ANTHROPOMETRY GUIDELINE

Paediatrics

Cape Town Metropole Paediatric Interest Group

Final: April 2007
Review: April 2009

CONTENTS **PAGE NO**

Section C: Evaluation of Anthropometric Measurements

Section D: Addendums

Motivation
The aim of this guideline is to provide health care professionals and health care workers with a standardized evidence based anthropometry guideline for use in the paediatric population.

Introduction

Anthropometry is defined as the science of measuring the size, weight and proportions of the human body.[1] This involves obtaining the physical measurements of an individual and relating them to standards. These measurements can be used as valuable indicators of health, development and growth of infants, children and adolescents.[2]

The body's composition is divided into five organizational levels, i.e. atomic, molecular, cellular, tissue-system and the whole body. A stable quantitative relationship exists between all these levels which remain relatively constant over months or years. Since age and disease can affect this quantitative relationship, anthropometry is a means that can be used to detect the resultant changes in the body.[3]

Anthropometric measurements can be divided into 2 types; namely ***body size*** and ***body composition***. In hospital, anthropometric indices of body size (i.e. head circumference, weight, length and height) are used primarily to distinguish between under and overnutrition and to monitor changes after a nutrition intervention.[4] Weight and length/height are also critical as a basis for calculating dietary requirements.[5]

These measurements alone do not give an indication as to whether a weight increment comprises lean body mass plus fat tissue or whether the weight gained is merely fat. Therefore to fully differentiate between lean body mass (muscle) and fat, measurements of body fat and fat-free mass are necessary. [4]

Anthropometric measurements have many advantages (Box 1), however it is important to note that the measurements are relatively insensitive and cannot detect disturbances over short periods of time. It can also not identify a specific nutritional deficiency, thus one is unable to distinguish disturbances in growth and body composition that may be caused by nutrient deficiencies (e.g. zinc). [3]

Anthropometry therefore forms part of one of the important components for the assessment of nutritional status, in addition to dietary intake, clinical and biochemical assessment.

BOX 1: Advantages of anthropometry measurements in nutritional assessment [3]

1. **Simple, safe, non invasive techniques** are involved, which can be used for both individuals as well as large population groups.
2. **Inexpensive equipment** is required, which is portable, durable and purchased or made locally.
3. **Unskilled personnel** can be trained to perform the measurement procedures with relative accuracy.
4. **Methods can be precise and accurate**, if standardized techniques and trained personnel are used.
5. **Retrospective** information can be generated on past long-term nutritional history, which cannot be obtained with equal confidence using other techniques.
6. **Mild to moderate malnutrition**, as well as severe states of under- or overnutrition can be identified.
7. **Changes in nutritional status** over time and from one generation to the next, a phenomenon known as the secular trend, can be evaluated.
8. **Screening tests** that identify individuals at high risk to under- or overnutrition can be devised.

Section A: Measurements[1,2,3,4,5,7,8,9,10,11,12,14]

1 Body Size

1.1 Head Circumference (HC)

- This is an important measurement as it is closely related to brain size. HC-for-age can be used to detect severe chronic protein-energy malnutrition in children < 2 years. Intrauterine growth retardation or extreme chronic malnutrition in the first few months can cause decreased brain development resulting in an abnormally low HC measurement.
- HC is also used with other measurements to detect conditions associated with either a macrocephalic (large) or microcephalic (small) head which may or may not be related to nutritional factors.
- HC rapidly increases during the first year but is much slower by 36 months.
- HC is plotted on the CDC (0 – 36 months) percentile charts. (Addendum 3).
- See Section B: 1 for the measurement technique of HC.

1.2 Weight (Wt)

- This is one of the most important measurements in nutritional assessment. It is an important variable used in equations predicting macronutrient and fluid requirements and a valuable index in acute malnutrition.
- Wt however does not distinguish between fat, protein, bone and water. It can also be influenced by fluid status, organomegaly and tumour growth.
- It is also important to note that conclusions can not be made from isolated "once off" measurements and nutritional status cannot be determined without length or height. *Current measurements must always be compared to previous values, and if it appears unusual, the measurements must be repeated.*
- Wt is plotted on the CDC (0 – 18 years) or the WHO (0 – 5 years) percentile charts (Addendums 2 and 3) or on the Down syndrome or Cerebral Palsy (CP) growth charts. (Addendums 5 and 6).
- See Section B: 2 for the measurement techniques of wt in ambulatory and non-ambulatory patients.

1.3 Length (Lt)

- Together with wt and other body size measurements, length is a sensitive and commonly used indicator of growth and development which can be assessed by comparing length-for-age and weight-for-length.
- Is also referred to as recumbent length (i.e. it is obtained while the patient is lying down).
- It is generally reserved for infants less than 24 months of age; or for children between 24 and 36 months who are unable to stand upright without assistance or are unable to straighten their knees; or in older children who are bedridden.
- When recumbent lt is used in bedridden children, with no skeletal abnormalities and the measurements are plotted on the growth charts for height/stature, ~2cm must be subtracted so as to make the adjustment between supine length and standing height, due to gravity.
- In patients who have spinal curvature, contractures or other musculoskeletal abnormalities or where recumbent lt in certain critically ill patients is not possible, than upper arm length (UAL) and lower leg length (LLL) can be measured. In infants (0 - 2 years), UAL is measured as shoulder-elbow length (SEL) and LLL is measured as knee-heel length (KHL).

- Length in infants is plotted on the CDC (0 – 36 months) or the WHO (0 – 2 years) percentile charts. (Addendums 2 and 3) or on the Down syndrome or CP growth charts. (Addendums 5 and 6).
- The measurements of UAL, LLL, SEL and KHL are plotted on the available reference percentile charts. (Addendums: 14 - 17).
- See Section B: 3 for the measurement techniques for the above-mentioned.

1.4 Height (Ht)

- Standing height (also referred to as stature) is used for children older than 2 years who are able to stand upright without assistance.
- The measurement of ht is important for calculating certain indices such as ht -for-age, wt-for-ht, Body Mass Index (BMI), the creatinine ht index and for estimating basal energy expenditure.
- Ht-for-age and wt-for-ht have been recommended by the World Health Organization (WHO) for use especially in low-income countries. Used in combination the degree of stunting and wasting can be assessed respectively and is thus an important indicator of acute and/or chronic malnutrition.
- Ht is plotted on the CDC (2 – 18 years) or the WHO (2 – 5 years) percentile charts. (Addendums 2 and 3)
- See Section B: 4 for the measurement technique of Ht.

1.5 Mid-Parental height

- The mid-parental height measurement is a means of determining the genetic potential of growth in height and is especially useful in chronically ill patients.
- The measurements (see section B: 7) are plotted on mid-parental height charts (Addendum 8) and if it is above or below average, adding or subtracting the centimeters accordingly adjusts the child's ht and this 'adjusted' ht is then plotted on the CDC or WHO growth charts.
- It is important to note that if this measurement is used in children from lower socio-economic groups, where stunting of the parents due to nutrition is suspected, this information becomes unreliable.
- See Section B: 5 for the measurement technique of mid-parental ht.

