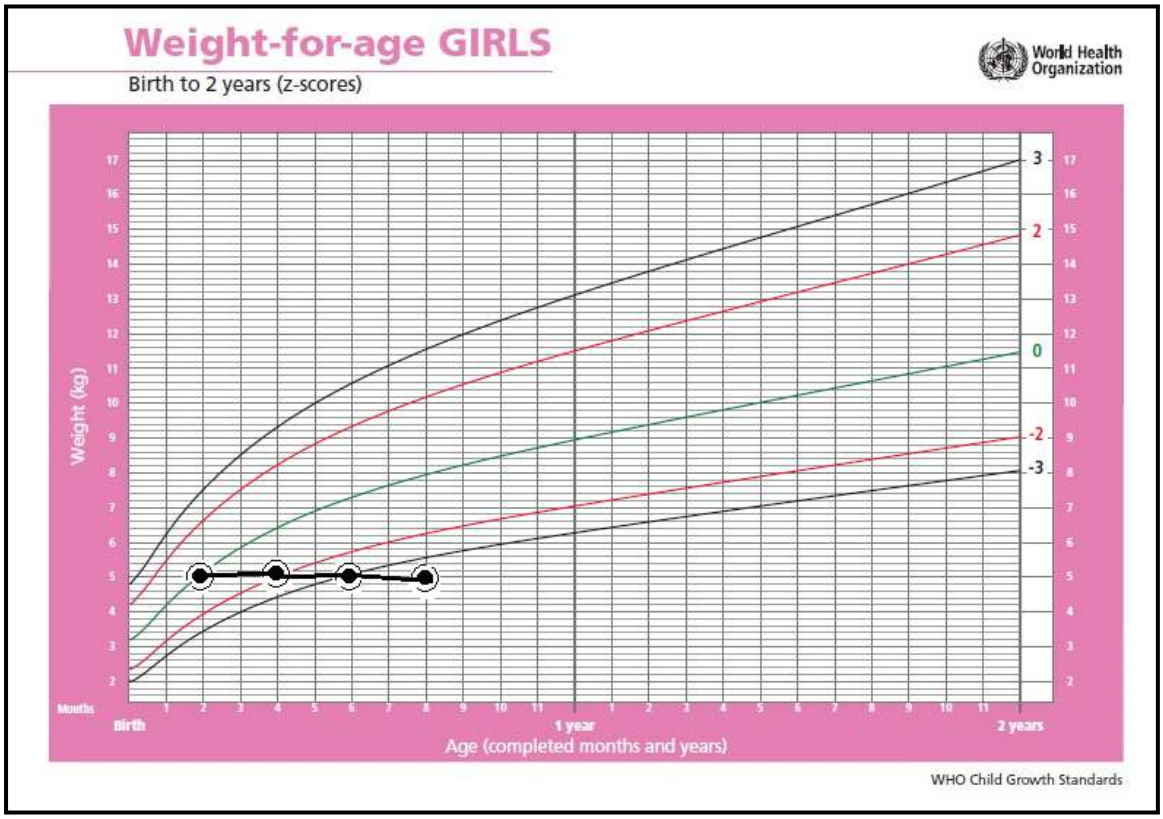
If a child was supposed to gained 1 kg over a certain period of time but has only gained ½ kg, this is slowing of growth, and is an early important sign of inpending malnutrition.

Following graph The example is the following graph



1. Abnormal growth pattern of weight loss

Graph above showing well-nourished infant showing loss of weight. The continued recording of weight at intervals is of far greater value than any single recording. Regular recording of weight will show progress the child is making, i.e., pattern of growth.



