# Chapter 2
# Antropometric Assessment

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# Objective

➔ At the end of this class, students will be able to

- ♣ List down types of anthropometric measurements
- ♥ List down types of instruments used to conduct anthropometric measurements
- ♦ Shown us the steps of conducting anthropometric measurements

## Exercise ??

1. What is anthropometry?
2. What is anthropometric assessment
3. What anthropometric measurements did you know: including the instruments used
4. What advantages and limitations of anthropometric measurements did you know
5. What anthropometrical indices did you know?
6. Did you ever conducted anthropometric assessment ? When ? Where?

# Chapter 2
# Anthropometric assessment

**Presentation outline**

- Introduction
- Anthropometric assessment of body size
  - Measurements of body size
  - Anthropometric indices

## Introduction

- Nutritional anthropometry is defined as:-
  - Measurements of the variations of the physical dimensions & the gross composition of the human body at different age levels & degrees of nutrition.
- Anthropometric measurements assess
  - Growth: head circumference, length, weight
  - Body fat: skinfolds, hip & waist circumference
  - Fat-free mass: mid-upper arm circumference

## 2.1 Anthropometric assessment of body size.

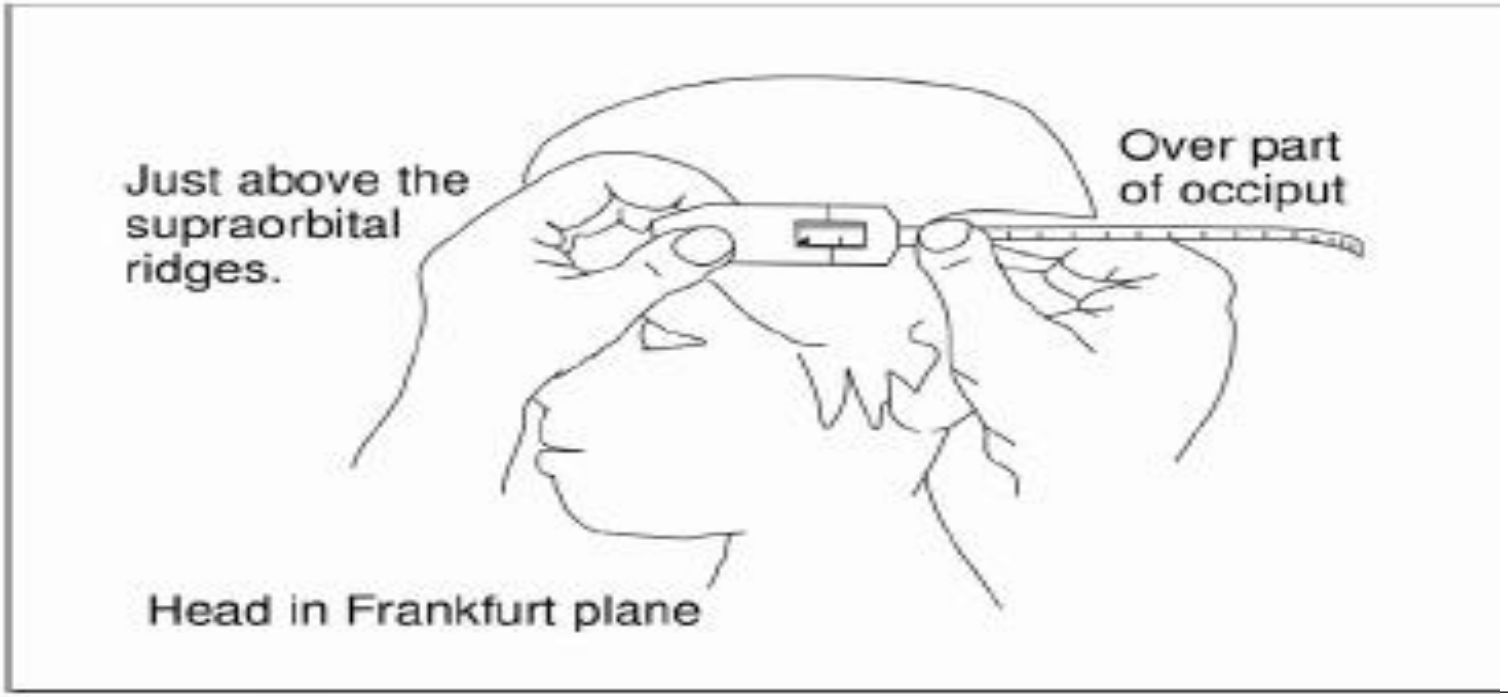
- Stature (height/length) & body weight: the most common
  - Can be made quickly & easily, & accurately with care & training

### 2.1.1 Measurements of body size

#### A. Head circumference

- Closely related to brain size
- To detect pathological conditions associated with unusually large (macro cephalic) or small (micro cephalic) head

- Need a flexible, non stretch tape
  - Subject stand with left side facing; arms relaxed; legs apart
  •Ensure tape at same level on each side of head; pull tightly to compress hair
  •Measure to nearest mm
  - HC-for age: index of chronic PEM for children < 2 y



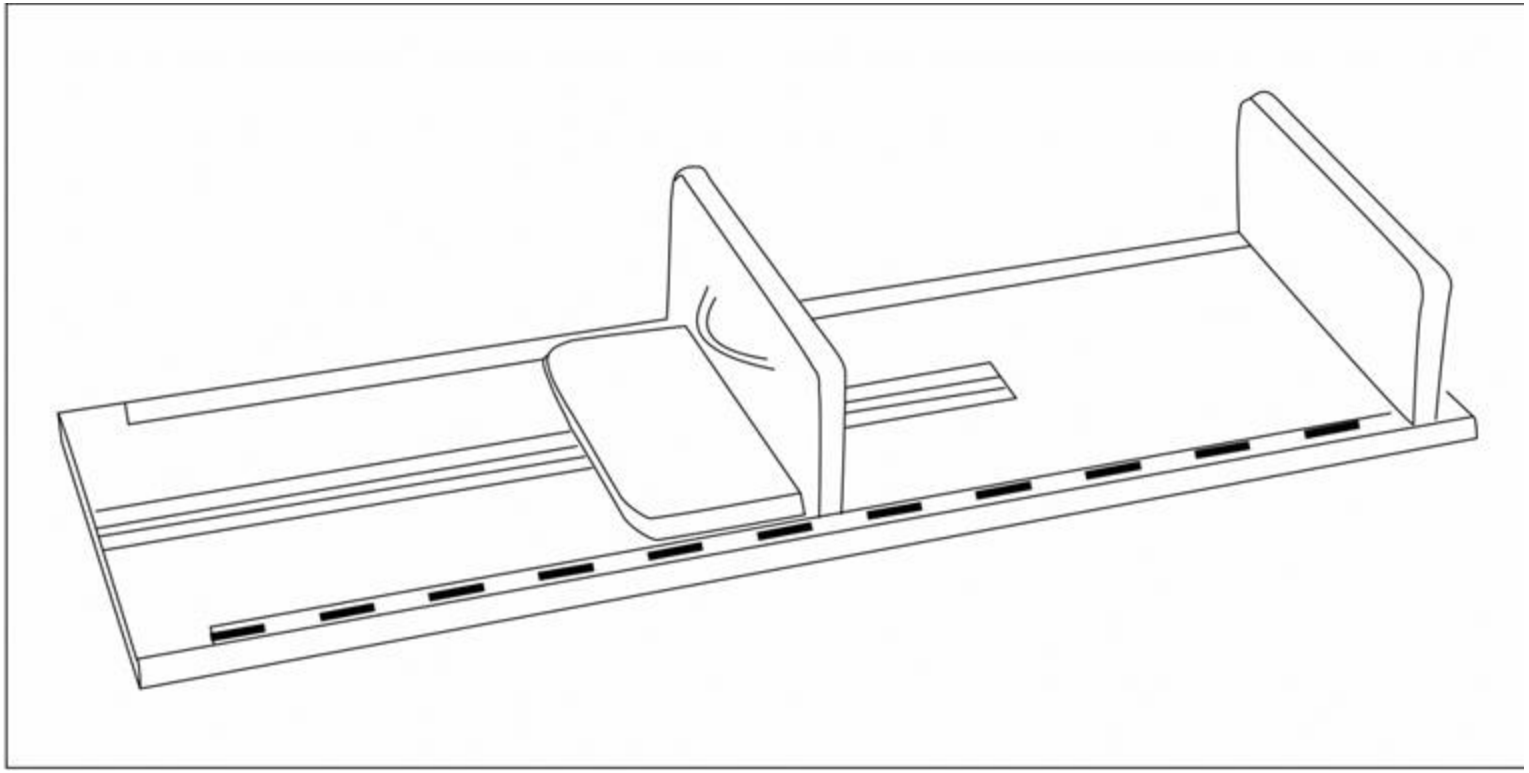
## B. Recumbent length

- In infants & children <2yrs having <=85cm
- Wooden measuring board used
- 2 examiners required to correctly position the subject & ensure accurate & reliable measurement
- Subject placed face upward, head towards fixed end of the board & body parallel to the board’s axis
- Shoulder rest against the surface of the board

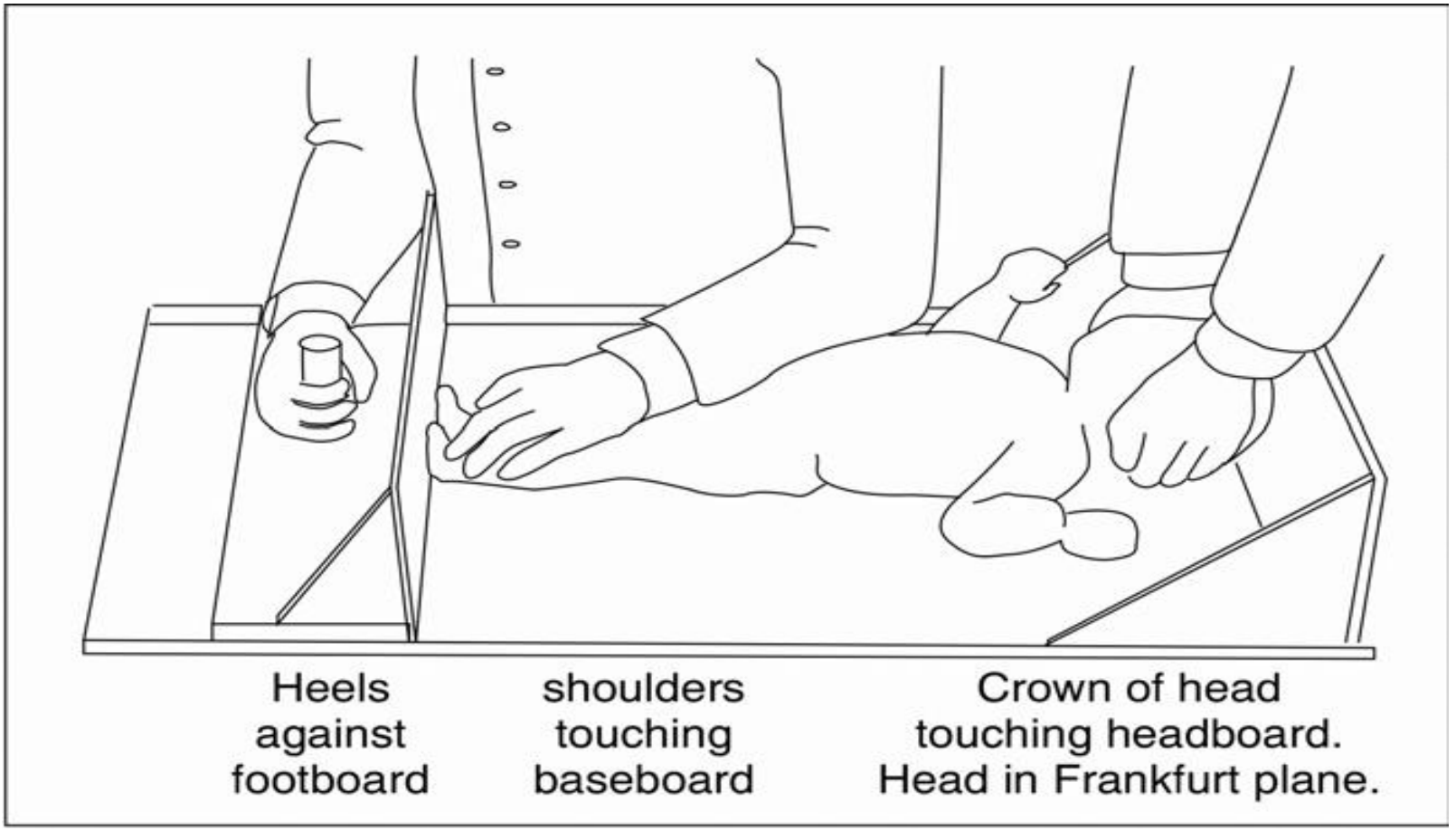
**Recmb. Length cont …**

- One examiner holds the child’s head in a Frankfurt position
- The other examiner holds the subject’s feet
  - Without shoes
  - Toes pointing upward
  - Keep knees straight
  - Brings moveable footboard to rest against the heals

# Recumbent length board



# Measurement of recumbent length



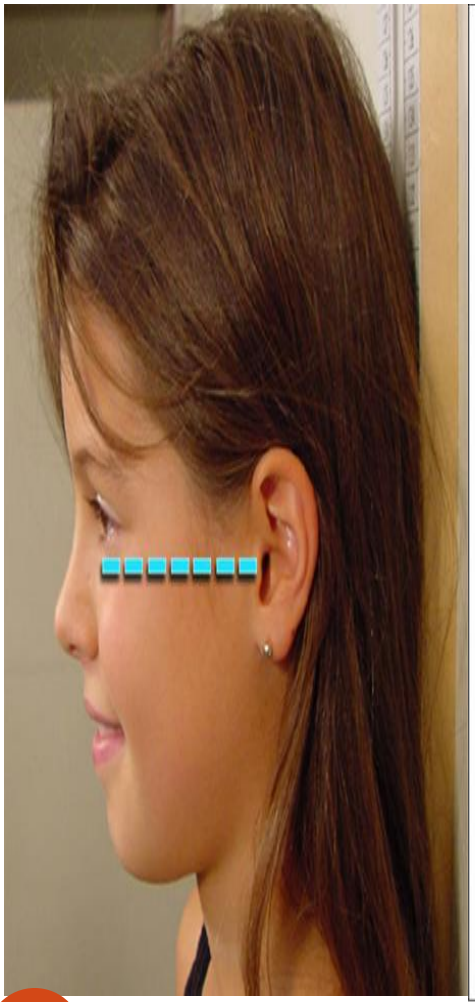
## C. Height

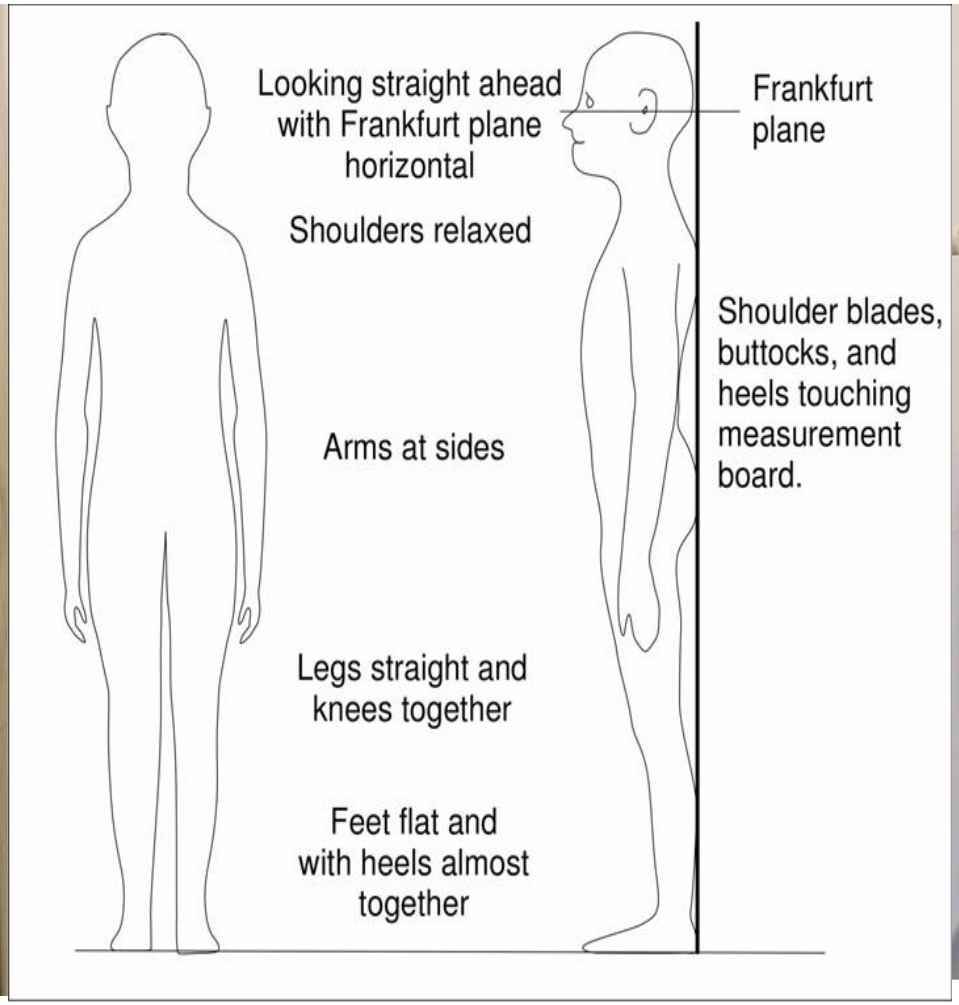
- For children >85cm & adults
- Measured in the standing position using a free-standing stadiometer
- There should be minimal clothing to see posture clearly
- Shoes & socks should not be worn