1.6 Body Mass Index (BMI)

- BMI (a wt-for-ht measurement) can also be used to determine nutritional status and is calculated by dividing wt in kilograms by the square of ht in metres [kg/m^2].
- It is a widely accepted measure of body fatness and although BMI is influenced by age, gender and race, it is increasingly being recommended as a useful indicator to define overweight and obesity in children and adolescents. (See Section C: 6)
- Since BMI is influenced by pubertal status, it should be interpreted with caution in early or late peripubertal children, especially in girls.
- BMI is plotted on the CDC (2 – 20 years) or the WHO (0 – 5 years) percentile charts. (Addendums 2 and 3)

1.7 Waist - Hip Ratio (W/H)

- This ratio is obtained by dividing the measurement of the waist circumference (cm) with the measurement of the hip circumference (cm).
- The W/H ratio has not been proven to be a useful predictor of obesity in pre-pubertal children and there is currently no suitable reference data available for paediatrics.

2. Body Composition

2.1 Skinfold (SF) Measurements

- A skinfold is a thickness of a double fold of skin and compressed subcutaneous adipose tissue. (Figure 1).
- The advantages of skinfold measurements include: the use of inexpensive equipment; the need for little space in order to carry out the measurements; measurements are easily and quickly obtained and if done correctly, it correlates well with measurements obtained from 'hydrostatic weighing'.
- SF is accepted as a predictor of body fatness because 40 – 60% of total body fat is in the subcutaneous region of the body and SF can be directly measured using a well-calibrated caliper.
- A combination of various SF measurements is the most widely used method to indirectly estimate percentage body fat.
- SF's are affected by age, hydration status, skin thickness, sport and in unstable patients (e.g. those in icu).
- SF's are not recommended in obese individuals (BMI > 95% for age) as the SF reading may be inaccurate or the SF may be too wide for the caliper.
- An accurate caliper must be used. The Harpenden and Lange calipers are recommended as these were used in developing prediction equations and reference values (Figure 2).
- The person using the calipers must be proficient and be able to make reproducible measurements before these can be considered accurate or useful.
- More than 19 sites have been used for measuring SF thickness. Commonly used sites include: triceps, subscapular, biceps, supra-iliac, calf, chest and abdomen, etc.
- It is recommended that at least more than one SF site should be used; usually the triceps and one on the body.
- The four SF's, i.e. triceps, biceps, subscapular and suprailiac are computed in equations to determine the percentage body fat. (Addendum 18)
- The sum of the triceps and subscapular sites can be used in young people aged 2 – 6 years. These sites correlate well with other measures of body fat composition; they are more reliably measured than most other sites and international reference data are available (South African reference currently not available).
- SF measurements are recommended for children from 1 year. Reference data for triceps and subscapular SF's for girls and boys, 1-17 years is available. (Addendum 8 and 9).
- See Section B: 6 and 8-12 for the measurement techniques of commonly used skinfolds.

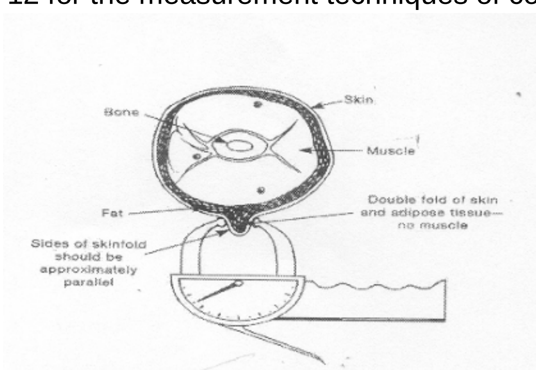

Figure 1: A double fold of a skinfold

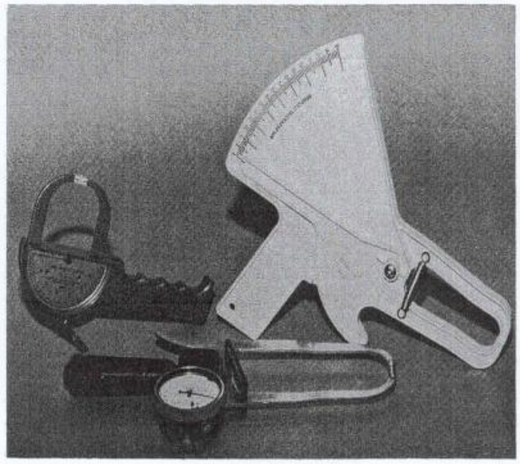

Figure 2: Calipers recommended for use in Skinfold measurements[2]

2.2 Mid-upper Arm Circumference (MUAC)

- The arm contains both subcutaneous fat and muscle; therefore a decrease in MUAC (also referred to as Mid Arm Circumference [MAC]) may reflect either a reduction in muscle mass, subcutaneous tissue or both.
- It is a simple, low-cost, objective method of assessing nutritional status. It can also be obtained quickly and non-invasively and can provide a more accurate assessment of nutritional status especially if it is difficult to obtain measurements for wt and ht (e.g. in CP children).
- MUAC remains fairly constant in children 1 - 5 years, thus a cut-off value of 11,5cm (i.e.-3 SD) is used for wasting. However, it has been shown that MUAC is not age independent and therefore WHO recommends MUAC-for-age reference data to be used in girls and boys 6 – 59 months old where possible. (Addendum 11).
- In certain settings, if age is not available, MUAC-for-ht reference data is used.
- MUAC may be more appropriate than wt-for-ht z-scores for identifying severe malnutrition in children between 1-5 years and changes in MUAC measurements can be used to monitor progress during nutritional therapy.
- When MUAC is used with SF measurements over the age of one year, arm fat area (AFA) and arm muscle area (AMA) can be calculated. (Addendum 18). Low AFA and AMA values can indicate protein energy malnutrition. (See Addendum 11).
- See Section B: 7 for the measurement technique of MUAC.

3. Bioelectrical Impedance Analysis (BIA)

- A number of useful tests to measure body composition, (e.g. isotope dilution), is not routinely used as it is impractical in the clinical setting and requires costly equipment.
- Although more costly, it is still more accurate than SF measurements.
- Bioelectrical Impedance Analysis (BIA) is much more convenient to use and has advantages of being quick, safe and non-invasive.
- It is used to determine total body water, fat-free mass and percentage of body fat.
- In BIA, an electronic instrument generates an alternating current, which passes through the body using 4 electrodes. The body's resistance to this current is then measured.
- The patient's wt, ht, age and gender are needed in obtaining the reading.
- BIA can be affected by hydration status, skin temperature, electrode placement, recent meal, exercise, albumin concentrations, blood viscosity and hematocrit.
- See Section B: 13 for the measurement technique of BIA.

SECTION B: MEASUREMENT TECHNIQUES[1,2,4,7,9,11,12,16,17]

1. Head Circumference (HC): 0 – 3 years

- A flexible, non-stretchable measuring tape must be used with 1cm increments.
- Infants can be measured whilst sitting in the caregivers lap and older children can be measured while standing.
- Headgear or any objects e.g. hairpins must be removed.
- The head must be in the Frankfort plane (Figure 3).
- The tape is positioned just above the eyebrows (i.e. supraorbital ridges), above the ears and around the back of the head (i.e. occiput) so that the maximum circumference is measured.
- The tape should be on the same plane on both sides of the head and tight enough to compress the hair.
- An average of 3 readings is taken and measurements are read to the nearest mm. (Figure 4).