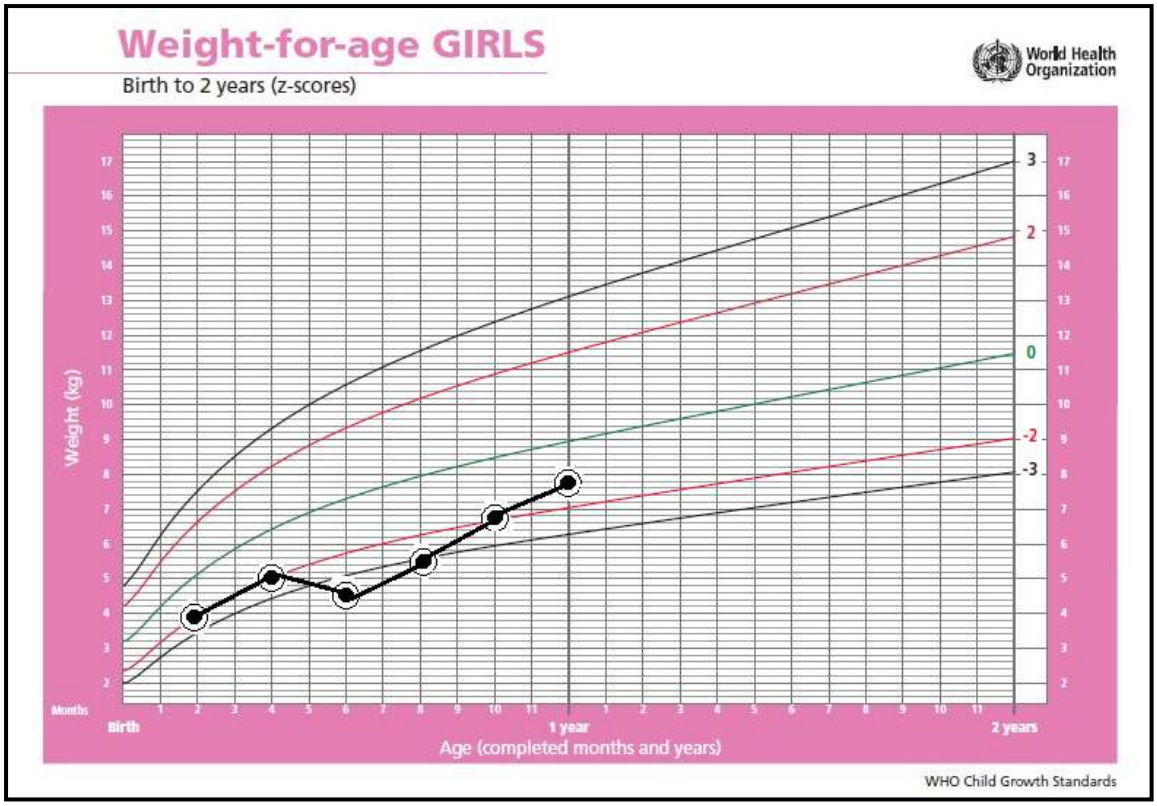
2. Abnormal growth pattern of poor weight gain

Graph above showing poor weight gain leading to malnutrition. Plotting once off on the weight chart may be misleading as it gives no indication of direction whereas repeated recordings give both the direction and adequacy of weight curve which is more important in assessing progress. Stopping breast feeding and giving only porridge may be seen as plotted in the above graph.

While most children with severe acute malnutrition (SAM) with oedema have weight for age below -2SD, fluid may falsely increase the weight. A gain of 500g due to fluid retention will however show as obvious oedema. Since SAM with oedema can develop rapidly, the child may still be within normal z-scores but will have deviated from his previous growth curve.