## Height cont…

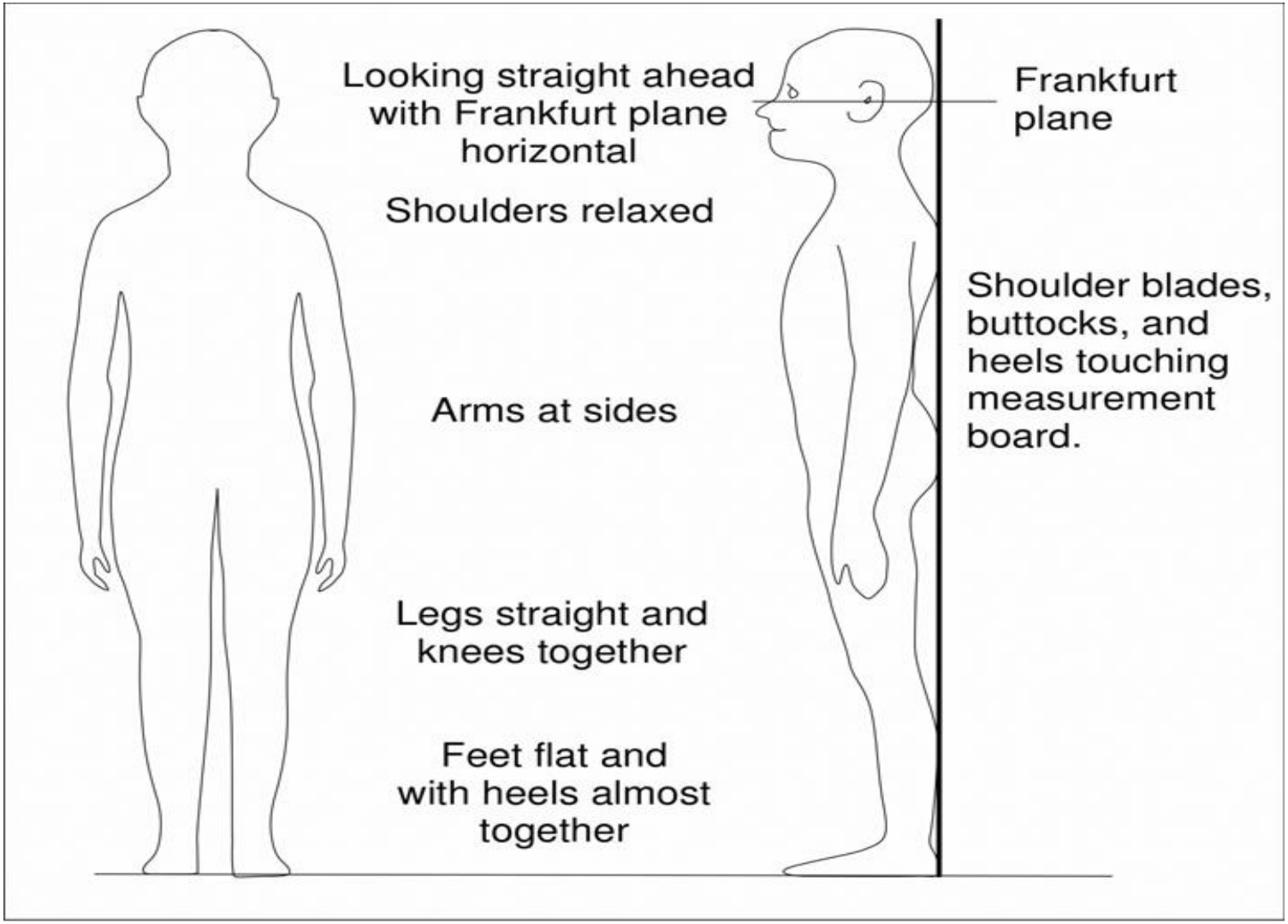
- To measure
  - Head in Frankfurt plane
  - Feet together, knees straight
  - Heels, buttocks, & shoulder blades in contact with the stadiometer
  - Arms hanging loosely at the sides with palms facing the thighs
  - For younger subjects hold the heel to ensure they do not leave the ground
  - Headboard lowered until it touches

# HEIGHT BOARD






# Positioning subjects for height measurement



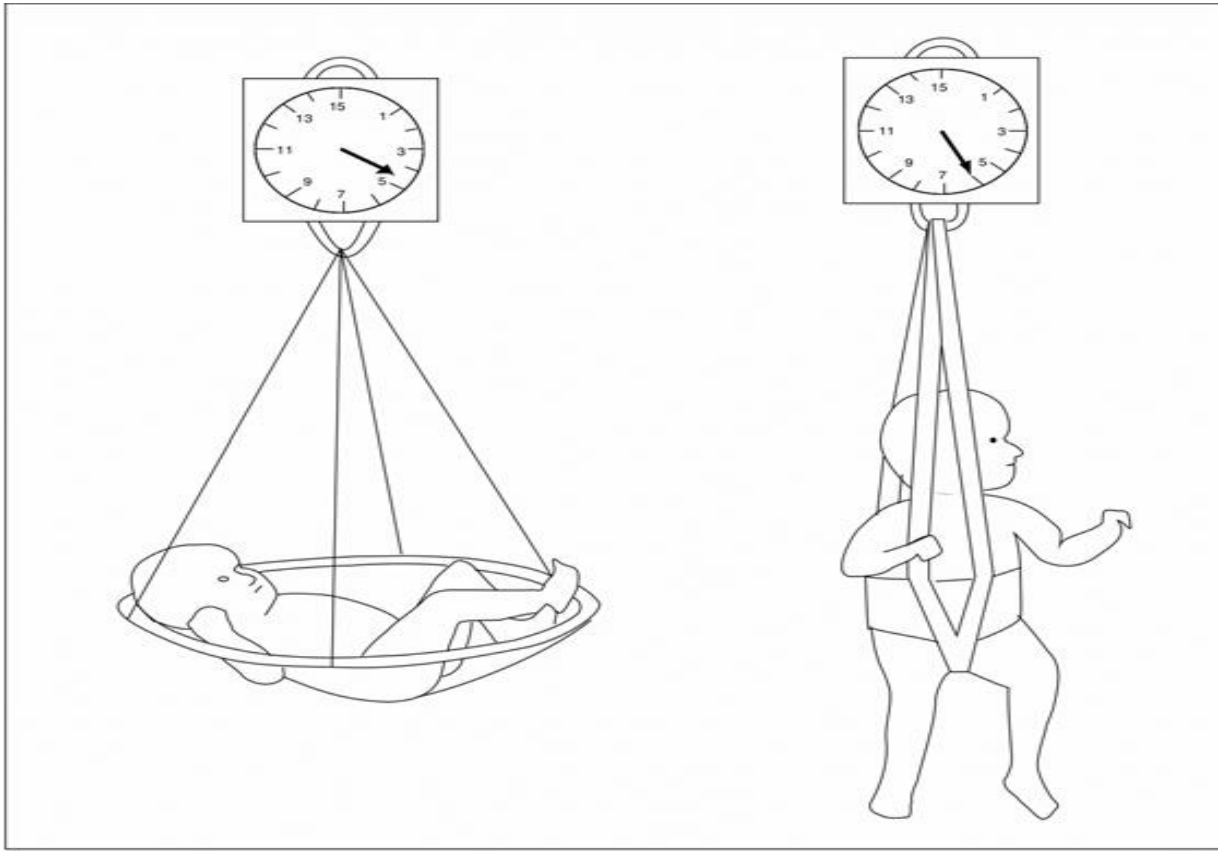
## D. Weight in infants & children

- Suspended scale & weighing sling for infants & children <2yrs
  - Slip the subject on it & record weight when indicator stabilized
- Pediatric scale-used alternatively
  - There should be equal distribution of weight on each sides of the center of the pan
  - Record weight when the infant lay quietly

## Weight cont…

- Beam balance or electronic scale - if no alternative
  - Weigh subjects together with the mother (A)
  - Weigh the mother alone (B)
  - Subjects weight = A-B
- Subjects should be weighed naked or with minimal clothing

Measurement of weight in infants & children
Suspended scale for those < 2 y
Weigh naked



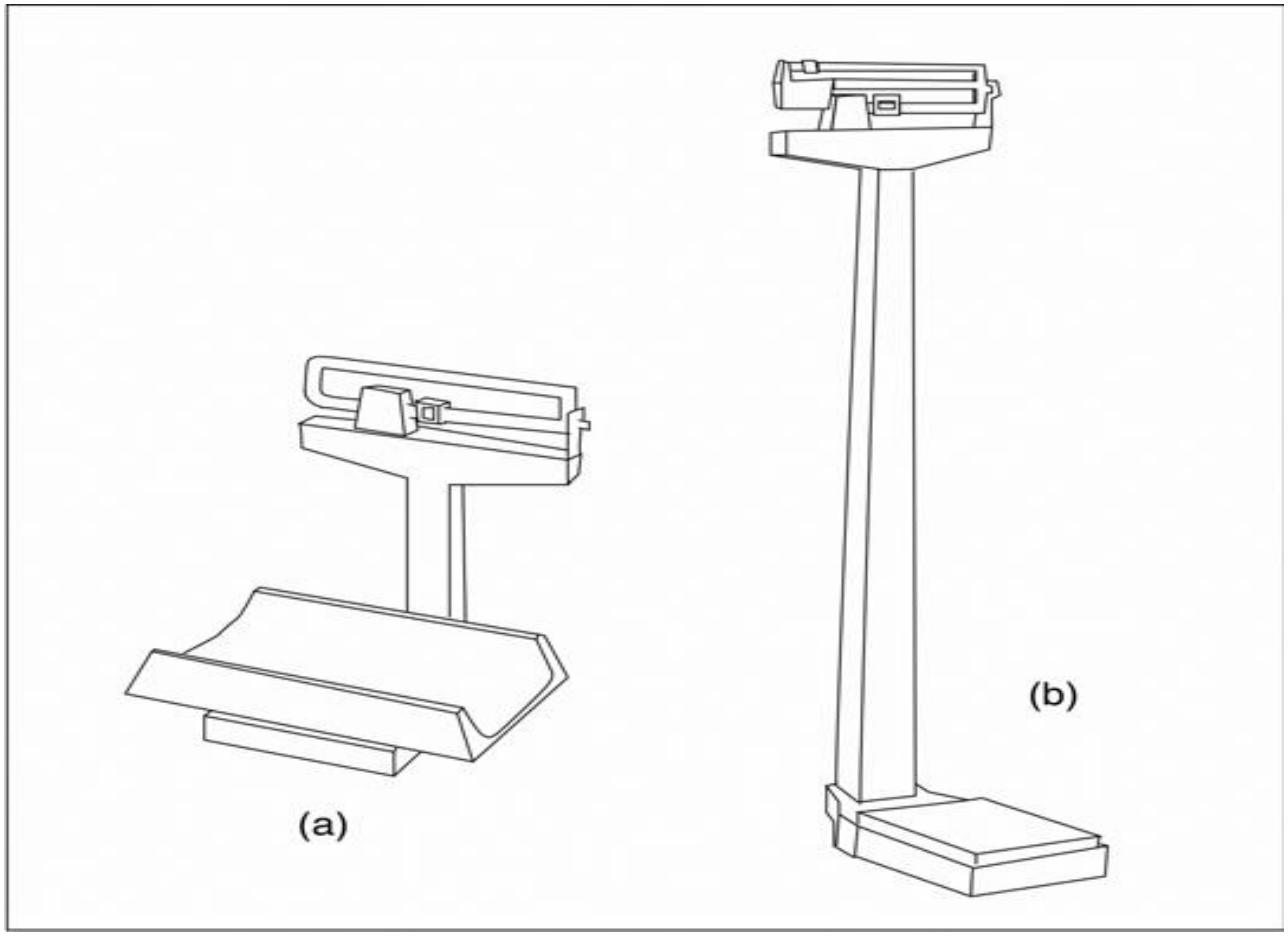
## E. Weight in older children & adults

- Preferably done after the bladder is empty & before meal
- Place balance on hard & flat surface, adjust for zero balance
- Subject stand: at center, look straight ahead, stand unassisted, relaxed, minimal clothing
- Balance should be calibrated with a set of weights

**Measurement of weight in infants, children, adults**

(a) Pediatric balance for infants

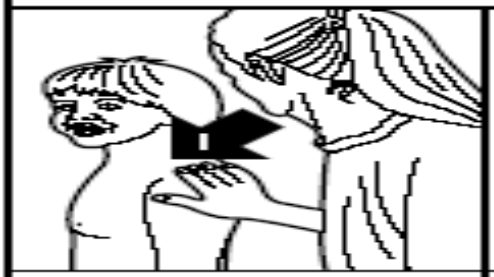
(b)Beam balance for older children & adults



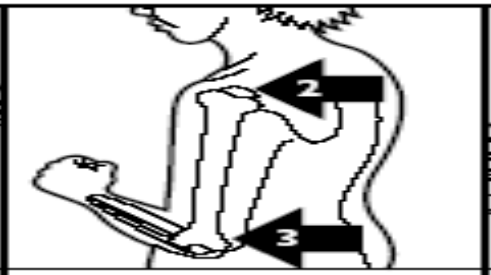
# F. MUAC Tape

- This arm circumference insertion tape measures mid-upper arm circumference of children, up to 25 cm.
- Colour-coded in (**red**, **yellow**, **green**), non-tear, stretch-resistant plasticized paper.
- Supplied in pack of tapes together with written and pictorial instructions for use