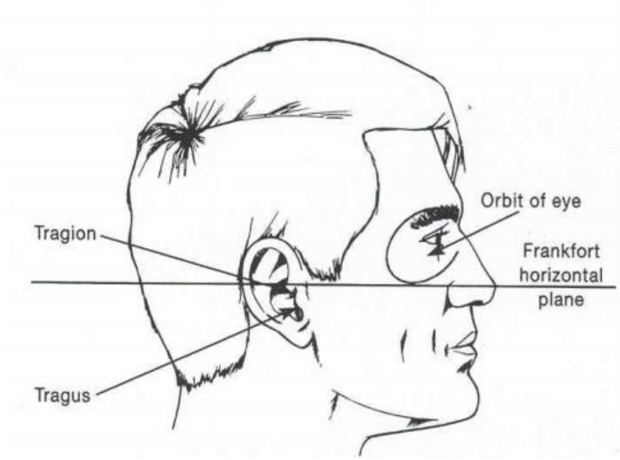

Figure 3: Frankfort plane

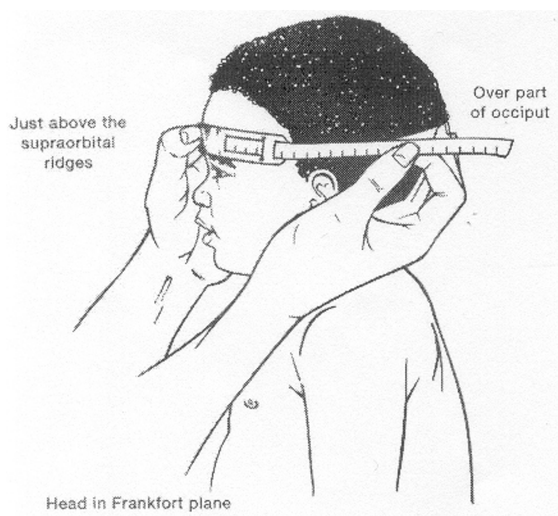

Figure 4: Head Circumference measurement

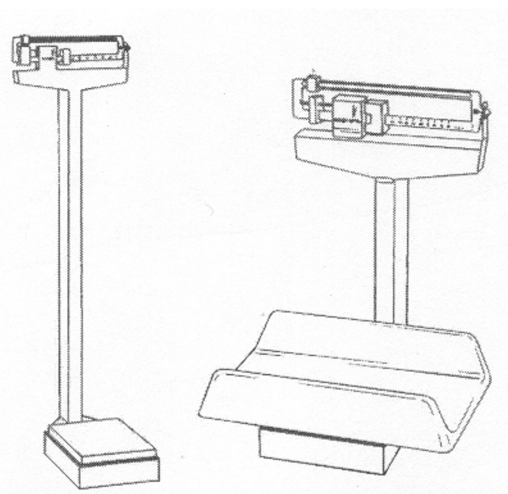

Figure 5: Balance-beam scales

2. Weight (WT)

- An electronic scale or a balance-beam scale with non-detachable weights (a pan-type for infants < 2 years and a leveled platform scale for children > 2 years) can be used, that is accurate to 0.01kg (< 2 years) and 0.1kg (> 2 years). (Figure 5)

- The zero weight on the horizontal beam of the scale should also be checked periodically and after the scale has been moved. *Spring type scales are not recommended because its accuracy cannot be assured after repeated use.*

2.1 Infants: 0 - 2 years

- Before measurements are taken zero calibration of the scale must be done.
- The infant must be placed in the middle of the scale, without any clothes or nappy. If a nappy is worn, the wt must be corrected by subtracting the wt of the nappy (i.e. the clean nappy is weighed separately).
- Before a reading is taken, wait for the baby to lie still.
- The baby must not hold onto anything for support.
- An average of 3 readings is taken and measurements are read to the nearest 0.01kg.
- The above method is also used in children (up to 20kg) who are unable to stand.

2.2 Children: 2 - 18 years

- Before measurements are taken zero calibration of the scale must be done.
- Weigh without shoes and only light clothing must be worn.
- The subject must stand still with the weight equally distributed on both feet.
- The child must not hold onto to anything for support.
- An average of 3 readings is taken and measurements are read to the nearest 0.1kg.

- In non-ambulatory patients, one can also weigh the child with the parent/caregiver and then subtract this amount from the parent/caregiver's weight to obtain the child's estimated weight.
- If a bed scale is used, patients are comfortably positioned in a weighing sling, which is then suspended off the bed. Wt is read off to the nearest 0.1kg.
- Using a chair scale, the child sits upright in the centre of the chair while leaning against the backrest. Wt is read off to the nearest 0.1kg.

3. Length (Lt): 0 – 2 years

- A wooden or Perspex length board with a solid headboard and a moveable footboard is used, with 1mm increments.
- Two people are required to do the measurement.
- No shoes, socks or headgear should be worn.
- One person holds the crown of the head against the headboard and with the Frankfort plane forming a 90^o angle with the backboard. This person also ensures that the head, shoulders and buttocks touch the backboard/flatboard.
- The other person keeps the legs straight against the backboard and slides the footboard against the bottom of the feet with the toes pointing upwards; if having difficulty, the leg/s can be pressed down at the knee to flex the foot up and one leg can also be used.
- An average of 3 readings is taken and measurements are read to the nearest 0.1cm. (Figure 6)

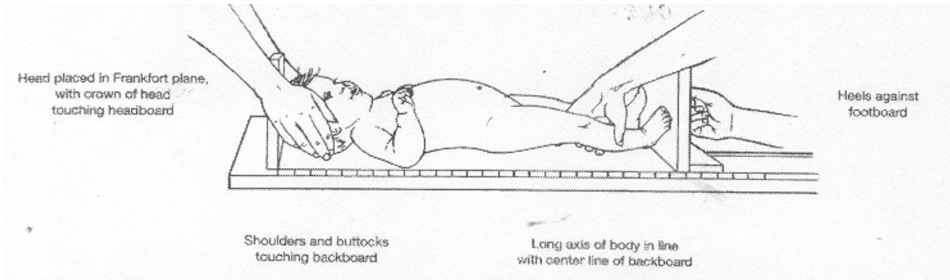

Figure 6: Measurement of length[2]

3.1 Recumbent Length (>2years)

- Align patient's body so that the lower extremities, trunk, shoulders and head are in a straight line.
- The bed must be flat. (Make sure that it is not elevated at one end).
- On the bed sheet, mark the position of the base of the heels and top of the crown.
- Measure the distance between these two lines using a tape measure.

3.2. Shoulder-Elbow Length, Knee-Heel Length, Upper Arm Length and Lower Leg Length

- Measurements are taken on the right side, unless a physical deformity affects the right side.
- The least affected side is then measured.
- The side that is used must then be noted so that the same side can be used for future measurements for accurate comparisons.
- Sliding calipers (0-200 mm) are used for young infants and an anthropometer is used for older infants and children.