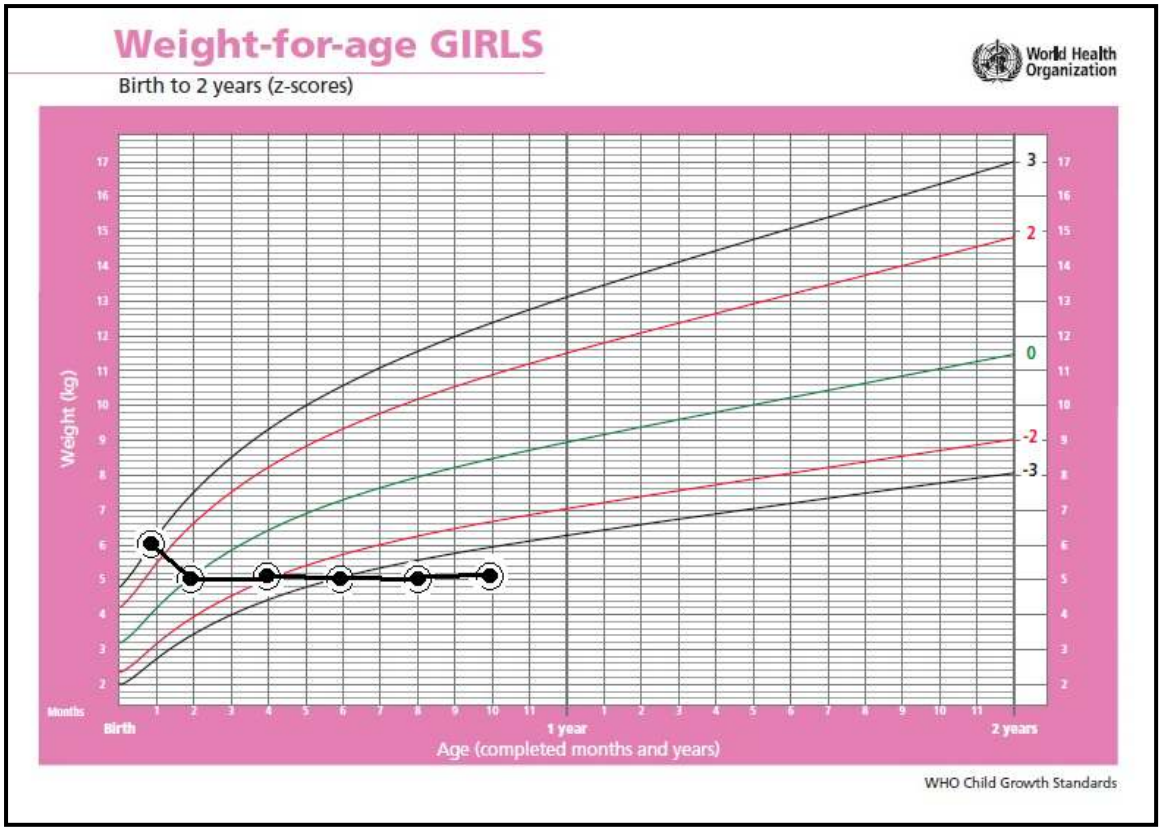
3. Infection and growth:

In babies who are weighed regularly and growth charts used, the frequent relationship between infection and poor growth is noted. Every time an infant suffers from gastro-enteritis, a respiratory tract infection and particulaly having measles, there will be weight loss. As poorly nourisehd children tend to get more frequent infections, so one problem leads to other. If recovery after an illness is satisfactory and complete, there should be a rapid regaining of the lost weight i.e. “catch up growth” so that the child continues again on his previous normal growth line.



Graph above indicates catch up growth

If this catch up growth doesn't occur, e.g. after measles, suspects some complication. In this case the probability of TB, which is common after or reactivated by measles. This can be picked up on the growth chart and early diagnosis or even permanent brain damage from TB meningitis.