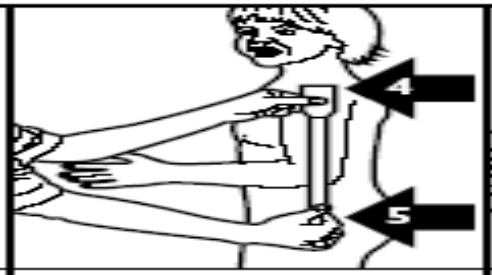
Arm circumference "insertion" tape

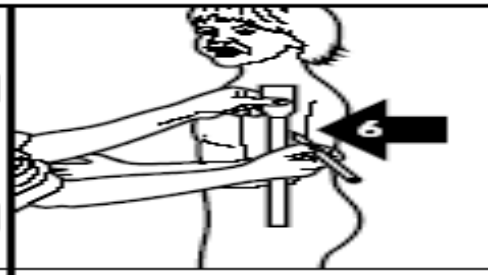

1. Locate tip of shoulder



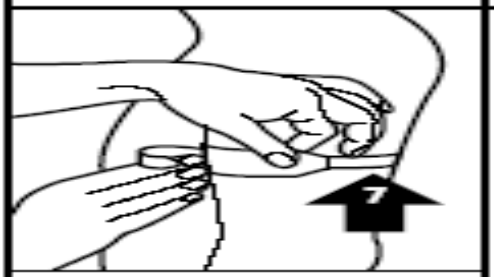

2. Tip of shoulder
3. Tip of elbow



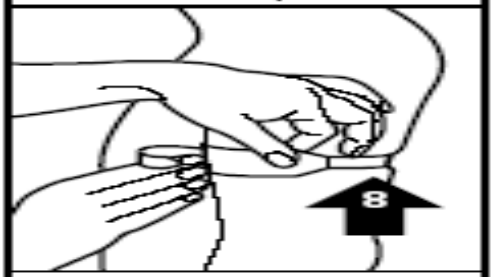

4. Place tape at tip of shoulder
5. Pull tape past tip of bent elbow



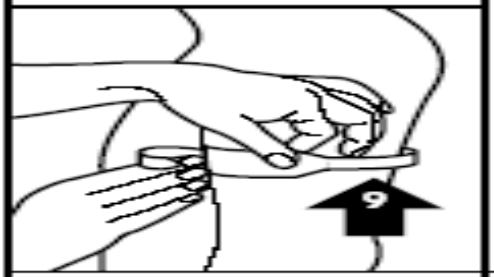

6. Mark midpoint



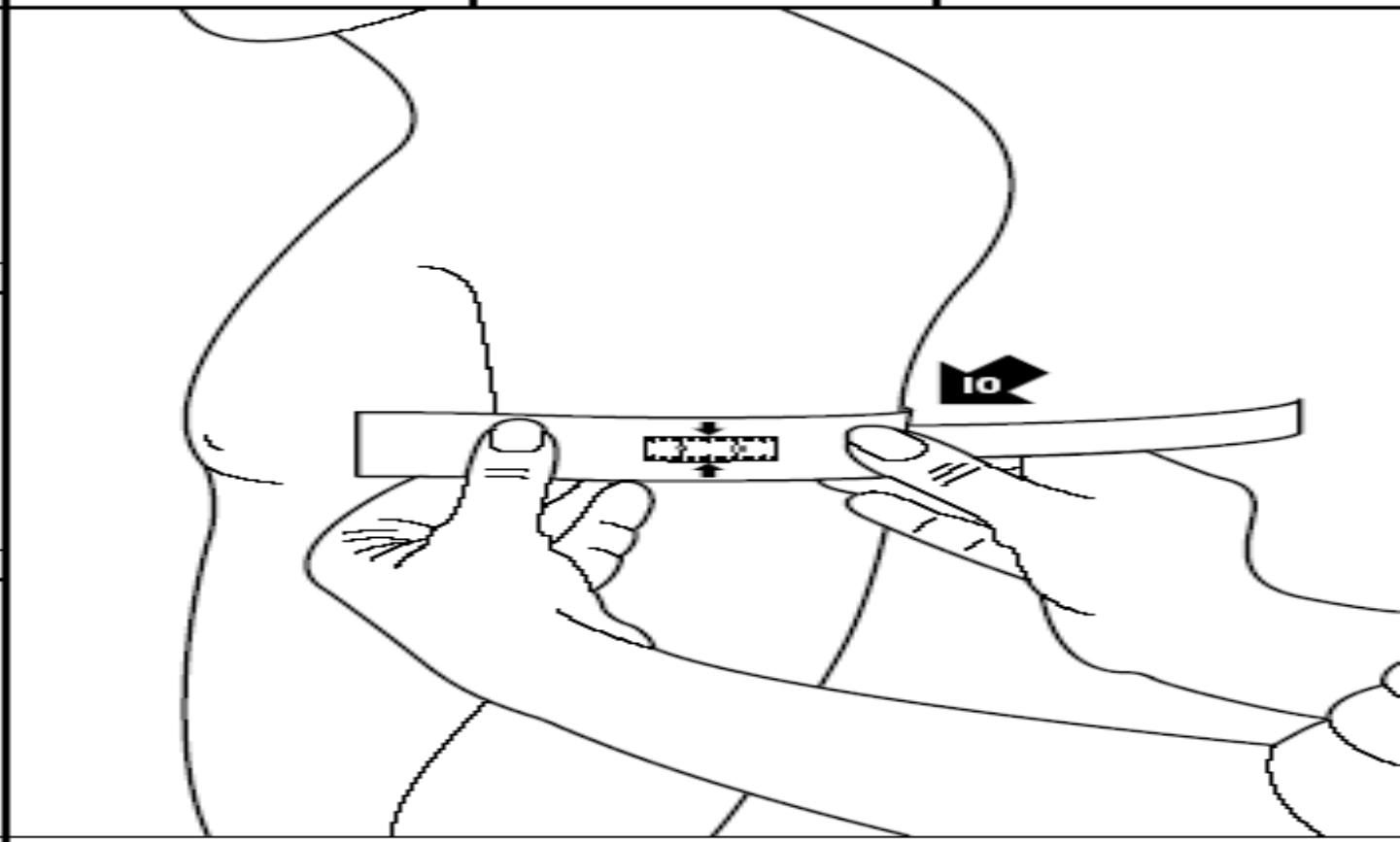

7. Correct tape tension




8. Tape too tight




9. Tape too loose




10. Correct tape position for arm circumference

# MUAC..

# 2.1.2 Anthropometric indices:

- Measurements of the **physical dimensions** and **gross composition** of the body at different levels and degrees of nutrition.
- Particularly useful when chronic imbalances of protein and energy are likely.
- Provides information about past nutritional history.

**Purposes of anthropometric measurements:**

- **In children**: to assess physical growth
- **In adults**: to assess changes in body composition or weight

# Anthropometric indices……

## ✍A. growth

- Derived from two or more *raw measurements*

**1. Weight-for-length or height:** low wt-for-ht = thinness and reflects wasting

- Failure to gain sufficient weight relative to height or losing weight
- Overweight: excess weight relative to height or insufficient height relative to weight
- Stunted children: weight may be appropriate for length

**Weight-for-length or height cont…**

- Poor linear growth should not be considered normal based on WFH alone
- If prevalence of stunting is much higher than wasting use a combination of WFH & HFA
- Useful where age is uncertain
- Independent of ethnicity: age 1-5yrs

2. **Length or height-for-age:** low ht-for-age = shortness and reflects stunting
   - An index of past nutritional status
   - From an extended period of inadequate food intake, poor dietary quality, increased morbidity or a combined effect
3. **Weight-for-age:** low wt-for-age = lightness and reflects underweight
   - Fails to distinguish tall, thin children from those that are short with adequate weight

# Meanings of the indices derived from growth measurements:

$$\text{Weight for Age} = \frac{\text{Weight of the child}}{\text{Weight the normal child of the same age}} \times 100$$

$$\text{Weigh for height} = \frac{\text{Weight of the child}}{\text{Weight of the normal child of the same height}} \times 100$$

$$\text{Height for age} = \frac{\text{Height of the child}}{\text{Height of the normal child of the same age}} \times 100$$

## 4. Head circumference-for-age:

- Reflects chronic PEM in children < 2 yr
- Abnormally low: intrauterine growth retardation or chronic malnutrition
- Non nutritional factors: disease, genetic variation, cultural practices(binding head), difficult or forceps assisted delivery may affect

## 5. Body mass index ( weight/height $^2$ )

- Indicate body weight in relation to height
- Measure of overweight & obesity
- Chronic energy deficiency
- Easy, quick, non invasive & more precise than skinfold thickness
- Does not distinguish weight associated with muscle & fat: elevated BMI: adiposity, muscularity, or edema
- No indication on distribution of fat: use it with skinfold thickness & waist circumference
- Affected by ethnicity

**Age groups for use in presentation of anthropometric data for populations (WHO,1983)**

- **Infants**
  - ✓0 - < 6 mo
  - ✓6 - <12 mo
- **Preschool children**
  - ✓12 - < 24 mo
  - ✓24 - < 48 mo
  - ✓48 - <72 mo
- **Primary school children**
  - ✓72 - < 96 mo
  - ✓96 - <120 mo

# ❑2.2 Assessment of Body composition

# Five levels of body composition assessment

- Atomic level(C, H, N, P, Ca, O)
- Molecular level(fat, Water, protein)
- Cellular level(body cell mass, intra/extra cellular water, intracellular solids)
- Tissue level(adipose tissue, muscle, bone)
- Whole body level(Weight, height, skin folds)

# ASSESSMENT BODY COMPOSITION

## Using Anthropometry

- Whole body level assessment is used:
  - ✓ In assessing body composition we consider the body to be made up of two compartments:
  - ✓ The fat mass and the fat free mass.
  - ✓ Total body mass= Fat mass + fat free Mass.
  - ✓ Therefore different measurements are used to assess these two compartments:

# A. Measurements used to assess fat mass :

- Skin fold thickness
- Waist to Hip circumference ratio
- Waist circumference
- Body mass index

# 1. Skinfolds Thickness

- **Be able to change skinfold thickness measurements to Indices and  Indicators**

- **Measure body fat percent (body composition)using skinfold thickness**

# Skinfold Thickness

- Measures double thickness of skin and subcutaneous fat
- **Advantages:**
  - inexpensive
  - fast
  - portable
  - large database

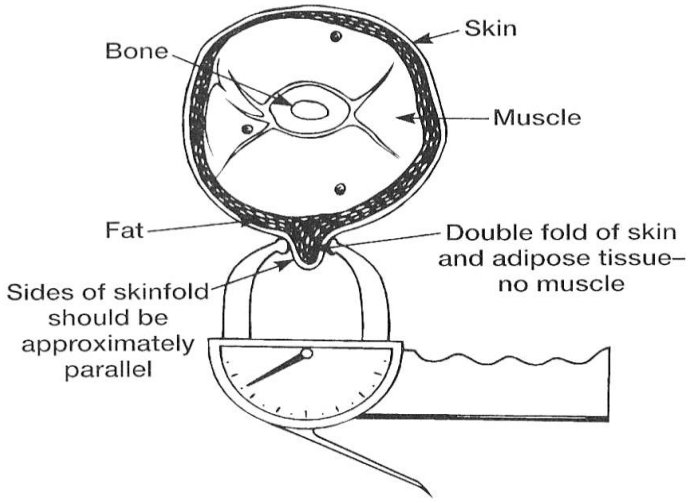
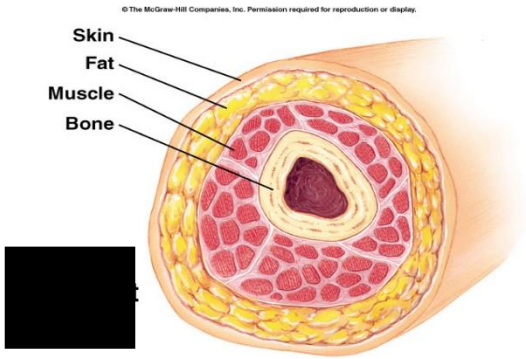


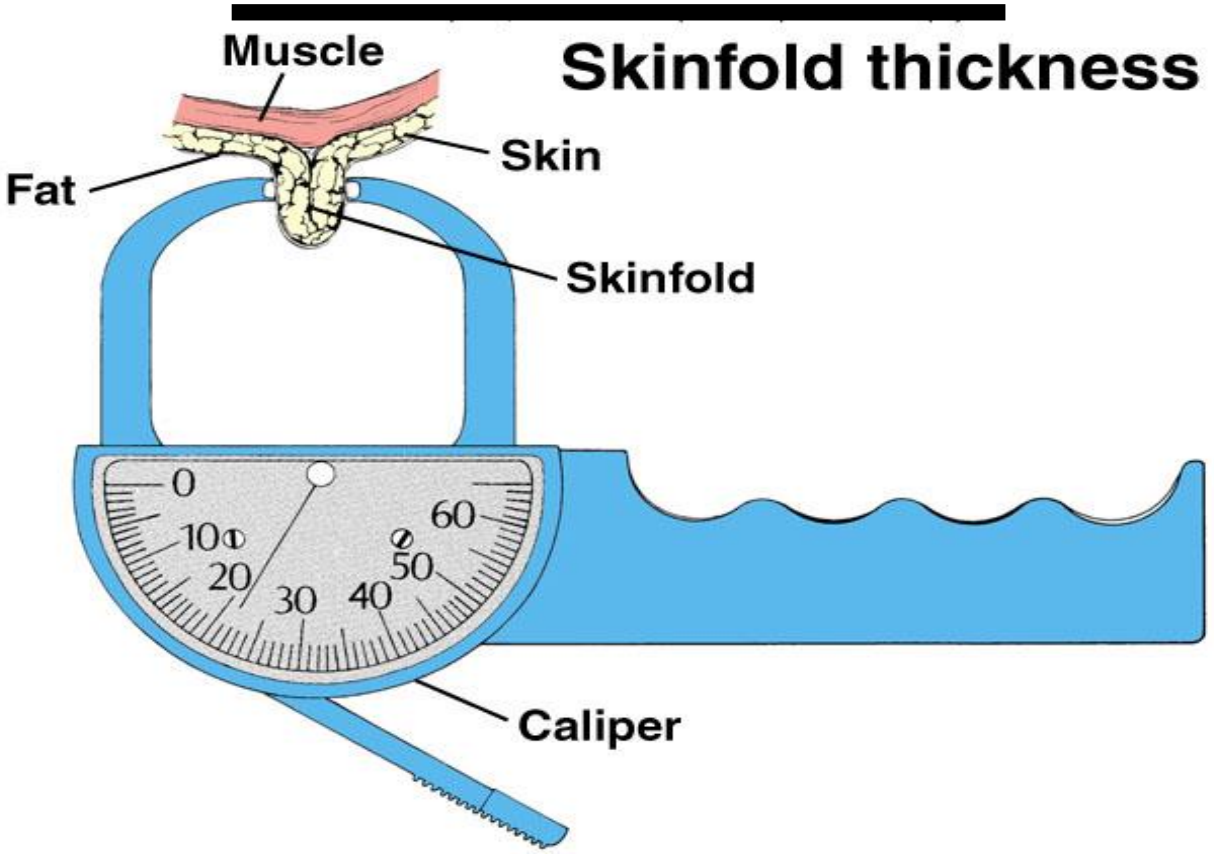

**Figure 6.15**
The double fold of skin and adipose tissue between the tips of the skinfold caliper should be large enough to form approximately parallel sides. Care should be taken to elevate only skin and adipose tissue, not muscle.

# Skinfold …

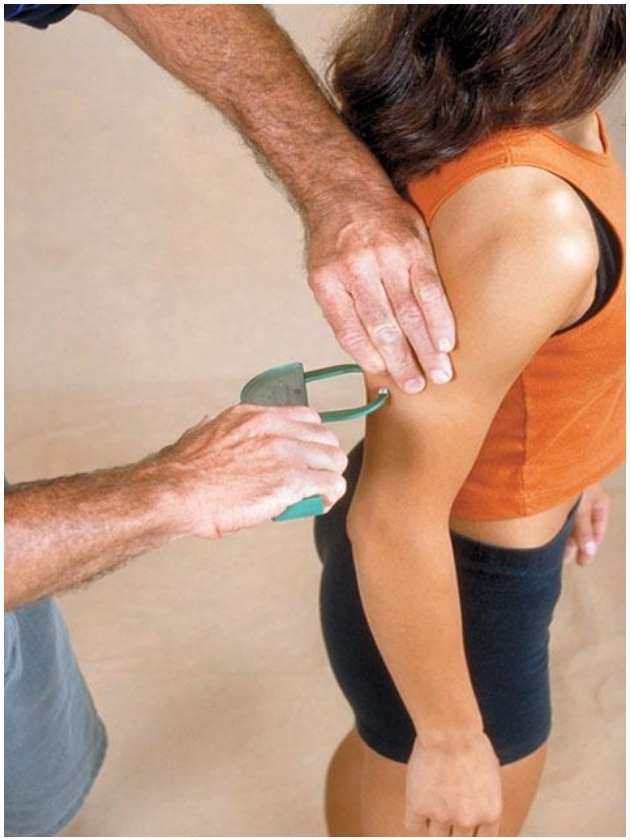
Layers of subcutaneous fat are measured at different sites of body to estimate total body fat levels

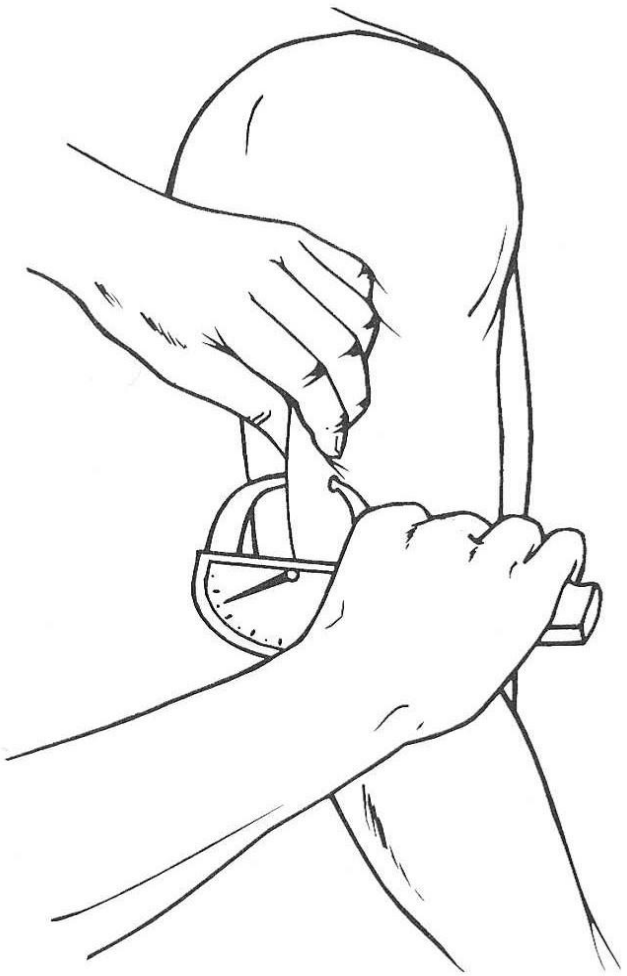



Cross sectional view



# Measuring Skinfold Fat Thickness at the Triceps Skinfold Site





Grasp a double fold of skin and subcutaneous adipose tissue with the thumb and index finger of the left hand.