3.2.1 Shoulder-Elbow Length: 0-24 months

- Measure shoulder-elbow length: from the superior lateral surface of the acromion to the inferior surface of the elbow.
- The arm must be flexed at a 90^o angle.
- The measurement is recorded to the nearest 0.1cm.

3.2.2 Knee-Heel Length: 0-24 months

- The infant lies on his/her back with the leg flexed to 90^o at the hip, knee and ankle.
- The infant's knee and heel are placed between the holders.
- The measurement is recorded to the nearest 0.1cm.

3.2.3 Upper Arm Length: 2-18 years

- The arm is relaxed.
- Measure shoulder-elbow length: from the superior lateral surface of the acromion to the radial process.
- The measurement is recorded to the nearest 0.1cm.

3.2.4 Lower leg length: 2-18 years

- Connect the slides to the two measuring arms with metallic holders.
- The child sits in a relaxed position.
- Measurement is taken from the medial malleolus to the medial tip of the tibia.
- The measurement is recorded to the nearest 0.1cm.

4. Height (Ht): 2 – 18 years

A stadiometer is used to measure stature or use a right-angled headboard and a non-stretchable tape measure with 1mm increments fixed to a vertical surface. Platform scales with moveable measuring rods are not indicated because of inaccuracy.

- Subject is measured with minimal clothing and no shoes and socks must be worn.
- Feet must be together, arms to the side, legs straight and shoulders relaxed.
- The head must be in the Frankfort horizontal plane (looking straight ahead).
- Heels, buttocks, shoulder blades and back of the head must be against the vertical board of the stadiometer.
- Measurement is taken at maximum inspiration.
- An average of 3 readings is taken and read to the nearest 0.1cm. (Figure 7)
- *To avoid errors of parallax, the measurer's eyes should be level with the headboard.*

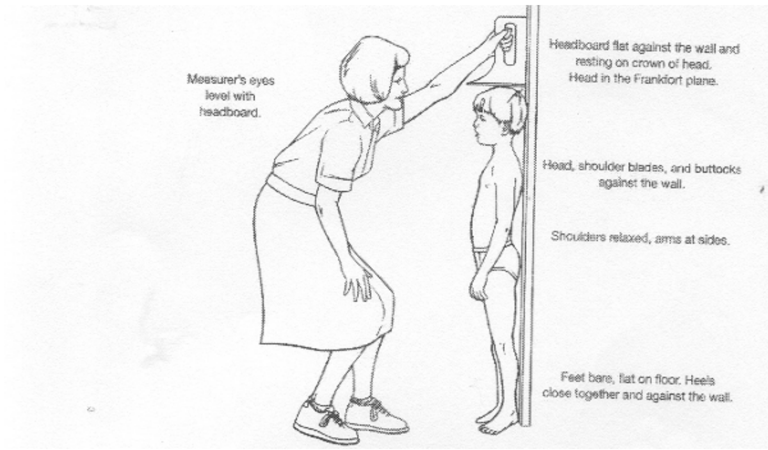

Figure 7: Measurement of height[2]

5. Mid-Parental height

- Obtain the ht of both biological parents by history or measurement.
- Add together parental heights and divide by 2.
- Plot the values on the mid-parental ht charts. (Addendum 7).
- Mid-parental height = add 7cm (male child), subtract 7cm (female child).
- Target height centile range = mid-parental height ± 8.5cm (girl), or ± 10cm (boy).

6. Mid Point of Arm

6.1 Standing Position

- Measurement is taken on the right arm using a non-stretchable tape measure.
- Patients stand erect with feet together.
- The arm is bent at the elbow to form a 90^0 angle.
- The palm of the hand faces upwards.
- The reading is taken midway between the acromion angle of the scapula and the most distant point of the olecranon process of the ulna. (Figure 7)

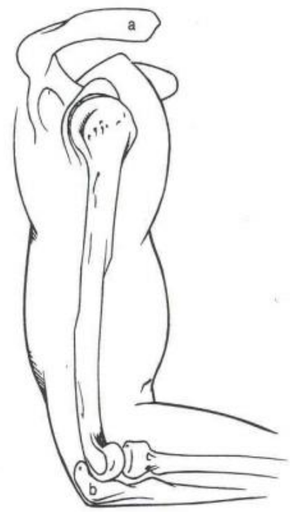

Figure 8: Location of the midpoint of the arm[2]

6.2 Recumbent Position

- Measurements can be taken on the right or left arm using a non-stretchable tape measure.
- The patient is in a supine position with the upper arm parallel to the body.
- The forearm is placed palm down across the middle of the body with the elbow bent at 90^0
- The reading is taken midway between the acromion angle of the scapula (**a**) and the most distant point of the olecranon process of the ulna (**b**). (See figure 8).

7. Mid Upper Arm Circumference (MUAC)

7.1 Standing Position

- A non-stretchable measuring tape is used.
- Measurement is taken on the right arm at the midpoint of the arm.
- Patient stands with arms relaxed at the side and with the palm facing towards the thigh.
- The measuring tape is placed perpendicular to the long axis of the arm.
- The tape must not cut into the flesh.
  The reading is taken to the nearest mm.

7.2 Recumbent Position

- A non-stretchable measuring tape is used.
- Measurement is taken on the right or left arm at the midpoint of the arm.
- The arm lies by the patient's side with the palm facing upwards.
- Place a folded towel or pillow under the patient's elbow to raise it slightly off the surface.
- The measuring tape is placed perpendicular to the long axis of the arm.
- The tape must not cut into the flesh.
- The reading is taken to the nearest mm.

8. General principles regarding SF measurement techniques.

- The patient is examined for the presence of oedema. (Measurements are not reliable in areas where oedema is present).
- The caliper is zero calibrated before measurements are taken.

- Measurements are taken on the right side in rotational order.
- It is preferable to mark the site to be measured especially those with little experience.
- The skinfold (skin and subcutaneous fat) is grasped with the thumb and index finger of the left hand 1cm above the mark.
- The caliper tips are placed on the site approximately parallel and 1cm distal to where the SF is grasped. (see figure 8)
- The SF is held firmly while the measurement is taken.
- A reading is taken 2–3 seconds after the measurer has released the lever arms of the caliper.
- Measurements are read to the nearest 0.1mm on the Harpenden or Holtain skinfold calipers and 0.5cm on the Lange calipers.
- An average of 3 readings is taken.
- Measurements should be at least 15 seconds apart to allow the SF site to return to normal.
- Consecutive measurements should not differ by more than 1mm.