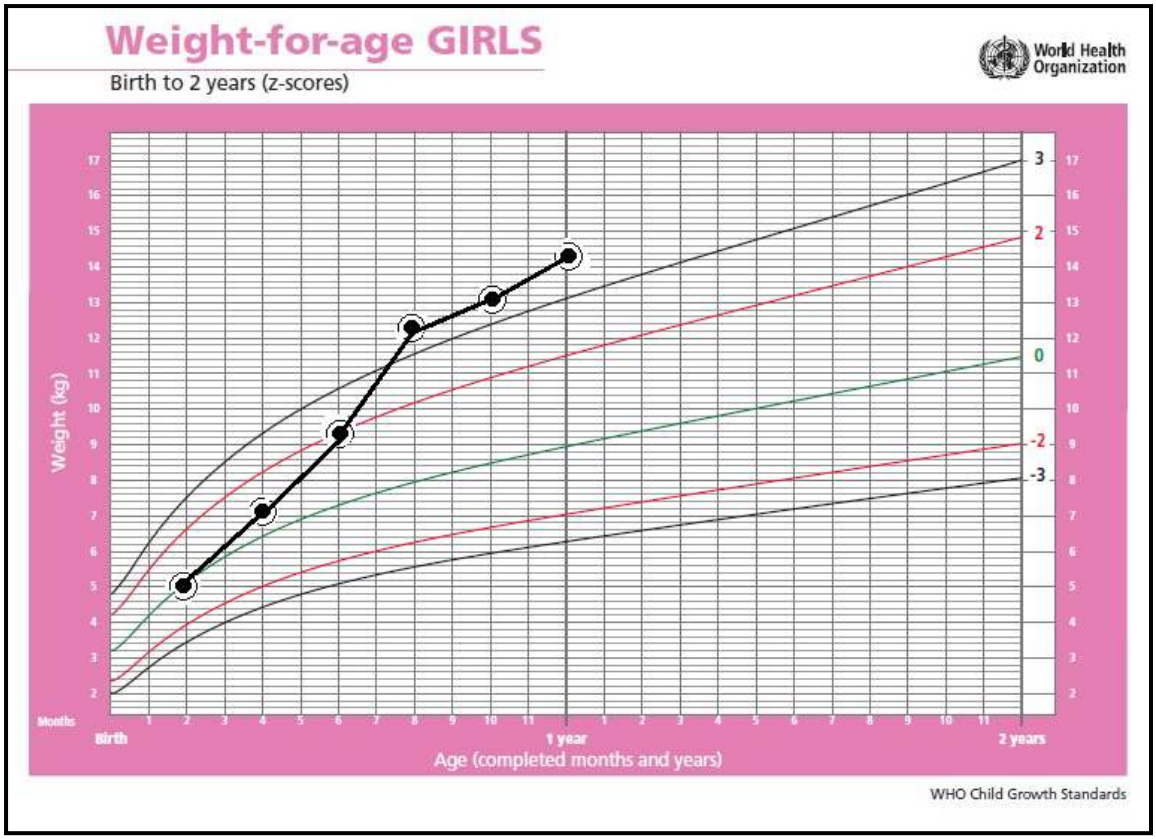


Graph above shows failure to regain weight and return to normal growth line.

If weight gain is inadequate, check for underlying disease, enquire about diet (type and frequency of feeds, and advise about food supplements). If above attempts to promote growth are unsuccessful – consider underlying infection or chronic illness.

4. Excessive growth

In infancy, particularly with artificial feeds and the early introduction of excessive amounts of cereals, a rapid and marked weight gain is undesirable and obesity may develop. This may persist into adult life causing problems such as hypertension, diabetes and cardiac disease and should be avoided.



Above graph growth shows pattern of excessive growth

NB! Standard Road to Health Booklets should be used for all babies wether rich or poor, state or private health care system. The same comprehensive record must be used to record not only growth but immunization, milestones of development, and other important information. Road to heath bookelt is an important document and parents should be encouraged to take it with them when they go for a clinic or a hospital visit.

In summary, the growth charts in road to health booklet can be used to;

- Determine and promote adequate growth
- Detect children at risk of malnutrition
- Introduce comprehensive health care to the family

In a busy clinic or POPD, can time be found for all this? Time must be found!

EXAMINATION OF A CHILD FOR ANTHROPOMETRIC ASSESSMENT

Look for obvious clinical features

- Child with visible severe wasting
- Child with generalised oedema
- Or is this is a chubby child

Measure the child's weight by relaible weighing scale

- Small infants with baby scale
- Older children with standard scale

Measure the child's

- Length: supine with infantometer while head position is in vertical Frankfurt plane
- Height: standing up with stadiometer while head position is in horizontal Frankfurt plane

Frankfurt plane: Frankfurt plane is an imaginary line from the center of the external auditary meatus to the lower border of the eye. It should be vertical in supine position and horizontal in standing position while measuring the length or heigth respectively.