Place the caliper tips on the site where the sides of the skinfold are approximately parallel and 1 cm distal to where the skinfold is grasped.

Position the caliper dial so that it can be read easily. Obtain the measurement about 4 sec after placing the caliper tips on the skinfold.

**Figure 6.16**
Accurate skinfold measurements require careful site selection and proper technique in placing and reading the caliper.

# Skinfold Thickness

**Assumptions:**

- Sites selected represent average thickness of all subcutaneous fat
- predicts non-subcutaneous fat as well
  - >50% of fat is subcutaneous
- compressibility of fat similar between subjects
- thickness of skin negligible

# Skinfold Thickness

**Limitations**

- Technician error
- Skinfold thickness affected by factors other than amount of fat
  - exercise increases skin thickness
  - dehydration reduces skin thickness
  - edema increases skin thickness
  - dermatitis increases skin thickness
- Poorly predicts visceral fat

# SKIN FOLD THICKNESSES # 3

- Skin fold should be read to the nearest 0.5 mm after 2-3 seconds of caliper application
- Measurements are made in triplicate until readings agree within ± 1.0 mm
- All the measurements should be made on the left side

# Precision skin fold calibers

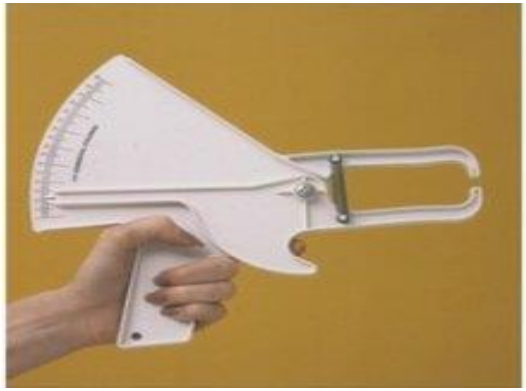
Some of precision skin fold calipers are:

- Lange (USA) measures to the nearest 0.5mm
- Holitain, Harpenden (UK) measures to the nearest 0.2 mm
- Low cost plastic Mcgaw calipers are also available

# SKIN FOLD THICKNESSES # 2

- The measurement should be performed using precision SFT calipers, which have a constant and defined pressure of **10g/sq.mm** through out the range of measured skin folds.

- Other ordinary SFT calipers result in underestimation of the subcutaneous fat as a result of compression.



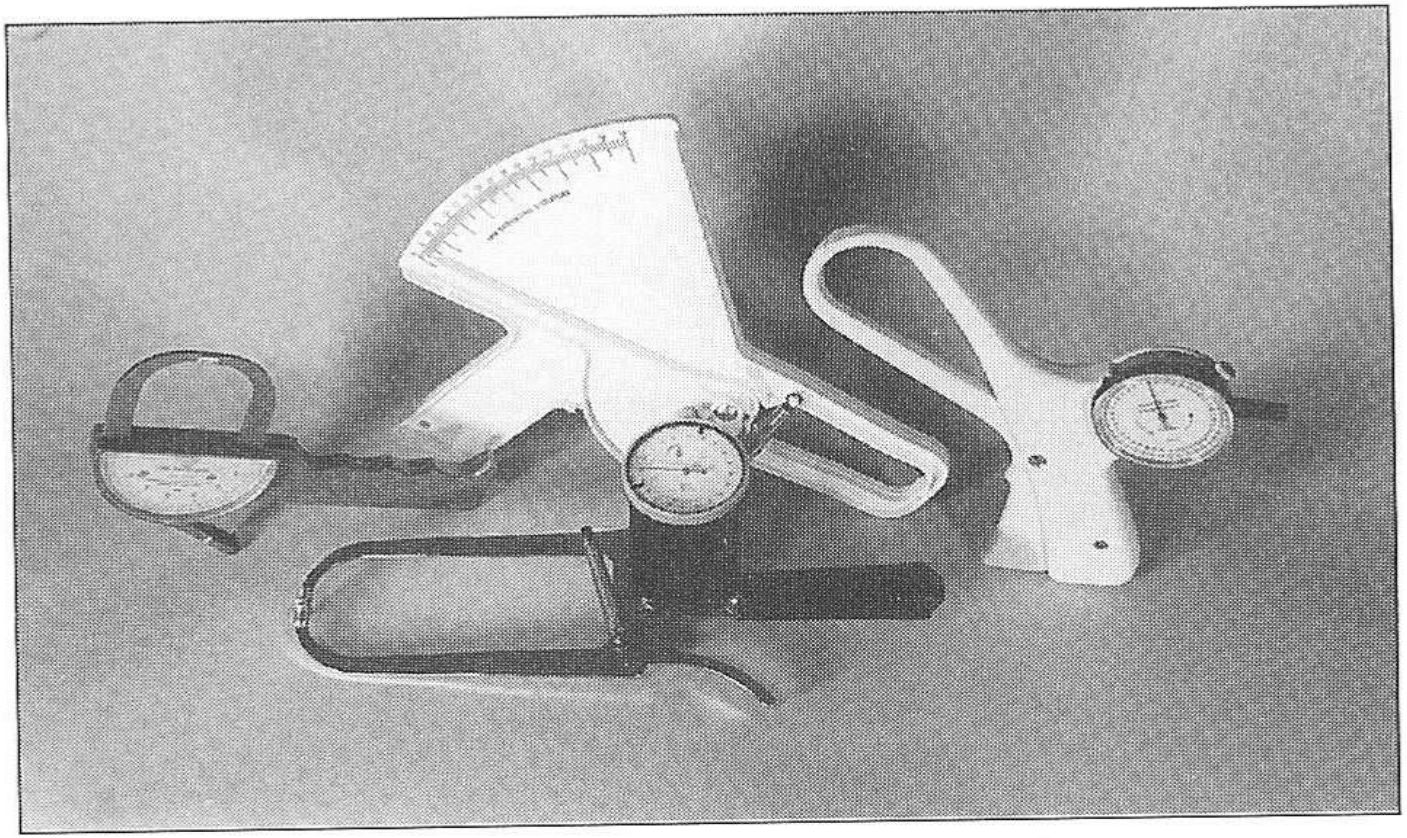


**Figure 6.17** **Examples of commercially available skinfold calipers. Back row, left to right: Lange, Slim Guide, Holtain. Front: Harpenden.**

*Source:* Photo by M. Ware.

# 7 Site Skinfold Measurements

- Triceps.
- Chest/Pectoral.
- Midaxillary.
- Subscapular.
- Suprailiac.
- Abdominal.
- Thigh.

**Single skin folds site**

- Used to estimate total body fat or percentage body fat
- No agreement on best site as index of total body fat
- Triceps most frequent site used

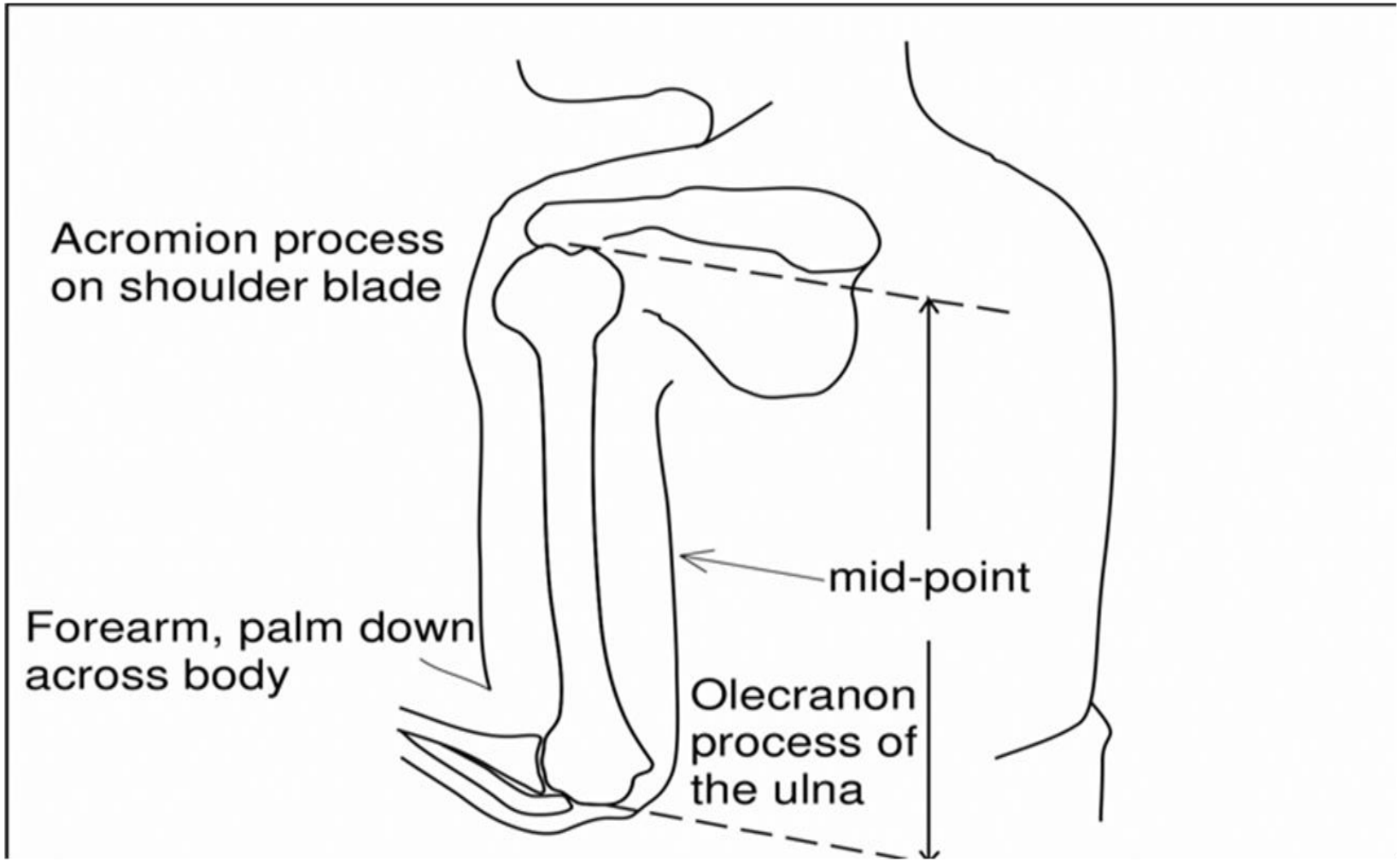
**Multiple skin folds**

- For total body fat: one limb skinfold (e.g., triceps) plus one body skinfold (Subscapular) recommended
- Because the distribution of body fat: depends on ethnicity, age, & sex
- Sites of skin fold thickness measurements are :
- biceps, triceps, Sabscapular and Suprailiac and midmaxillary skinfolds

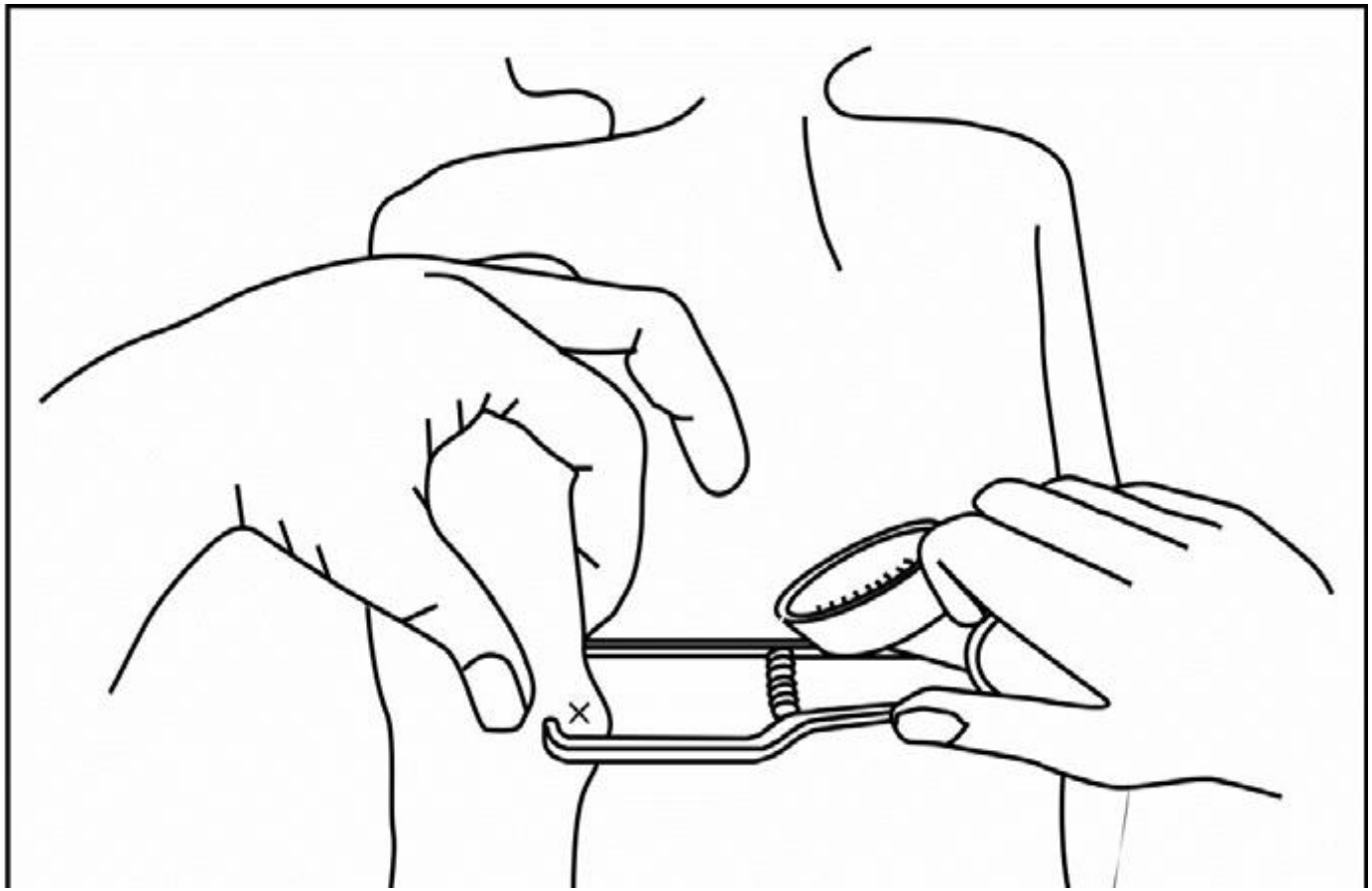
# Measurement of triceps skinfold thickness

- Subjects stands erect, arms hanging freely at sides
- Vertical fold grasped 2 cm above midpoint in line with elbow
- Skinfold pulled away gently from muscle & caliper applied at marked midpoint
- Skinfold held while measurement taken to nearest 0.1 or 0.5 mm Difference between trainee-trainer 0-0.9 mm
- Generally all skin fold measurements
  - Estimate size of subcutaneous fat depot
  - Measure compressed double fold of fat plus skin otherwise leads to underestimation of actual subcutaneous fat
  - Must 1$^{st}$ locate mid-point of back of upper left arm when arm bent at 90$^{0}$
  - Use skin fold calipers of different types

# Measurement of triceps skinfold thickness…..



# Measurement of triceps skinfold thickness…..



- **What indicators can we drive from skinfold thickness measures?**

# Calculating Body fat % from Skin fold Thickness

The calculation of body fat % involves:

- Measuring skinfold sites, triceps, biceps, subscapular and suprailiac…..