9. Triceps skinfold:

9.1 Standing Position

- Subject stands erect with feet together.
- Arms hang relaxed at the side.
- Measurement is taken on the mid point of the arm.
- The SF runs parallel with the length axis of the arm.
- The measurer stands behind the subject, with the reading taken in the posterior position. (Figure 9)

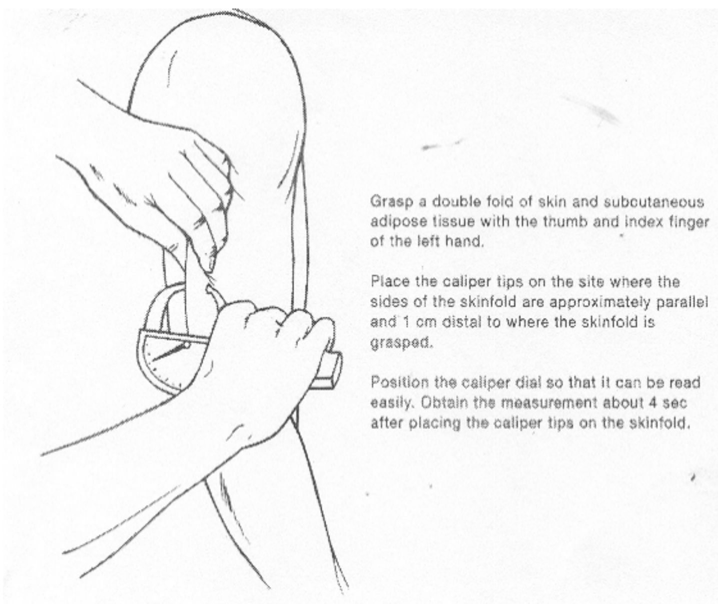

Figure 9: Measurement of the triceps skinfold[2]

9.2 Recumbent position

- The patient lies on their left side with knees bent.
- The patient lies with the head on the cushion and the left arm under the cushion.
- The right arm rests on the body with the palm facing downwards.
- Measurement is taken on the midpoint of the arm.
- The SF runs parallel with the length axis of the arm.
- The reading is taken in the posterior position.

10. Biceps skinfold

- The patient sits with the arm resting on the lap and the palm facing upwards.
- Measurement is taken on the anterior position of the biceps on the same level as the triceps SF.
- The SF runs parallel with the length axis of the arm.

11. Subscapular skinfold

11.1 Standing Position

- Patient stands erect with feet together.
- Arms hang relaxed at the side.
- The site can be located by gently feeling for the lowest angle of the scapula or by having the patient place their right arm behind the back. (Figure 10)
- Measurement is taken 1cm below the scapula.
- The SF runs at a 45^o angle directed down and towards the right side. (Figure 11)

11.2 Recumbent position

- The patient lies on their right side with knees bent.
- The right arm rests on the body with the palm facing downwards.
- The subscapular skinfold site is just distal to the inferior angle of the left scapula.
- Measurement is taken 1cm below the scapula
- The SF runs at a 45^o angle directed down and towards the right side.

13. Suprailiac skinfold

- Patient stands erect with feet together.
- Arms can hang at the side, although the right arm can be flexed slightly to improve access to the site.
- The SF is grasped 1cm above the iliac crest at the midaxillary line and runs diagonally (45^o angle) to the front.

14. Bioelectrical Impedance Analysis(BIA) Technique

Various instruments can be used to determine BIA. Below is the procedure for when the 'Bodystat' machine is used.

- The Bodystat is calibrated.
- Patient lies down and feet must not touch each other. Socks and shoes are removed.
- All metal objects must be removed.
- Measurements are taken on the right side.
- Electrodes are placed just behind the second toe, between the lateral and medial maleoli and just after the middle finger.
- The red clips are placed distally and the black clips are placed proximally.
- Relevant data (i.e. wt, ht, age and gender) should then be entered into the Bodystat.

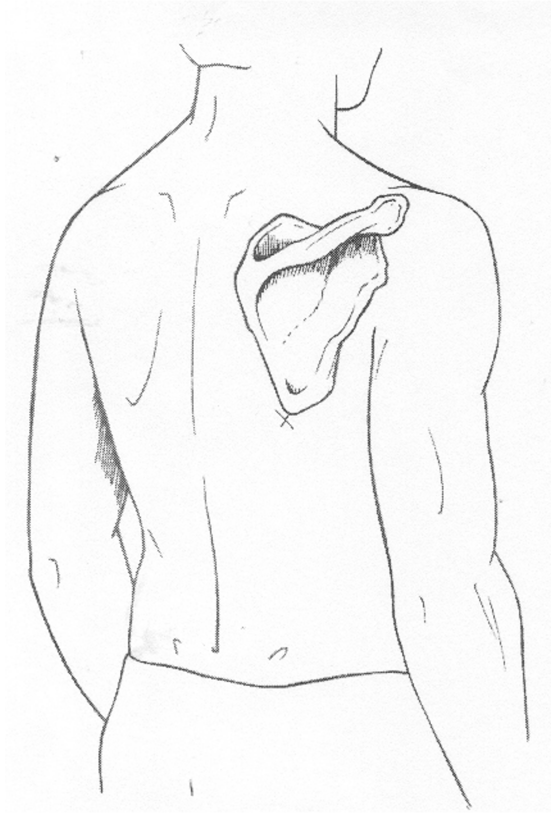

Figure 10: Location of the Subscapular skinfold[2]

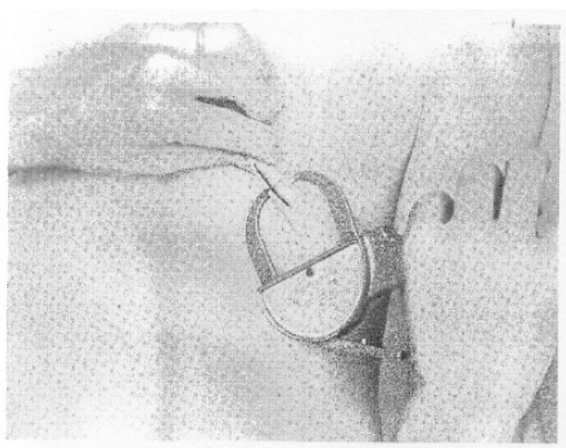

Figure 10: Measurement of the Subscapular skinfold[2]

Section C: Evaluation of Anthropometric Measurements[3, 4, 5, 7, 11, 15, 16,17]

1. The Preterm and Low Birth Weight Infant

- A Preterm infant is defined as an infant born < 37 weeks gestation.
- Prematurity is corrected up to the age of 2 years. In cases of severe prematurity and intra-uterine growth restriction (IUGR), prematurity can be corrected up to 3 years of age.
- Expected weight gain: **≥** 15g/kg/day. These rates of growth are usually achieved 2 -3 weeks after birth (i.e. once full feeds are given).
- Expected length gain: 0,8 – 1,0 cm / week.
- Expected head circumference rate: 0,5 – 0,8 cm / week.

1.1 Classifications

Table 1: Classification of Birth Weight

Low birth weight **(LBW)**	< 2500 g
Very Low birth weight **(VLBW)**	< 1500 g
Extremely Low birth weight **(ELBW)**	< 1000 g

Table 2: Classification for Weight-for-Gestational-Age at Birth

Small for gestational age **(SGA)**	< 10th percentile or z-score < -2
Appropriate for gestational age **(AGA)**	Between the 10th and 90th percentile
Large for gestational age **(LGA)**	> 90th percentile or z-score > +2

Table 3: Classification of Growth Restriction

Symmetrical Growth Restriction	Wt, Lt and HC fall below the 10th percentile.
Asymmetrical Growth Restriction	Only one or two of the three parameters falls below the 10th percentile.