Measure child's occipito-frontal circumference (OFC) with measuring tape. Plot the child's weight, height, and head circumference on the growth charts provided. Before plotting make sure that measurements do make sense to you and you have the correct growth charts in hand.
Separate growth charts are available for:

- VLBW infants (wt <1500g)
- Turners & Downs Syndromes
- Achondroplasia

Plotting

- Plot completed weeks, months, years on the vertical line not in between lines like 5½ month – plot at 5 months
- Plot length or height on or between horizontal lines precisely
- Judge if the plotted point seems sensible

Z score lines on growth charts are numbered:
Positively +1, +2, +3 or
Negatively -1, -2, -3

Plotted point that is far from Median in either direction i.e. close to +3 or -3 Z score, may represent growth problem, although other factors should be considered like:

- Growth pattern on road to health booklet i.e. acute drop in weight, plateau pattern or crossing of a Z score
- General health of the child
- Height and weight of parents in case of abnormality noted in child's anthropometry

Crossing a Z score line

- If child's line crosses a Z score line, it means there has been a significant change in the child's growth:
    - If shift is towards a higher median – it is possibly a good change
    - If shift is away from the median above – this signals a problem or a risk

Growth Patterns

- If child has been ill or severely undernourished, a sharp incline is expected during re-feeding period as the child experiences catch-up-growth. Otherwise sharp incline is not good which may indicate change in feeding practices, which may result in the child being overweight.

- If a child has gained weight rapidly, then look at the height. If there is no change in height then there may be a problem of overweight
- Flat growth line is called stagnation which indicates a problem
- For children in age groups where the growth rate is fast as shown by steep growth curves i.e. during 1st 6 months of life, even one month's stagnation in growth represents a problem.

BODY MASS INDEX

BMI is an index for classifying adiposity and is recommended as a screening tool for children and adolescents to determine wether an individual is overweight. Growth charts for ploting of BMI are also available.

Calculate BMI especially in children >5 years old as follows and plot on the growth charts:

BMI = Weight / Height^2

BMI	
Under weight	<18.5
Normal	18.5 – 24.9
Overweight	25 – 29.9
Obese	30 – 39.9
Morbid obese	≥40

MUAC

- MUAC is measured at a mid-point between acromion and olecranon
- Measurement is usually done every 3 months from 6 months of age
- If MUAC is <11.5 cm, child is classified as SAM and must be referred to a hospital for assessment & treatment
- If MUAC is 11.5 - <12.5 cm and child has no oedema, this indicates moderate acute malnutrition and child can be managed as an outpatient according to IMCI guidelines.

MUAC REFERENCE RANGE ACCORDING TO AGE (IMCI GUIDELINES)

Age of patient	< -3 Z score Sever acute malnutrition	< -2 Z score Moderate acute malnutrition
6 – 12 months	<11.0 cm	<12.0 cm
1 – 5 yrs	<11.0 cm	<13.0 cm
6 – 9 yrs	<13.5 cm	< 14.5 cm
10 – 14 yrs	<16.0 cm	< 18.5 cm

Classification of malnutrition according to WHO

WHO classification				
Assessment	**Weight for age**	**Weight for Height**	**MUAC**	**Other**
Moderate acute malnutrition	WFA Z score < -2 SD	WFH Z score < -2 SD	Yellow band 11– 12.5 cm	
Sever acute malnutrition	WFA Z score < -3SD	WFH Z score < -3 SD	Red band < 11 cm	Visible wasting or oedema of both feet
	Under wight for age (UWFA)	Wasting	Wasting	SAM with oedema