- substitute the log of their sum into one of the following equations, Where

D = predicted density of the body (g/ml),

L = log of the total of the skinfolds (mm).

The density value can then converted to percent bodyfat (%BF) using the Siri Equation.

- We can also use body fat calculators
  - http://www.health-calc.com/body-composition/skinfold-d-and-w

# Body density calculations

| age (years) | equations for males | equations for females |
|---|---|---|
| < 17 | D = 1.1533 - (0.0643 X L) | D = 1.1369 - (0.0598 X L) |
| 17-19 | D = 1.1620 - (0.0630 X L) | D = 1.1549 - (0.0678 X L) |
| 20-29 | D = 1.1631 - (0.0632 X L) | D = 1.1599 - (0.0717 X L) |
| 30-39 | D = 1.1422 - (0.0544 X L) | D = 1.1423 - (0.0632 X L) |
| 40 -49 | D = 1.1620 - (0.0700 X L) | D = 1.1333 - (0.0612 X L) |
| > 50 | D = 1.1715 - (0.0779 X L) | D = 1.1339 - (0.0645 X L) |

**L= log (sum of the skin fold thicknesses)**

# SIRI EQUATION

**Assumed Densities:**

FAT MASS(Density) = 0.9 gm/ml

FAT FREE MASS(Density)= 1.1 gm/ml

**Equation:**

**% Body Fat = (4.95/Density) - 4.5) x 100**

# BROZEK EQUATION

**Assumptions:**

**FAT MASS(Density)= 0.9 gm/ml**

**LEAN BODY MASS(Density)=1.095 gm/ml**

**(some essential lipids in Lean Body Mass)**

**Equation:**

**% Fat = (4.57/Density)-4.142) x 100**

# Cut-off for percentage of body fat

| Description | Women | Men |
|---|---|---|
| Essential fat | 10–13% | 2–5% |
| Athletes | 14–20% | 6–13% |
| Fitness | 21–24% | 14–17% |
| "Average" | 25–31% | 18–24% |
| Obese | 32%+<br>>35%(WHO) | 25%+ |

Source: American Council on Exercise

## 2. WAIST TO HIP CIRCUMFERENCE RATIO

- It is the circumference of the waist measured mid-way between the lowest rib cage at the mid-clavicular line and anterior superior iliac spine divided by the circumference of the hip measured at the level of the greater trochanter off the fumer (widest Area) (both are measured to the nearest 0.1cm)

# Cut-off point

The optimal **cutoffs** points for **WHR** were

- >1 in men and
- > 0.85 for in women

**3. Waist circumference: proxy for central fat**

No universally accepted method of measurement

WHO: taken around natural waist at its widest point (Fig.A)

Midway defines WC level *OR* At least 2.5cm above belt (Fig.B)

- cut-off points of 90 cm in men and
- 80 cm in women for the optimum
- Recommended cutoffs for increased health risk are a **waist circumference**
- of more than 102 cm (>40 inches) for men and more than 88 cm (>35 inches) for women. [4].**Waist circumference** is strongly associated with risk of death, independent of BMI.

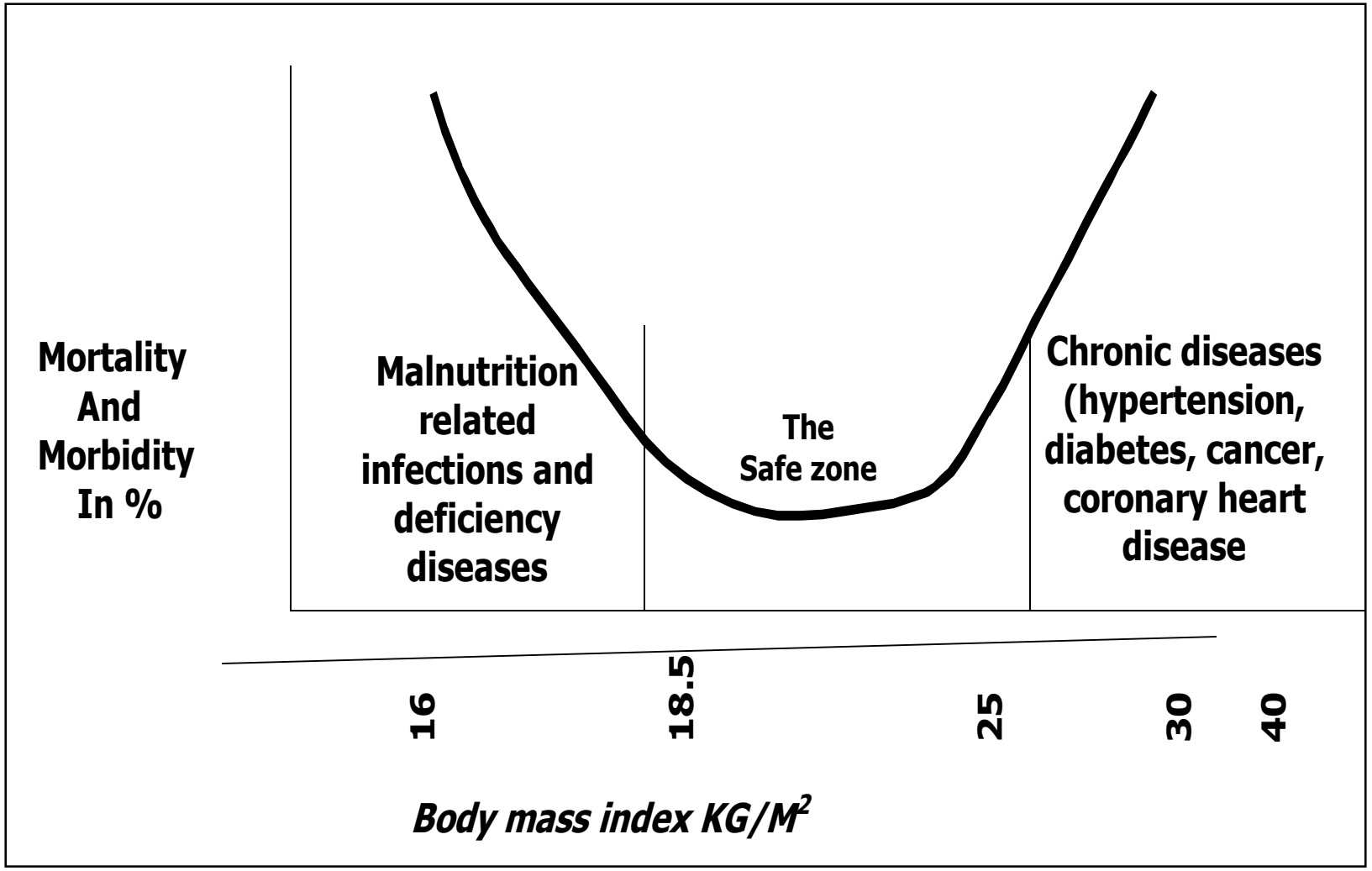
# 4. Body mass Index(BMI)

- ✓ The best method for assessing adult nutritional status as the index is not affected by the height of the person.
  - Best used for individuals between the ages of 20 and 65 years
- ✓ Therefore, it is most frequently used for assessing adult nutritional status

# Cut-off points for BMI

- ✓ ≥ **35** kg/m2 = Very obese
- ✓ 30-34.9 kg/m2 = Obese
- ✓ 25-29.9 kg/m2 = Overweight
- ✓ **18.5-24.9kg/m2 = Normal**
- ✓ 17-18.4 kg/m2 = mild chronic energy deficiency
- ✓ 16-16.9kg/m2 = Moderate chronic energy deficiency
- ✓ < 16 kg/m2 = severe chronic energy deficiency

The classification is based on the mortalities and morbidities associated with either extremities



# BMI...

- **Advantage:**
  - Used in large-scale surveys:
    - Easy, quick, non-invasive
    - More precise than skin folds
- **Disadvantage:**
  - Does not distinguish between weight associated with muscle vs body fat.
  - High BMI may be due to:
    - Excessive adiposity
    - Muscularity
    - Edema
  - No indication of distribution of body fat.

# Arm span and Demi-span and Knee height

- ✓ When it is not possible to measure height as in the case of :
  - Elderly people
  - Kyphosis / Scoliosis
  - People unable to assume erect position
- ✓ Height can be estimated from arm span or demi-span.

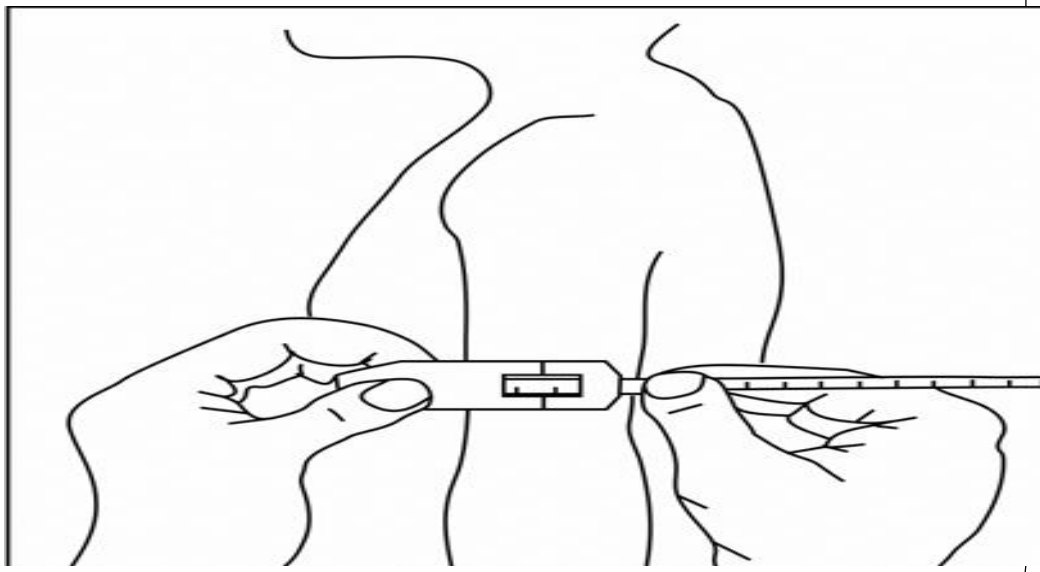
## Arm span and Demi-span and Knee height

- **Arm span:**
  - The distance between the two tallest fingers when a person stretches his/her arm on straight line with 180 degree .
- **Demi-span:**
  - The distance between the roots of the two tallest fingers when a person stretches his/her arm on straight line
- **Knee height:**
  - The distance measured from the heel to the top of the knee.

## 3.2.2 Assessment of fat free mass

### A. Mid-upper arm circumference

Subject erect and sideways to measurer
Head in Frankfurt plane
Measurement taken at marked mid-point upper left arm
Arm must be hanging loosely at side with palm facing inward
Do not squeeze arm



# Mid-upper arm circumference cont …

- MUAC for age can be used to differentiate those with PEM from normal: used for screening
- Measurement taken at mid-point of upper arm
- Flexible non-stretch tape should be used
  - Fibre-glass insertion tape preferred
- Subject should stand erect with head in Frankfurt plane
- Measurement taken at mid-point of upper arm between acromiom process and tip of olecranon
- Precision of measurement must be high as MUAC varies little at any given age
- Difference between trainee and trainer should be 0 – 5 mm

# Mid upper arm circumference (MUAC)

- ✓ Is used for screening purposes especially in emergency situations where there is shortage of human resource, time and other resources as it is less sensitive as compared to the other indices.
- ✓ It is measured half way between the olecranon process and acromion process using non stretchable tap.
- ✓ In children the cut-off points are:
  - Normal > 12.5 cm
  - Mild to moderate malnutrition 11.5-12.5 cm
  - Severe malnutrition < 11.5 cm

# MUAC…

- ✓ It is a sensitive indicator of risk of mortality.
- ✓ Useful for screening of children (6-59 months) for community based nutrition interventions.
- ✓ Useful for the assessment of nutritional status of pregnant women.
- ✓ MUAC < 110(115) mm indicates severe wasting or SAM.
- ✓ MUAC 110(115) to 125 mm indicates moderate wasting or MAM.

# Evaluation of measurement error in anthropometric measurements

| Measurement | Trainee-trainer difference | | |
|---|---|---|---|
| | Good | Fair | Poor |
| Height or length (mm) | 0 – 5 | 6 – 9 | 10 – 19 |
| Weight (kg) | 0 – 0.1 | 0 – 2 | 0.3 – 0.4 |
| Arm circumference (mm) | 0 – 5 | 6 – 9 | 10 – 19 |
| Skinfolds (any) (mm) | 0 – 0.9 | 1.0 – 1.9 | 2.0 – 4.9 |

After Zerfas (1985). Differences greater than those under "Poor" should be taken to indicate gross error

## 2.3 Anthropometric reference data

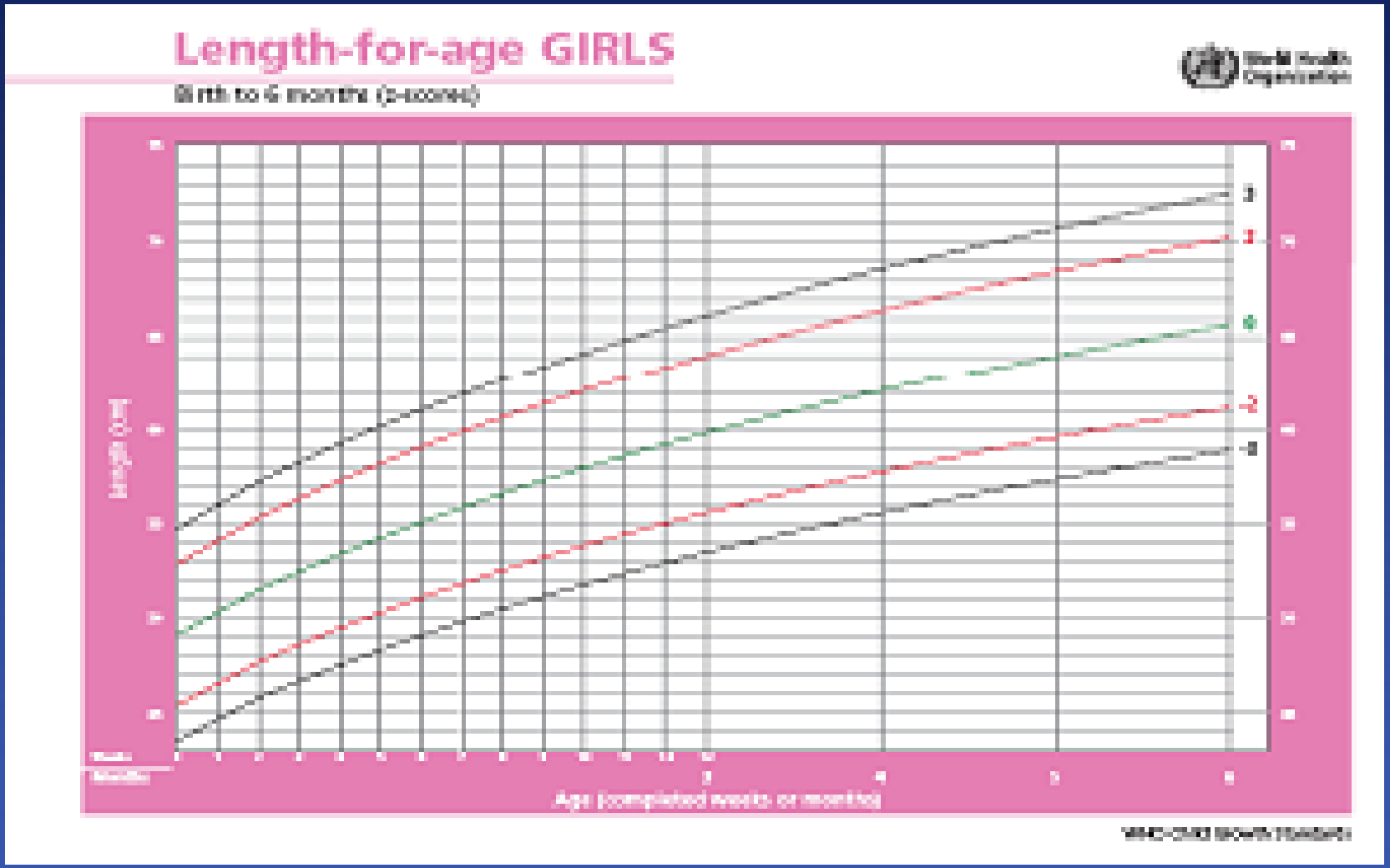
### International growth reference data

- New WHO 2005 growth curves: for children < 5 y
- NCHS/WHO 1977 Reference data for children 2 to 18 y
  - Still recommended for children >5 y – 19y
- Adults: NCHS/WHO 1977 for height at 18 y
- Adults age-specific BMI percentile cutoffs