2. Infants and Children

2.1 Weight, Length and Head Circumference gain in healthy infants and children

Table 4: Ideal weight gain in healthy full term infants (g/day)

Age	Weight	Weight gain
0 – 4 months	± 3 – 6 kg	30 g/day
4 – 8 months	± 6 – 8 kg	20 g/day
8 – 12 months	± 8 – 10 kg	15 g/day

Table 5: Ideal weight gain for healthy full term infants and children (g/week)

Age	Weight gain
0 – 3 months	200 g/week
4 – 6 months	150 g/week
7 – 9 months	100 g/week
10 – 12 months	50 – 75 g/week
1 – 2 years	40 g/week
2 - puberty	30 g/week

Normal birthweight averages 3kg (according to the South African Department of Health). There is some weight loss during the first 5-7 days, then birthweight is normally regained by the tenth to the fourteenth day. The fullterm baby doubles birthweight at 4 months and triples it at 12 months.

Length gain

- Birth length x 1,5 at 12 months.
- Birth length doubles at 5 years.
- 25cm during the first year of life.
- 12cm during the second year of life.
- 10cm per year, steadily declining to 6cm until the growth spurt at puberty.
- Estimated height as adult: length at 2 years x 2.

Table 6: Head Circumference increase from birth to 4 years in girls and boys

Age	Boys (cm)/year	Girls(cm)/year
0 – 3 months	5.9	5.7
3 – 6 months	3.2	3.0
6 months – 1 year	3.2	3.1
1 -2 years	2.2	2.2
2 -4 years	1.7	2.1

2.2 Weight Gain during Nutrition Recovery

- Expected weight gain in nutritional recovery > 30g/day < 1 year of age and > 10g/ day in over 1 year of age.
- Nutrition recovery achieved when weight for height > 0 Z score or > 90% EWH.

3. Weight-for-Age; Height-for-Age; Weight-for Height; Height-Age (HA) and Weight-Age (WA)

- **Wt-for-Age** – This reflects body mass relative to chronological age. A low wt-for-age (according to the Gomez classification) is termed underweight-for-age. A high wt-for-age is seldom used as an index, since an increased wt-for-ht is more accurate in determining overweight and obesity.
- **Ht-for-Age** – This reflects achieved linear growth. A low ht-for-age can be due to shortness (due to a normal variation or a pathological process) or stunting (a failure to reach linear growth potential due to undernutrition). A high ht-for-age or tallness is of little clinical concern unless due to endocrine disorders.
- **Wt-for-Ht** – This reflects body wt relative to current ht. A low wt-for-ht can be due to thinness (not due to a pathological process) or wasting (due to acute starvation or disease). A high wt-for-ht is either overweight or obesity. Although a high wt-for-ht can be due to an increased lean body mass, it can still be used as an indicator for obesity.
- **Ht-Age** – This is the age at which the current ht falls on the 50th percentile on the lt or ht-for-age growth charts. Ht-age is used in calculations of nutritional requirements in children who are much smaller than their chronological age.
- **Wt-Age** – This is the age at which the current wt falls on the 50th percentile on the wt-for-age growth charts. Wt-age is used in calculations of nutritional requirements in children who are very much underweight according to age.

3.1 Expected wt-for-age (EWA), Expected ht-for-age (EHA) and Expected wt-for-ht (EWH)

In order to classify the degree of malnutrition, overweight and obesity, the expected or ideal wt-for-age, ht-for-age or wt-for-ht needs to be calculated:

1. Plot wt-for-age or ht-for-age on the CDC or WHO growth charts.

2. Extend the line horizontally until it reaches the 50th percentile curve for wt or ht.
3. The actual wt or ht is then divided by the value obtained in no.2 and multiplied by 100 which will give a percentage.
4. An added step is used to determine EWH. Find the corresponding 50th percentile wt for the 50th percentile ht point. Actual wt is then divided by this wt multiplied by 100 to give a percentage.

4. Classification of malnutrition

4.1 Mid-Upper Arm Circumference (MUAC)

Table 7: Classification of MUAC

MUAC	Classification (1 – 5 years)
> 13,5 cm	Normal
12,5cm – 13,5cm	Possibly mildly malnourished
< 12,5 cm (z-scores of -2)	Moderately malnourished
< 11,5 cm (z-scores of -3)	Severe wasting

- A single cut-off of 13,5 cm is also used (above 13.5cm being normal and below 13.5 cm being malnourished)
- MUAC-for-age from 6 – 59 months for girls and boys can also be determined from the WHO reference data (Addendum 11).

4.2 The **Waterlow** and **Gomez** classifications do not take oedema into account, thus cannot differentiate between marasmus and kwashiorkor. The Gomez classification also does not differentiate between wasting and stunting as height is not taken into account.

Table 8: Waterlow Classification for Wasting and Stunting

Normal	Height above 90% height for age Weight above 80% weight for height
Wasted (acute malnutrition)	Weight below 80% weight for age with a normal height for age (> 90%)
Stunted (chronic malnutrition)	Height below 90% height for age with a normal weight for height (> 80%)
Wasted and stunted (acute on chronic malnutrition)	Weight below 80% weight for height and height below 90% height for height

Table 9: A summary of the Classification of the severity of malnutrition

	Gomez Classification	Waterlow Classification	
	% Weight-for-age (underwt)	% Weight-for-height (wasting)	% Weight-for-age (underwt)
Grade of malnutrition	% Weight-for-age (underwt)	% Weight-for-height (wasting)	% Height-for-age (stunting)
Normal	90-110	90-110	> 95
Mild	75-89	80-89	90-94
Moderate	60-74	70-79	85-89
Severe	<60	<70	<85

4.3 WHO Classification of Malnutrition

Table 10: The WHO classification of malnutrition

	Classification	
	Moderate Malnutrition	**Severe Malnutrition (type b)[a]**
Symmetrical oedema	No	Yes (oedematous malnutrition)[b]
Weight for height	-3 ≤ SD score <2[d] (70-80%)[e]	SD score <-3 [d](<70%)[c] **Severe wasting**
Height for Age	-3 ≤ SD score <2[d] (80-85%)	SD score <-3[d] (<85%) **Severe stunting**

a. The diagnosis is not mutually exclusive.
b. This includes kwashiorkor and marasmic kwashiorkor in older classifications. To avoid confusion with the clinical syndrome of kwashiorkor, which includes other features, use the term oedemateous malnutrition.
c. Below the median NCHS/WHO reference value.
d. Percentage of median NCHS/WHO reference.
e. This corresponds to marasmus (without oedema) in the Welcome classification and to grade III malnutrition in the Gomez system. To avoid confusion use the term "severe wasting".
f. NB: A child may have moderate malnutrition with moderate wasting and no stunting.

5. Growth Monitoring

5.1 Healthy infants and children in the community setting

- A single measurement might indicate absolute shortness and tallness; however 2 or more measurements over a period of time are needed to detect a change in growth.
- Gestational age and measurements at birth including wt, length and HC and must be recorded immediately on the infant's RtHC.
- Table 11 shows the frequency of measurements to be done on the community level.
- It is common for mothers/caregivers to take their infants and/or children for their immunization visits only. For the most vulnerable group, i.e. 0-6 months this is usually at 6, 10 and 14 weeks, and this could be inadequate for nutrition monitoring.
- Weight is usually the only measurement taken at clinics/community health centres, however in those patients who are identified to be at nutrition risk, measurements such as length and MUAC, etc need to be performed and they should be followed up more frequently.