HEAD CIRCUMFERENCE

- Measure the OFC of your patient and plot it on the growth chart
- Comment as microcephaly (Z-score <2SD) or macrocephaly (Z-score >2 SD)
- Small OFC - parents may be of smaller head size (genetic heritage). Baby's brain may not be growing well during early crucial period of brain growth spurit that lasts until 2 yrs of age which can lead to microcephaly due to failure of brain development.
- OFC can be small in sever chronic malnutririon but increased in vitamin D deficiency

CAUSES OF MICROCEPHALY (Small head)

1. Trisomies 21, 13, 18
2. Intrauterine infections like TORCH, syphilis, HIV, varicella
3. Head injury, perinatal hypoxia, stroke
4. Post meningitis, encephalitis
5. Teratogens like radiations or alcohol (foetal alcohol syndrome)
6. Undernutrition or chronic illness (renal, cardiac, pulmonary disease)
7. Hypothyroidism or hypopituitarism
8. Agenesis of carpus callosum
9. Craniosynostosis totalis
10. Grey matter dx, White matter dx

CAUSES OF MACROCEPHALY (Big head)

1. Rickets (vitamin D deficiency)
2. Osteogenesis imperfecta
3. Galactosaemia
4. Leukodystrophy
5. Head injury, haematoma (NAI)
6. Infections
7. Perinatal infections like TORCH, syphilis, HIV
8. Post natal infections like meningitis, encephalitis
9. IVH, Stroke or intravascular haemorrhage
10. Tuberous sclerosis, Sturge Weber Syndrome

Organs which are obligate glucose users

- Brain
- Errythrocytes
- Cells of renal medulla

TYPES OF HYDROCEPHALUS WITH CAUSES

1. **Obstructive hydrocephalus**
   - Acqueduct stenosis
   - Spina bifida
   - Dandy-Walker malformation
   - Brain tumors
2. **Non-obstructive hydrocephalus**
   - Fibrosis secondary to haemorrhage
   - Brain malformations
   - Neurofibromatosis
   - Tuberous sclerosis
   - Papilloma of choroid plexus

ASSESSMENT OF ANTHROPOMETRY

- If the child has oedema or ascities it does not reflect the true weight so oedema and ascities need to be resolved for the assessment of true weight
- If stunted or wasted: interprete as a chronic problem
- If the weight and height are both normal look for other signs of chronic disease like clubbing and say even though anthropometry is normal, child still shows signs of chronic disease.

Now see the trend of growth in the Road to Health Booklet

- Common finding is poor weight gain
- Height of the child can be significantly small in:

1. Chronic disease
2. Hypothyroidism
3. Hypopituatarism
4. Chronic malnutrition
5. Zinc deficiency
6. Rickets
7. Achondroplasia

INTERPRET THE GOWTH PARAMETERS

Z-scores	Growth indicators			
	Length/height for age	**Weight for age**	**Weight for length/height**	**BMI for age**
Above 3	(See note 1)	(See note 2)	Obese	Obese
Above 2			Overeweigth	Overweight
Above 1			Possible risk of overeweight (See note 3)	Possible risk of overweight (See note 3)
0 (median)				
Below -1				
Below -2	Stunted (See note 4)	Underweight	Wasted	Wasted
Below -3	Severely stunted (See note 4)	Severly underweight (See note 5)	Severely wasted	Severely wasted

Notes:

1. A child at this range is very tall. Tallness is rarely a problem, unlessnit is so excessivetahtit may indicate an endocrine disorder such as growth hormone tumor. Refer a child in this range for assessment if you suspect an endocrine disorder (i.e. if parents of normal height have a child who is excessively tall for his or her age).
2. A child whose weight for age falls in this range may have a growth probplem, but this is better assessed from weight for length/height ot BMI for age.
3. A plotted point above 1 shows possible risk. A trend towards the 2 z-score line shows definite risk
4. It is possible for stunted or severely stunted child to become overweight.
5. This is referred to as very low wight in IMCI training modules.

Make your final assessment:

- Child has normal anthrpomerty and normal growth pattern
- Child has severe or moderate malnutrition or at risk of malnutrition
- It is acute or chronic malnutrition