- NCHS/WHO (1983)*
  - still recommended for:
    - children > 5 yrs
    - adults: height at 18 yrs recommended
    - Based on data from several sources
- NB: * Best used for children < 10y only because of differences in age of peak height velocity for some populations (e.g.: Asians)

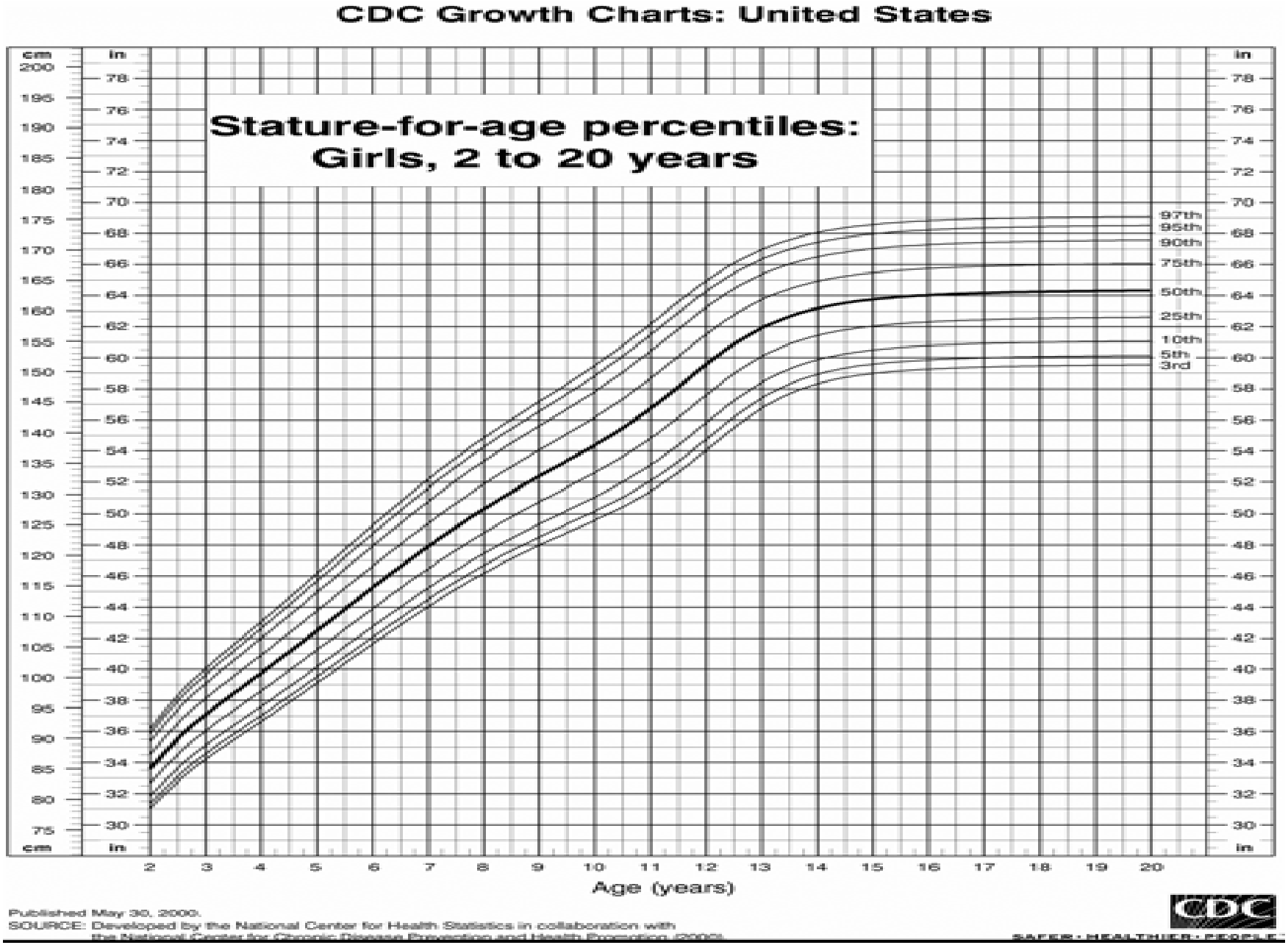
- US National Center for Health Statistics/Center for Disease Control & Prevention (NCHS/CDC) 2000 growth data

# New WHO growth standard: for girls (Z-scores)

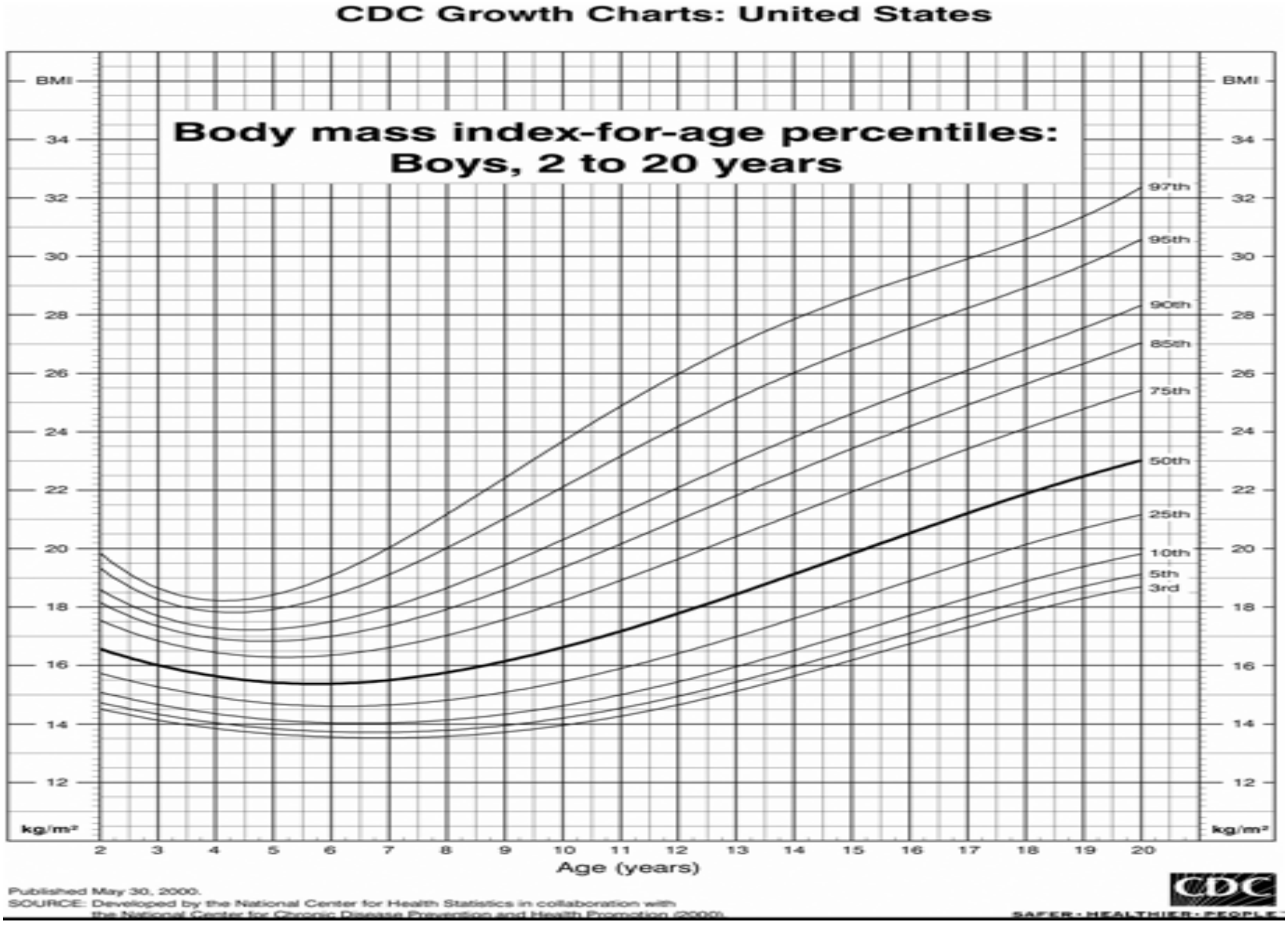


# New WHO growth standard: for boys (Z-scores)

# CDC 2000 Growth Chart. Stature-for age: Girls 2 to 20 y



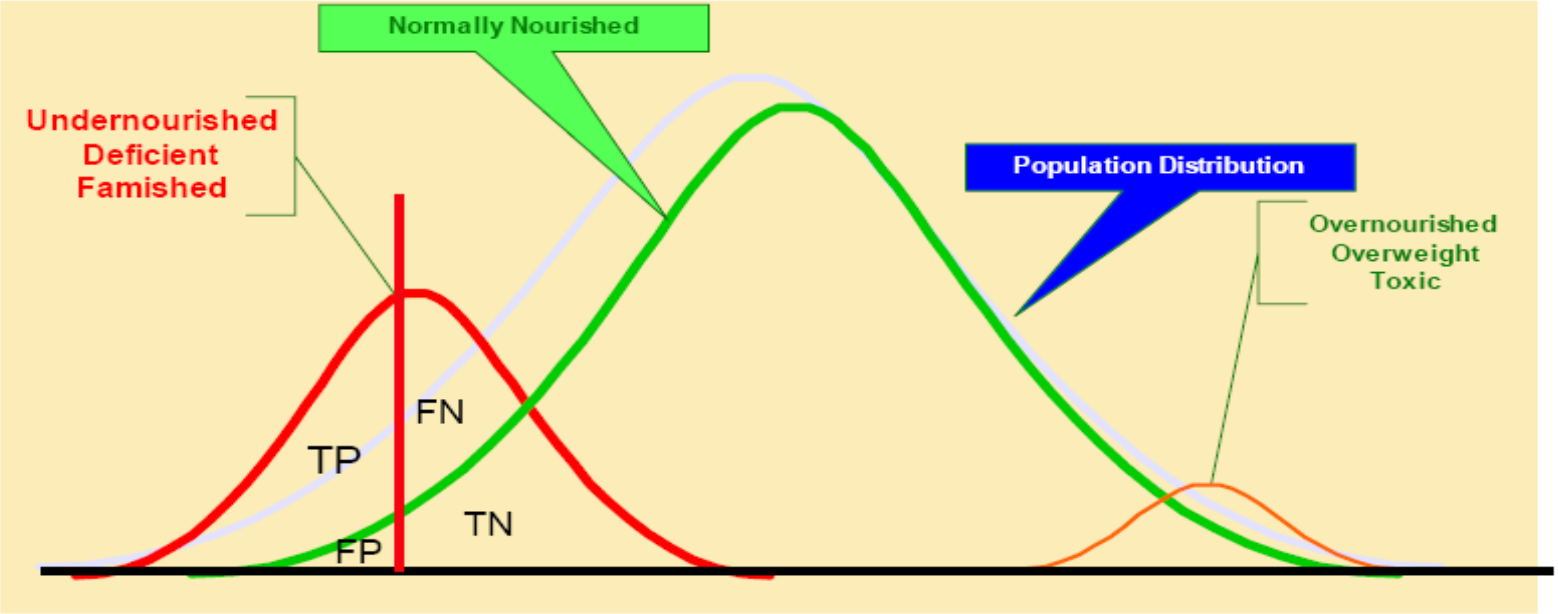
# CDC Growth Charts – BMI for age, Boys 2 to 20 y



# 2.4 Evaluation of Nutritional Assessment Indices

- Nutritional assessment indices can be evaluated by comparison with a distribution of **reference values, or with reference limits** drawn from the reference distribution which is obtained from a healthy reference sample group.

***Population Distributions of Nutritional Status***
***Mostly Undernourished (PEM, Micronutrient Deficiencies)***



## 2.4 Evaluation of anthropometric indices

### A. How to compare growth indices with reference data?

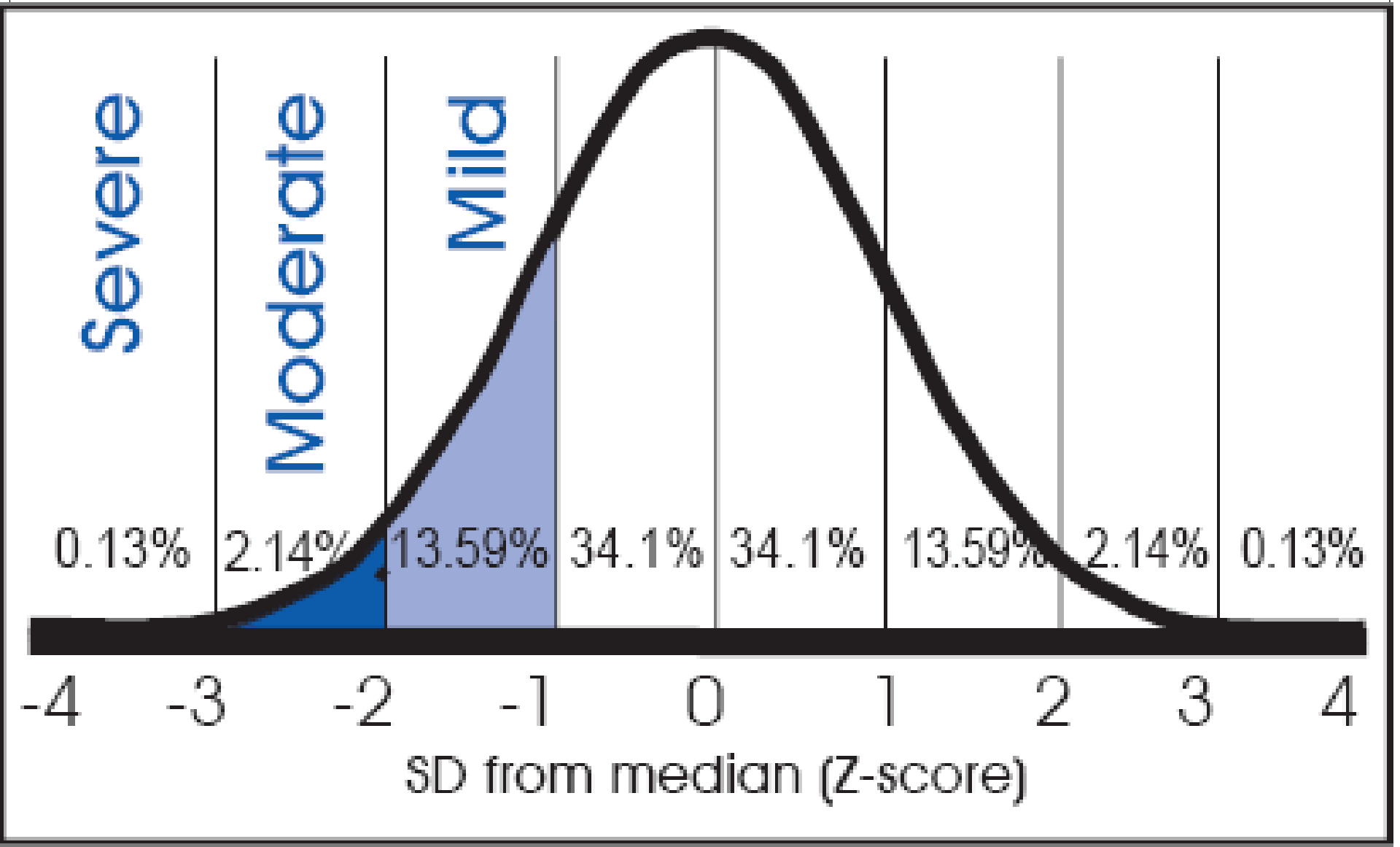
- Taking age and sex into consideration, differences in measurements can be expressed in a number of ways:
  - Z-score
  - Percent of the median
  - Percentiles

## 1. **The Z-score or standard deviation (SD)**

- Is the difference b/n the value for an individual & the median value of the reference population for the same age or height, divided by the SD of the reference population.
- For low income countries exact z-score value calculated using reference SD values