Table 11: The frequency of growth measurements for healthy infants and children

	Birth – 1 m	1 – 2 m	2 – 6 m	6 – 24 m	2 – 6 y	6 – 18 y
Wt	At birth, thereafter every week	Every 1 m	Every 2 m	Every 3 m	Every 1 y	Every 1 y
Lt	At birth	Every 1 m	Every 2 m	Every 3 m	Every 1 y	Every 1 y
HC	At birth	Every 1 m	Every 2 m	Every 3 m	Every 1 y	Every 1 yr

5.2 Sick infants and children in the hospitalized setting

- Measurements in hospital must be performed more frequently, e.g. wt in infants up to 12 months are done daily.
- Table 12 shows the frequency of measurements to be done in sick patients.
- Measurements of wt, lt/ht and HC can be also be plotted weekly for infants up to 6m on the WHO percentile charts; monthly (6m – 36m) and quarterly (2 – 18y) on the rest of the WHO or CDC growth charts.

Table 12: The frequency of growth measurements for hospitalized patients

	Preterm	Term – 12 m	12 – 24 m	2 – 18 y
Wt	Every d	Every d	Every 2nd d	Every wk
Lt	Every 2 wk	Every 2 m	Every 3 m	Every 1 y
HC	Every 2 wk	Every m	Every m	-
MUAC	Every m	Every m	Every m	Every m
TSF	-	-	Every m	Every m
AMA	-	-	Every m	Every m
AFA	-	-	Every m	Every m

6. Growth Faltering (GF)

- When a child has Failure to Thrive (FTT), e.g. crossing centiles, plateauing or fluctuating weight this should be a cause for concern.
- Table 13 classifies FTT in various age groups according to failure to gain wt over a certain period or having wt loss
- The definition of GF from birth to 18 years according to the Department of Health's Nutrition Supplementation Programme (NSP) is as follows:
  - 0 – 6 m: the growth curve flattens or drops over two consecutive **visits** on the RtHC.
  - 6 – 12 m: the growth curve flattens or drops over two consecutive **months** on the RtHC.
  - 1 – 5 yrs: the growth curve flattens or drops over two consecutive **months** on the RTHC.
  - 6 – 18 yrs: the growth curve flattens or drops over two consecutive **months** on the wt-for-age growth chart.

Table 13: Criteria for growth failure

Age group	No weight gain for:	*or* loss of weight of:
Birth - 3 months	2 weeks	100g
4 - 6 months	1 month	250g
7 - 12 months	6 weeks	500g
13 - 24 months	3 months	1kg

7. Adolescents

- The WHO defines adolescents at the ages of 10 – 19 years.
- This is an important period of human growth and maturation.
- The adolescent growth spurt may differ in timing, intensity and duration in individual children, but usually coincides with the onset of puberty. As a result there can be large variations in anthropometric dimensions.
- Maturational status (assessed by a clinician) can be used to interpret anthropometric indices of nutritional status.
- BMI-for-age (determined from the CDC percentiles: Addendum 4) is recommended to be used above weight-for-height for interpretation of nutritional status in adolescents. A BMI-for-age of < 5th percentile indicates wasting. Classifications of overweight and obesity are given below.

8. Overweight and Obesity

Table 14: Classification of Overweight and Obesity

	Overweight/ at risk of obesity	**Obese**	**Superobese**
BMI-for-age (CDC growth charts)	85th – 95th percentile for age and sex	> 95% percentile for age and sex	
% Expected wt-for-ht (CDC growth charts)	110 – 120%	> 120%	> 140%

9. Reference Data

9.1 Z-scores or standard deviation score (SDS)

- The WHO recommends the use of Z-scores for evaluating anthropometric data in low-income countries, so as to accurately classify individuals with indices below the extreme percentiles. Z-scores is useful in countries with a high prevalence of malnutrition.
- Z-scores is defined as "deviation of the value for an individual from the median value of the reference population, divided by the standard deviation for the reference population.
- The calculation of the SDS gives a numerical score indicating how far away from the 50th centile for age the child's measurements falls.
- A score of -2 indicates a risk of moderate malnutrition and a score of +2 indicates over-weight. A score of -3 indicates severe malnutrition and a score of +3 indicates obesity.
- Z-score percentile charts developed recently by the WHO are available. These can be accessed from their website, i.e. http://www.who.int/childgrowth/standards/en/.

9.2 Growth Charts

Growth charts may display a Horizontal, Descending or an Ascending line (or all 3), indicating:

- **Horizontal line** – No growth; dangerous sign; first signs of marasmus, kwashiorkor or disease; follow-up and nutrition education is needed.
- **Descending line** – decrease in growth; very serious; needs immediate attention.
- **Sharp ascending line** – Improvement from underweight or on the way to overweight or obesity.
- **Sharp descending line** – Improvement from overweight/obesity or cutting centiles/FTT.
- **Curve displays horizontal, descending and or ascending lines** – the growth curve is not being followed, indicating fluctuations in growth between over and/or undernutrition.

9.2.1 Road to Health Chart (RtHC)

- All infants are given a RTHC at birth.
- It combines both genders and is from birth up to 5 years. (Addendum 1)

9.2.2 CDC Percentile Growth Charts

The 1977 National Centre for Health Statistics (NCHS) growth charts have been revised by the Centre for Chronic Disease Prevention (CDC) in 2000, due to the following concerns:

- Data was collected at the Fels institute in Ohio using a small select sample with restricted genetic, geographic and socio-economic backgrounds.
- Observations were only recorded at 3-month intervals from 3 to 12 months of age, whereas during infancy reference data at 1-month intervals are needed.
- Accuracy of the recumbent length measurements has been questioned.
- Predominantly formula fed Infants were included, hence size and growth patterns do not represent that of breastfed or combined breast or formula fed infants.

- No reference data for weight-for-ht for adolescents is available.

The CDC 2000 growth charts are presented as nine percentile curves (3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 97th) for each group, i.e. 3 - 36 months and 2 - 20years. An 85th percentile has also been included in the new CDC BMI charts for 2 – 20 years to use as a cut-off for adolescents in the diagnosis of overweight and obesity. (Addendum 4)

9.2.3 WHO Percentile Growth Charts

In 2006, new WHO International Growth References for infants and children from birth to 5 years have been made available. These include percentiles of girls and boys for wt for age, lt/ht for age, wt for lt/ ht and BMI wt for age percentile charts as well as z-scores percentiles. New growth references for children and adolescents for HC for age, MUAC for age, subscapular skinfold for age and triceps skinfold for age as well as velocity reference data are also in the process of been developed.

The main motivation of the development of the new WHO growth references was:

- An approach was needed to describe how children *should* grow rather than describing how children grow.
- These references are intended to prevent the development of country-specific growth norms, which can lead to difficulties in cross-country comparisons.
- A diverse sample from various geographic sites was used.
- Infants used complied with the WHO feeding recommendations.
- Percentiles for infants from 0 - 6m allow wt and lt to be plotted weekly. (Addendum 1)

9.2.4 Growth charts for children with special needs

- Children with developmental disorders, mental retardation and certain genetic disorders have growth patterns that differ from the reference growth curves.
- Special charts have been developed for children with Down's syndrome whose growth rate and stature tend to be reduced.
- Growth charts are also available for children with Marfan syndrome, achondroplasia, sickle-cell disease, Noonan, Wiliams and turner syndrome.
- Growth charts were also developed for children with cerebral palsy.

9.2.5 Growth Velocity

- The growth curve of the child can provide information on the varying rate of growth with age.
- This rate of growth is generally termed the "growth velocity".
- This helps to detect abnormal changes in growth and to evaluate individuals in terms of changes in rates of growth and response to nutritional therapy.[3] (Addendum 6)

Conclusion

Growth can be an extremely complex process from infancy through to adolescence. The assessment of nutrition and growth status is thus an important and integral part of care in the paediatric population. Regular assessment can help identify infants and children at risk of malnutrition and thereby allowing nutritional intervention to take place. Accurate measurements with the proper equipment and plotting of growth charts are the best approach to determine and classify the nutritional status of infants, children and adolescents.

SUMMARY of ANTHROPOMETRY MEASUREMENTS in PAEDIATRICS

Premature & LBW Infants
- Wt
- Lt
- HC

Infants (0-1yr)
- Wt
- Lt
- Ht
- HC
- Muac

Children (1-10yrs)
- Wt
- Lt (<2yrs) or Ht (>2yrs)
- HC (≤ 3yrs)
- MUAC (1 – 5 yrs)

Those with chronic illnesses:
- SF
- Mid Parental ht
- BIA

Adolescents (10-19y)
- Wt
- Ht

Those with chronic illnesses:
- SF
- Mid Parental ht
- BIA

Premature & LBW Infants

AT BIRTH:
- Classify according to BW
  - LBW (<2500g)
  - VLBW (<1500g)
  - ELBW (<1000g)
- Plot BW, BLt and BHC on Perinatal chart and determine: SGA, LGA, Symmetric/Assymetric growth restriction.

AFTER BIRTH:
- Monitor % wt loss.
- Determine when BW was regained.
- Calculate wt gain in g/kg/day & compare to the expected wt gain of 15g/kg/day.
- Plot Wt, Lt and HC weekly on the percentile growth charts.
- Calculate adapted age.

Infants (0-1yr)

- **AT BIRTH:**
- Classify according to BW
  - LBW (<2500g)
  - VLBW (<1500g)
  - ELBW (<1000g)
- Plot BW, BLt and BHC on disease appropriate growth charts and determine: EWA, EHA, EWH.

AFTER BIRTH:
- Plot on age and disease appropriate growth charts.
- Determine: EWA, EHA, EWH, HA (if stunted)& WA (if underweight)
- Classify according to Waterlow &/or WHO
- Calculate BMI & plot on WHO BMI-for-age charts.
- Determine % wt loss or GF (look on the infant's RtHC)
- Classify MUAC-for-age.
- Determ. wt-for-lt.

Children (1-10yrs)

- Plot on age & disease appropriate growth charts
- Plot on Growth velocity charts
- Determine linear growth potential from mid parental ht
- Determine: EWA, EHA, EWH, HA (if stunted) & WA (if u/wt)
- Classify according to Waterlow or WHO
- Calculate BMI & plot on WHO / CDC BMI-for-age charts
- Classify overwt or obesity according to BMI cut-offs.
- Determine % wt loss or GF (look on the child's RtHC)
- Classify MUAC-for-age.
- Determine SD wt-for-lt.
- Interpret TSF, SSC according to WHO reference date
- Calculate AFA, AMA.
- Determine % Body fat & % FFM from BIA

Adolescents (10-19y)

- Plot on age & disease appropriate growth charts
- Determine: EWA, EHA, EWH, HA (if stunted) & WA (if underweight)
- Classify according to Waterlow or WHO
- Calculate BMI & plot on WHO / CDC BMI-for-age charts
- Classify overwt or obesity according to BMI cut-offs.
- Determine % wt loss
- Classify MUAC-for-age.
- Determine SD wt-for-lt.
- Plot on Growth velocity charts
- Determine linear growth potential from mid parental ht
- Interpret TSF, SSC according to WHO reference date
- Calculate AFA, AMA
- Determine % Body fat & % FFM from BIA

References

1. Mahan, L and Escott-Stump, S. *Krause's Food Nutrition and Diet Therapy*. 10th Edition, 2004.

2. Lee, R and Nieman D. *Principles of nutritional Assessment.* 3rd Edition, 2001.

3. WHO Expert Committee. *Physical Status: the Use and Interpretation of Anthropometry*. WHO Technical Report Series. Geneva, World Health Organisation. 1995.

4. Gibson, RS. *Principles of Nutritional Assessment*. 2nd Edition, 2005.

5. Shaw, V and Lawson, M. *Clinical Paediatric Dietetics*. 2nd Edition, 2001.

6. Garza, C and de Onis, M. *Rationale for developing a new international growth reference*. Food and Nutrition Bulletin. 2004: 25: No 1 (supplement 1).

7. Mascarenhas MR, Zemel B, Stallings VA. *Nutritional assessment in pediatrics.* Nutrition 1998; 8:285-307

8. Bini V, Celi F, Berioli MG, Bascosi ML, Stella P, Giglio P, Tosti L, Faorni A. *Body mass index in children and adolescents according to age and pubertal stage.* Eur J Clin Nutr 2000; 54:214-8

9. Wang J, Thornton JC, Kolesnik S, Pierson RN. *Anthropometry in body composition. An overview.* Ann NY Acad Sci 2000; 904:317-326.

10. Berkley J, Mwangi I, Griffiths K, Ahmed I, Mithwani S, English M, Newton C, Maitland K. *Assessment of severe malnutrition among hospitalized children in rural Kenya: comparison of weight for height and mid upper arm circumference.* JAMA 2005; 294: 591-596.

11. De Onis, M, Yip R, Mei Z. *Development of MUAC-for-age reference data recommended by a WHO Expert Committee*. WHO Bull OMS 1997; 75: 11-18.

12. Mei Z, Grummer-Strawn LM, De Onis, M, Yip R. *The development of MUAC-for-height reference data, including a comparison to other nutritional status indicators*. WHO Bull OMS 1997; 75: 333-341.

13. Ellis KJ, Bell SJ, Chertow GM, et al. *Bioelectrical Impedance Analysis in clinical research: A follow-up to the NIH technology assessment conference*. Nutrition. 1999; 15: 874-880.

15. Hall D. *Growth monitoring*. Arch Dis Child 2000; 82: 10-15

16. Krick, J, et al. *Pattern of growth in children with cerebral palsy*. Journal of the American Dietetic Association. 1996; 96:680-685.

17. Puntis, J.W.L, Wardley, B.L. *Nutrition in the under 5s*. A pocket guideline for Health Care Professionals. 2002