- $$\text{Z-score} = \frac{(\text{observed value}) - (\text{median reference value})}{\text{SD of reference population}}$$

# International Reference Standard Distribution



# Class activity

- If a 6 years old child has:-
  - Weight 13.3 , height 107.5 and
- median values are:-
  - H/A = 118.5
  - W/A = 21.6
  - W/H = 17.6 and standard deviation are 4.9, 3.2, 1.6 respectively.
- Calculate
  a. HFA Z score
  b. WFH Z score
  c. WFA Z score

## 2. **Percentage of the Median**

- The median is the value at exactly the midpoint b/n the largest & smallest
- If a child's measurement is exactly the same as the median of the reference population we say that they are "100% of the median"

$$\text{Percent of median} = \frac{\text{observed value}}{\text{median value of reference population}} \times 100$$

# *Cut off points for acute malnutrition (weight for height)*

- Acute malnutrition based on weight-for-Height in z-scores and percentage of the median

| | Degree of malnutrition | Definition using z-score | Definitions using % of median |
|---|---|---|---|
| **Acute** | None/Mild | ≥ -2.0 | ≥ 80% |
| | Moderate | ≥ - 3.0 but <-2.0 | ≥70% but <80% |
| | Severe | <-3.0 or oedema | <70% or Oedema |
| **Global Acute (GAM)** | Moderate + Severe | <-2.0 and/or Oedema | <80% and/or Oedema |
| **Severe Acute (SAM)** | Severe | < - 3.0 and/ or Oedema | <70% and/or Oedema |

# *Cut off points for chronic malnutrition (height for age)*

- Chronic malnutrition based on Height-for-Age in z-scores and percentage of the median

| | Height for age z-scores | Height for age % of median |
|---|---|---|
| **Normal/Not Stunted** | ≥-2 z-scores | ≥ 90% |
| **Moderate chronic malnutrition** | ≥ - 3.0 but <-2.0 | ≥ 80% and <90% |
| **Severe chronic malnutrition/Severely stunted** | <-3 Z scores | <80% |
| **Total chronic malnutrition/Total stunted (moderate + severe)** | <-2 Z score | <90% |

# *Cut off points for Underweight*

- Underweight based on Weight-for-Age in z-scores and percentage of the median

| Description of Nutritional Status | Weight for Age Index Z scores | Weight for Age % of median |
|---|---|---|
| **Severe Underweight** | <-3 Z scores | <70% |
| **Moderately Underweight** | ≥ - 3.0 but <-2.0 | ≥ 70% and <80% |
| **Total Underweight (moderate plus severe)** | <-2 Z score | <80% |
| **Normal** | ≥-2 Z-scores | ≥ 80% |

## 3. Percentiles

- The percentile is the rank position of an individual on a given reference distribution arranged in order of magnitude.
- Percentiles are stated in terms of what percentage of the group the individual equals or exceeds
- E.g., the child's height-for-age being at the 80th percentile means that 80% of children of his age in the reference population have a height lower than him
- If a boy’s height is 141.8 cm and he is at the 10th percentile, it means 10 percent of boys have a height below 141.8 cm

**Percentiles**

- The percentile reference limits commonly used for designating individuals “at risk” to malnutrition are either below 3$^{rd}$ or 5$^{th}$ percentile or above 97$^{th}$ or 95$^{th}$ percentile
- Used for affluent countries
- Not recommended for low income countries because some persons may have indices *below extreme percentiles*

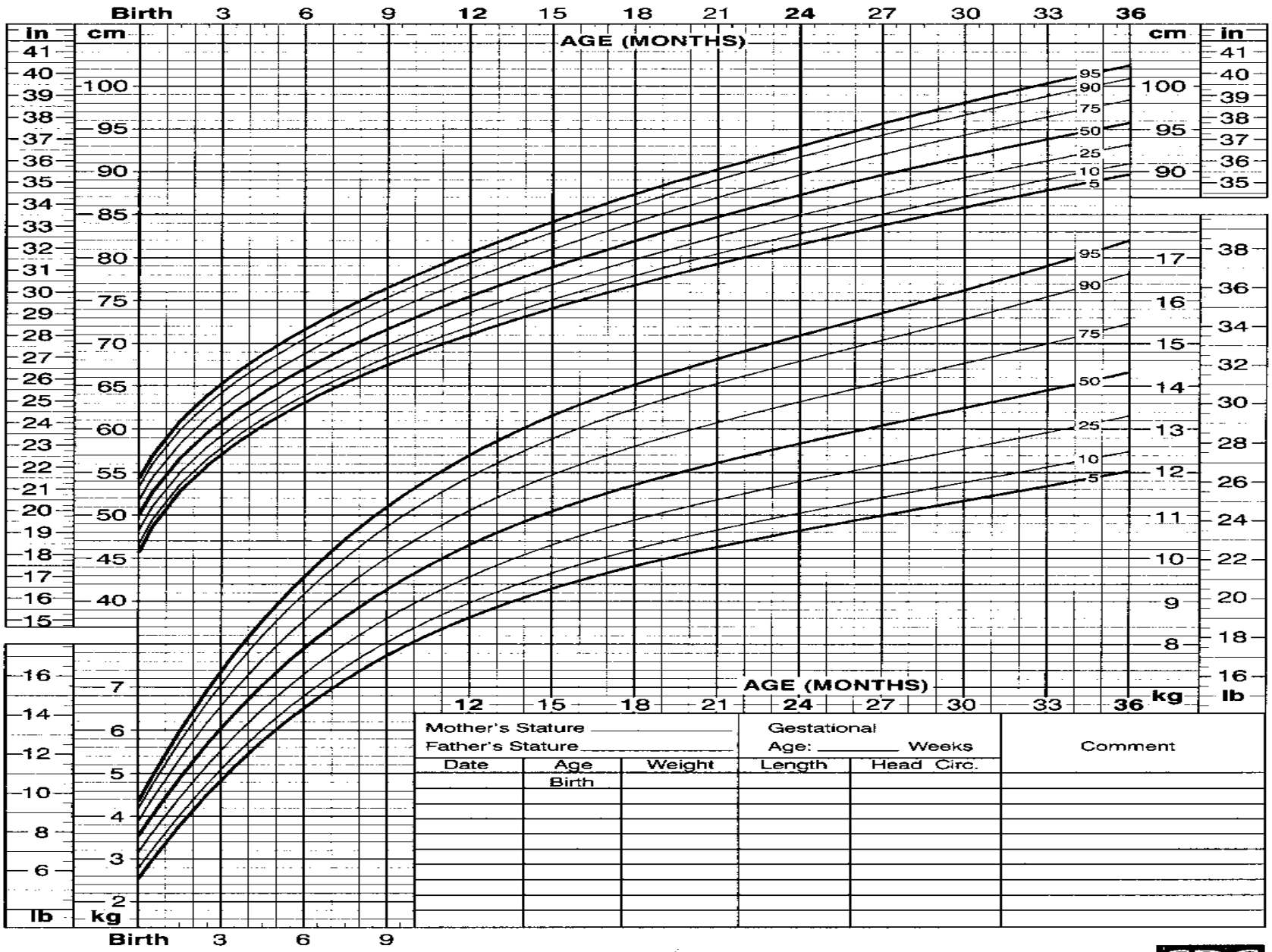
## *Exercise*

- Plot the height & weigh percentiles of a 12 mo old boy weighing 12 kg and being 75 cm.
- What is his weight & length percentile?
- How do you interpret it?

# Birth to 36 months: Boys
## Length-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____




Mother's Stature _____

Father's Stature _____

Gestational Age: _____ Weeks

| Date | Age | Weight | Length | Head Circ. | Comment |
|---|---|---|---|---|---|
| | Birth | | | | |
| | | | | | |
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Revised November 21, 2000.

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

CDC

## Reference limits for defining risk of malnutrition based on SD scores or percentiles

| | | |
|---|---|---|
| Weight-for-age<br>"lightness"- reflects underweight | < - 2SD | <3rd P |
| Weight-for-height<br>"thinness"- reflects wasting | < - 2SD | <3rd P |
| Height-for-age<br>"shortness"- reflects stunting | < - 2SD | <3rd P |

NB: NCHS/CDC2000 used 3rd P

# WHO criteria for assessing *severity of* under- nutrition in children < 60 months

| | Percent Prevalence | | | |
|---|---|---|---|---|
| Indicator | Low | Medium | High | V High |
| Underweight | <10 | 10-19.9 | 20-29.9 | ≥30 |
| Stunting | <20 | 20-29.9 | 30-39.9 | ≥ 40 |
| Wasting | <5 | 5-9.9 | 10-14.9 | ≥15 |

From Gorstein et al. (1994)

# Growth Monitoring and Promotion {GMP}

- GMP  is a periodic measurement of the weight of under five children.
- It is important to detect nutritional problems earlier.
- GMP is a simple and powerful tool to:
  - Monitor the growth of children
  - Detect growth faltering early before it becomes too late
  - Assess and make the growth pattern of a child visible to the parents

## Using a child growth card to assess nutritional status (Weight for Age)

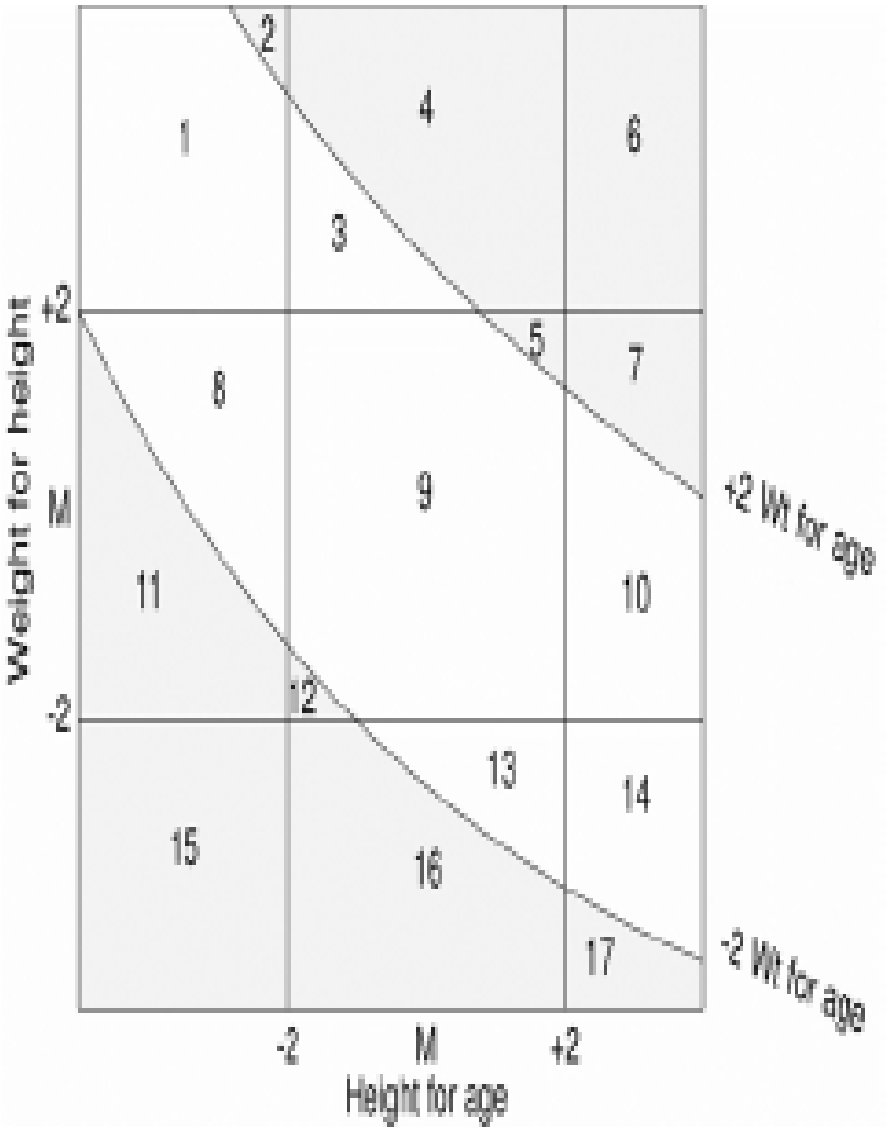
- Determine age of child in months
- Weigh child (lightly dressed)
- Plot weight of child against age in months
- *Determine if point is the normal or indicating under nutrition*
- Direction of growth is important, so more than one point in time is desirable

**Using multiple growth indices for screening, &/or assessing response to interventions**

- Three growth indices often used
  - wt-for-ht; ht-for-age, wt-for-age
  - each can be classified as: low; normal, high based on reference limits i.e. percentiles or Z-scores
- Combination yields following possible interpretations:
  - Normally fed with past history of malnutrition
  - Normal
  - Tall, normally nourished
  - Currently underfed
  - Obese
  - Currently overfed with past history of malnutrition
  - Overfed but not necessarily obese

# Using a combination of growth indices

- Use of wt-for-ht + ht-for-age + wt-for-ht useful to identify children "at risk" and to evaluate an intervention
- Figure shows relation between classifications of "low", "normal", and "high" for the three growth indices based on 2 Z scores below and above the NCHS/WHO reference data
- Note children falling within the lower stippled area have wt-for-age < - 2 Z-scores and are "light"; those within upper stippled area are "heavy"
- Numbered areas are different combinations of low, normal, high for three indices



# Classifying Nutritional status of Adults using BMI

| Adult BMI level | Nutritional Status |
|---|---|
| <16 $kg/m^2$ | Severely Malnourished |
| 16-16.99 $kg/m^2$ | Moderately malnourished |
| 17-18.49 $kg/m^2$ | Mildly malnourished |
| 18.5-24.99 $kg/m^2$ | Normal weight |
| 25-29.99 $kg/m^2$ | Overweight |
| >30 $kg/m^2$ | Obese |

**NB. BMI is not used for pregnant and lactating mothers rather MUAC is used?**

# Classifying Nutritional status of 5-17 years using BMI

| **Age 5-17** | **Nutritional Status** |
|---|---|
| <-3 SD | Severely Malnourished |
| -2 to -3 SD | Moderately malnourished |
| -1 to -2 SD | Mildly malnourished |
| >-1 | Normal weight |

# Classifying Nutritional status of 6 months to 5years old children using MUAC

| **MUAC cut-off points** | **Nutritional Status** |
|---|---|
| < 11 cm | Severe Acute Malnutrition |
| 11-12 cm | Moderate Acute Malnutrition |
| >12 cm | Not malnourished |

# Classifying Nutritional status of 5-14 years using MUAC

| **Age In years** | **MUAC level** | **Nutritional Status** |
|---|---|---|
| 5-9 | <135 mm | Severe malnutrition |
| 10-14 | <160 mm | |
| 5- 9 | < 145 mm | Moderate malnutrition |
| 10-14 | < 180 mm | |
| 5- 9 | >145 mm | Normal |
| 10-14 | > 180 mm | |

# MUAC cutoff for pregnant and lactating women

| Nutritional Status | Severe acute malnutrition | Moderate acute malnutrition | Normal |
|---|---|---|---|
| MUAC level | <18.0cm | 18-21 cm | > 21 cm |

# *Classification of Nutritional Status Based Anthropometric Indices*

# General Classification of Child Undernutrition by Anthropometry

## 1. (Waterlow Classification)

| Ht-for-Age / Wt-for-Ht | Normal (> - 2 SD HAZ) | Stunted (< - 2 SD HAZ) |
|---|---|---|
| Normal (> - 2 SD WHZ) | Normal | Stunted |
| Wasted (< - 2 SD WHZ) | Wasted | Stunted & Wasted |

JC Waterlow BWHO 1977;55:489

**Advantage:** Differentiates between "wasting" and "stunting"

**Limitations:** The need for height, weight and age and the relative complexity of the classification could be a disadvantage in some situations

# 2. The Gomez Classification

**Indicator: Weight-for-age**

| % Expected Weight for Age | Category of Nutritional Status |
|---|---|
| 90-109% | Normal |
| 75 - 89% | 1st degree malnutrition (mild) |
| 60 - 74% | 2nd degree malnutrition (moderate) |
| < 60% | 3rd degree malnutrition (severe) |

**Limitations:** ** Now used only in few countries

# Disadvantages of Gomez classification

- ✓ The cut off point 90% may be too high as many well-nourished children are below this value,
- ✓ edema is ignored and yet it contributes to weight
- ✓ Does not take account of height differences.
- ✓ Age of the child must be known.
  - Difficult to know in developing countries (agrarian society).
- ✓ It does not indicate the duration of malnutrition.
- ✓ It does not also differentiate between kwashiorkor and marasmus.

# 3. The Welcome Classification

**Indicator: Weight-for-age and edema**

| % expected Weight for Age | OEDEMA | |
|---|---|---|
| | Present | Absent |
| 80 - 60 | Kwashiorkor | Underweight |
| < 60 | Marasmic-Kwashiorkor | Marasmus |

**Advantage: Useful for classifying more severe forms of malnutrition**

# Disadvantages

- ✓ Does not differentiate:
  - ✓ Acute malnutrition (for emergency planning) and
  - ✓ Chronic malnutrition( for food security planning).
- ✓ Depends on knowledge of the child's age.
- ✓ Does not take height differences in to account.

***OEDEMA***

# Alternative Classification of Wasting Status of Children

| Ht-for-Age / MUAC (cm) | Normal (> - 2 SD HZ) | Stunted (< - 2 SD WHZ) |
|---|---|---|
| Normal (≥ 12.5) | Normal | Stunted |
| Wasted (< 12.5) | Wasted | Stunted & Wasted |

MUAC=mid-upper arm circumference

## Evaluation of data for studies of anthropometry among populations

- Compare the *distribution of anthropometric indices with* the reference population using:
  - percentiles : for affluent countries
  - standard deviation scores (Z-scores): for low-income countries
- Calculate number & % of persons with anthropometric indices at low levels compared to reference
- Calculate mean Z-scores for growth indices across countries
  - provides no information on distribution of indices

## Uses of anthropometric data: at population level

- For international comparisons of growth
- To identify trends in growth over time
- For nutritional surveillance
  - continuous monitoring of population in emergencies
- For targeting interventions
- For assessing response to an intervention
- Identifying determinants and consequences of malnutrition

## Assessing response to an intervention

- At least *two measurements are needed, taken* before and after the intervention
- Difference in population mean Z-score of chosen indicator is then calculated; *OR*
- Difference in proportion of population below chosen reference limit of indicator is calculated
- Choice of indicators is critical
  - depends on type and length of intervention; baseline anthropometry; study design; time delay before indicator can be expected to show evidence of change

## Screening adults & children at individual and population levels for risk of chronic energy deficits & obesity

### Screening individuals at risk to underweight, & obesity based on anthropometry

#### Adults

- BMI: for under- weight, over-weight and obesity
- Waist: Hip circumference:
  - Waist: proxy for central fat
  - Hip: proxy for peripheral fat
- Waist circumference: Proxy for central fat

**Screening individuals at risk to underweight, & obesity based on anthropometry**

**Children**

- Weight-for-height Z scores: under-weight and over-weight
- BMI percentiles: overweight and obesity

# WHO classification scheme for adults based on low BMI

**Chronic energy deficiency (FAO) or thinness (WHO) in adults**

- **Normal** > 18.5
- **Grade I** 17.0-18.4
- **Grade II** 16.0-16.9
- **Grade III** <16.0

# WHO classification to assess public health significance of low BMI's

| Situation | Percent w. BMI < 18.5 |
|---|---|
| Low prevalence | 5-9 |
| Medium prevalence | 10-19 |
| High prevalence | 20-39 |
| Very high prevalence | > 40 |

# WHO classification scheme to screen for overweight for adults based on BMI

| Classification | BMI | Risk of comorbidities |
|---|---|---|
| Normal range | 18.5 - 24.99 | Average |
| Overweight | ≥ 25 | |
| Pre-obese | 25.0 - 29.99 | Increased |
| Obese class I | 30.0 - 34.99 | Moderate |
| Obese class II | 35.0 - 39.99 | Severe |
| Obese class III | ≥40.00 | Very severe |

## Rational for use of BMI as index of body fatness in adults

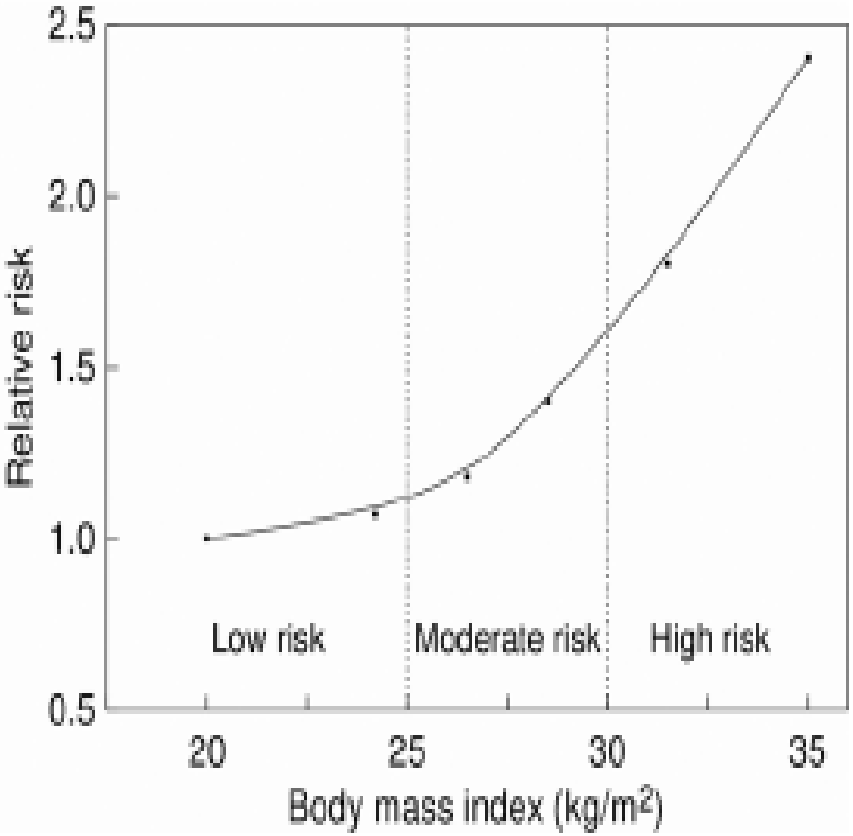
- BMI correlates well with percent body fat
- BMI unbiased by height
- Height and weight are quick; non invasive; more precise than skinfolds
- BUT:
  - high BMI could = lean or fat
  - Provides  no information on distribution of body fat

# Relationship between BMI and relative risk of mortality

As BMI increases, risk increases of:

- High blood pressure
- Type 2 diabetes mellitus
- Other CVD risk factors
- Mortality

From WHO (2000)



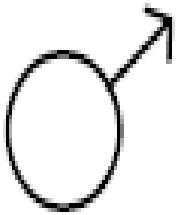
# BMI and measures of body fat and disease risk

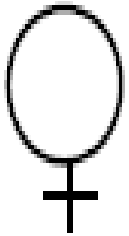
- BMI said to be an independent index of body fat
  - subjects with same BMI said to have *same relative fatness* irrespective of age, sex, ethnicity
- BUT: relationship b/n BMI & body fat depends on:
  - Age: older women more percent fat than younger women with same BMI
  - Sex: women more fat than men for same BMI
  - Ethnicity: Chinese, Asian Indians, Indonesian more percent fat than Caucasians for same BMI
  - Pacific islanders: less percent fat for same BMI

# Health risks also associated with regional body fat distribution as well as total body fat

Fat can be stored primarily in the central or peripheral regions

| Central | OR | Peripheral |
| --- | --- | --- |
| android | | gynoid |
| upper body | | lower body |
| apple | | pear |





## Health risks associated with central body fat

**Central fat consists of:**

- visceral (intra-abdominal) fat
- subcutaneous fat
  - increased health risk due mostly to visceral fat

**Central fat:**

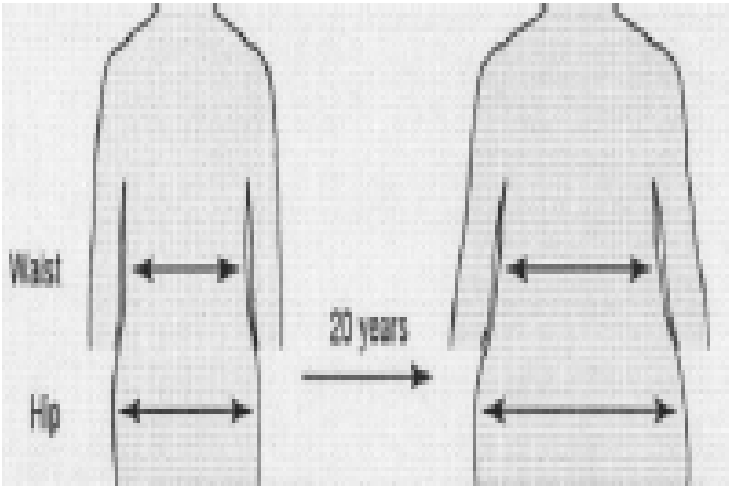
- tends to be greater in men; related to testosterone and other factors
- tends to increase with age
- women put on more central fat after menopause
  - protected by oestrogen in pre-menopausal women

## Waist-hip circumference

- Distinguishes fatness in lower trunk (hip & buttocks) (mainly subcutaneous) and in upper trunk (waist & abdomen)
- WHR correlates with total body fat
- Elevated WHR strongly associated with increased risk of CHD, stroke, type 2 diabetes in childhood, adolescents, adults

# Limitations of waist: hip circumference ratio

- W:H ratio measurement can be misleading in longitudinal studies.
- Here W:H ratio is stable over 20 yrs despite accumulation of visceral adipose tissue which would have been predicted from 20cm increase in waist
- Thus waist circumference is a crude index of the absolute amount of abdominal tissue whereas W:H ratio is an index of the relative accumulation of abdominal fat




| | | |
|---|---|---|
| BMI | 24 | 35 |
| Waist | 80cm | 100cm |
| Hip | 100cm | 125cm |
| WH ratio | 0.8 | 0.8 |

From BMJ March (2001)

## Cutoffs for waist-hip circumference ratio

- WHO: adult cutoffs: M, > 1.0 ; F, > 0.85
- Cutoffs may vary with: age, sex, race, geographic region, degree of overweight
- Ability of serial measurements of WHR to assess changes in intra-abdominal fat over time uncertain
- Negative correlation of WHR with serum HDL across age, sex, ethnicity in children from NHANES III: may be useful to assess atherosclerosis risk in childhood
- More research to establish need for ethnic-specific cutoffs

## Rational for using waist circumference (WC)

- Studies shows that:-
  - WC more strongly associated with total body fat than WHR
  - Higher correlations between WC and abdominal visceral fat than with WHR
  - WC better index of central adiposity than WHR
  - WC more closely related to atherogenic metabolic disturbances associated with abdominal obesity than WHR

## Adult cutoffs for waist circumference for risk of abdominal obesity

- WHO cutoffs for Caucasians :
  - M>102cm;F>88cm
- WHO cutoffs for urban Asians: lower
  - M > 90 cm; F > 80 cm
  - high rates of obesity-related disorders
  - more prone to central adiposity
- Use of universal cutoffs for WC to delineate health risks may not be appropriate
- Additional population-specific cutoffs needed

## Methods for screening for overweight in children and adolescents

### ✍ Weight-for-height

- Greater than + 2 Z scores
- Omits adolescence

### ✍BMI percentiles

- U.S classification
  - 85th P: risk of overweight; > 95th P: overweight
- WHO classification
  - cutoff based on Cole approach

## Basis for use of BMI as indicator of overweight & obesity in children

- Strong +ve correlations b/n BMI and fatness
- Association b/n BMI or changes in BMI & risk factors for CHD
  - increased blood pressure; adverse lipoprotein profiles; late onset diabetes; early atherosclerotic lesions
- BMI in childhood tracks more closely with BMI in adulthood than skinfolds
- Boys with BMI > 75th P have increased risk of mortality from all causes, CHD, cerebrovascular disease

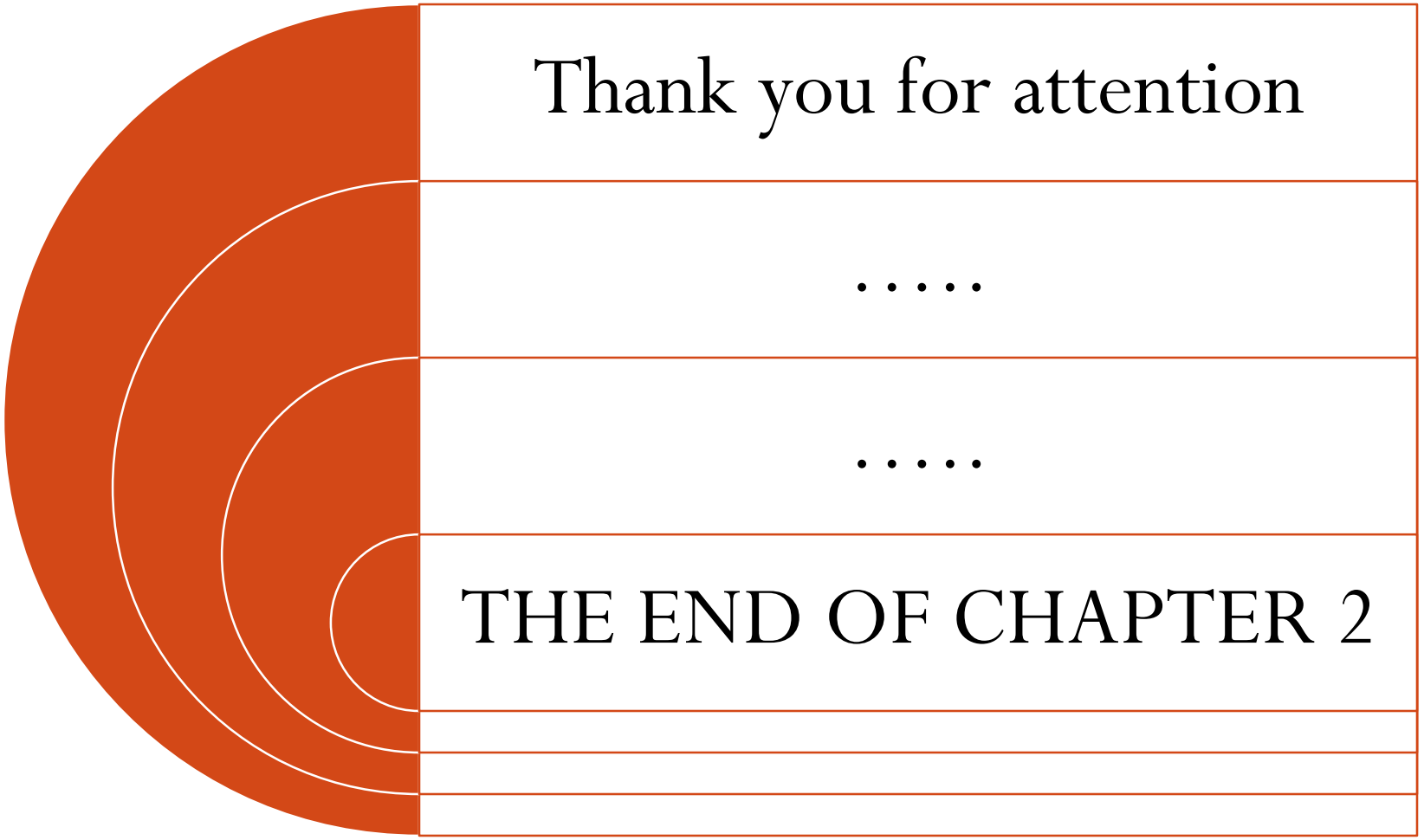
## WHO classification for overweight and obesity in children: Cole approach

- Cutoffs for *overweight by sex from 2-18 y, defined to* pass through BMI = 25 at 18 y
- Cut offs for *obesity by sex from 2-18 y, defined to* pass through BMI = 30 at 18 y
- NB: Not known whether these age-specific BMI cutoffs in childhood are associated with health risks similar to those for adults.

- **Anthropometry Advantages:**
  - Simple, safe, non-invasive
  - Equipment is inexpensive, portable, & durable
  - Needs less skill
  - Precise and accurate
  - Info is obtained on past nutritional history which cannot be obtained with equal confidence using other techniques
  - Can be used to evaluate changes in nutritional status overtime (secular trend)
  - Can serve as a screening test

# Anthropometry Limitations:

- Relatively insensitive and can't detect changes in nutritional status over short periods of time
- Can't identify specific nutrient deficiencies (e.g. stunting from Zn deficiency Vs PEM)


Thank you for attention
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THE END OF CHAPTER 2