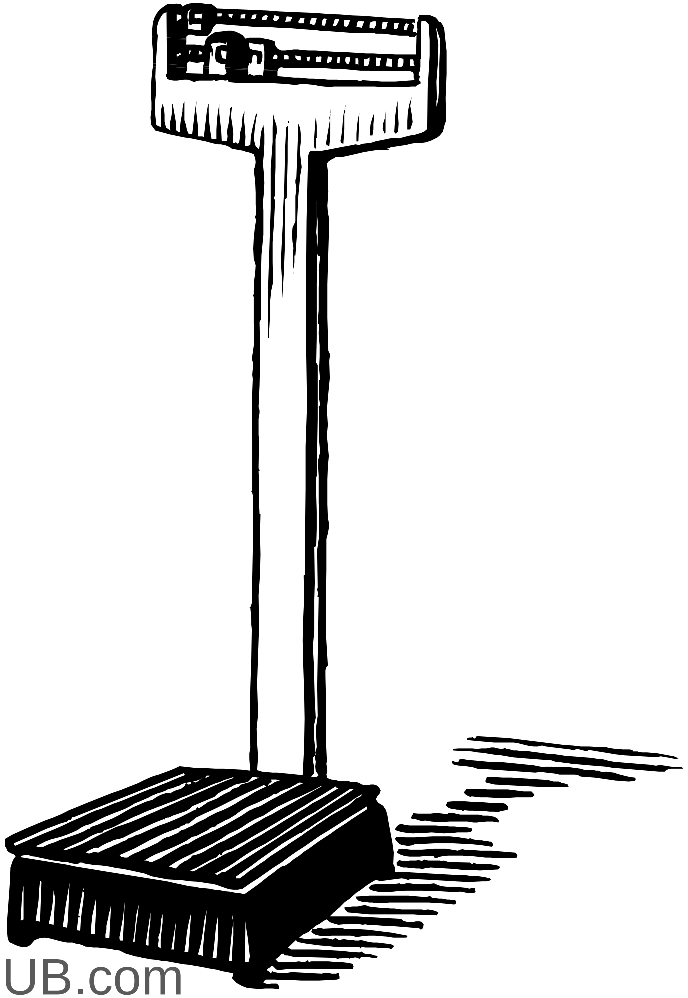
Anthropometric Assessment

Chapter 6



What is Anthropometry??

- **“ Measurement of the variations of the physical dimensions and gross composition of human body”.**

Jelliffee (WHO, 1996)

- **“Measurement of body size, weight, and proportions”.**

Lee & Nieman (1993)

Anthropometric

- Body composition & weight reflect **type** and **quantities** of body stores.

- Influenced by nutrition, especially in infancy and children.

Anthropometry includes:

- Stature (height) or length
- Body Weight
- Circumferences (head, waist, limb)
- diameters (sagittal abdominal diameter, SAD)
- Body fat (skinfold thickness)

Advantage of Body Measurements

- Rough estimate of body composition or changes in body composition
- Reproducible
- They are valuable in monitoring the effects of nutritional intervention for disease, trauma, surgery, malnutrition.

Sources of Error in Anthropometry

- **Measurement errors**
  - Inadequate training
  - Instrument error
  - Measurement difficulty

Body Measurement

- **Head Circumference**
  - Related to brain size, use to detect pathological conditions
    - Macrocephaly
    - Microcephaly
  - **It is recommended that head circumference be measured routinely for infant & children up to 36 months.**

- The tape position:
  - Just above (not over) the eyebrows
  - Above the ears
  - Around the back of the head

Body Measurement

- **Recumbent length (Length)**
- For children less than 24 months
- Or between 24-36 months who cannot stand correctly

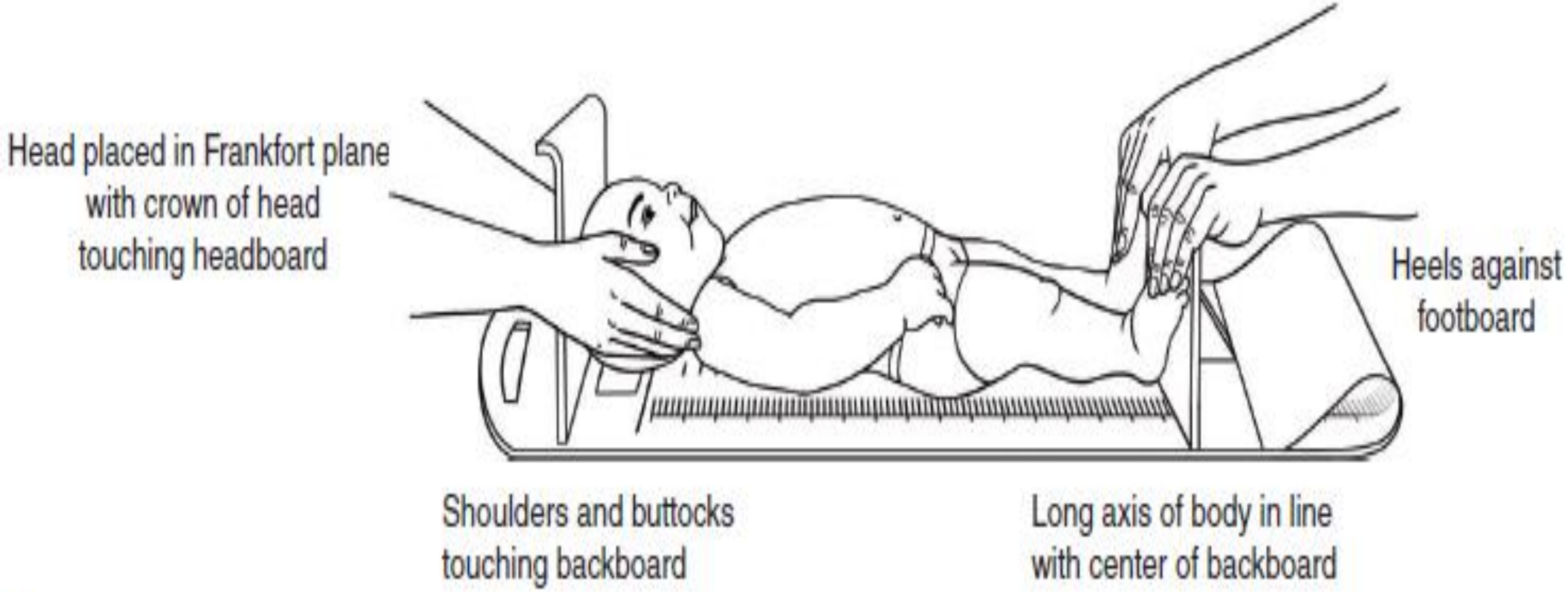


Figure 6.2 Special device for measuring the length of children who cannot stand erectly without assistance; the device has a stationary headboard and a moveable footboard.

Body Measurement

- **Stature or standing height**

For person older than 2-3 years

1. Fasten a measuring tape to flat, vertical surface
2. Or use stadiometer

3. Read more measurement specifications p157

Frankfort horizontal plane- when measurement of length and stature

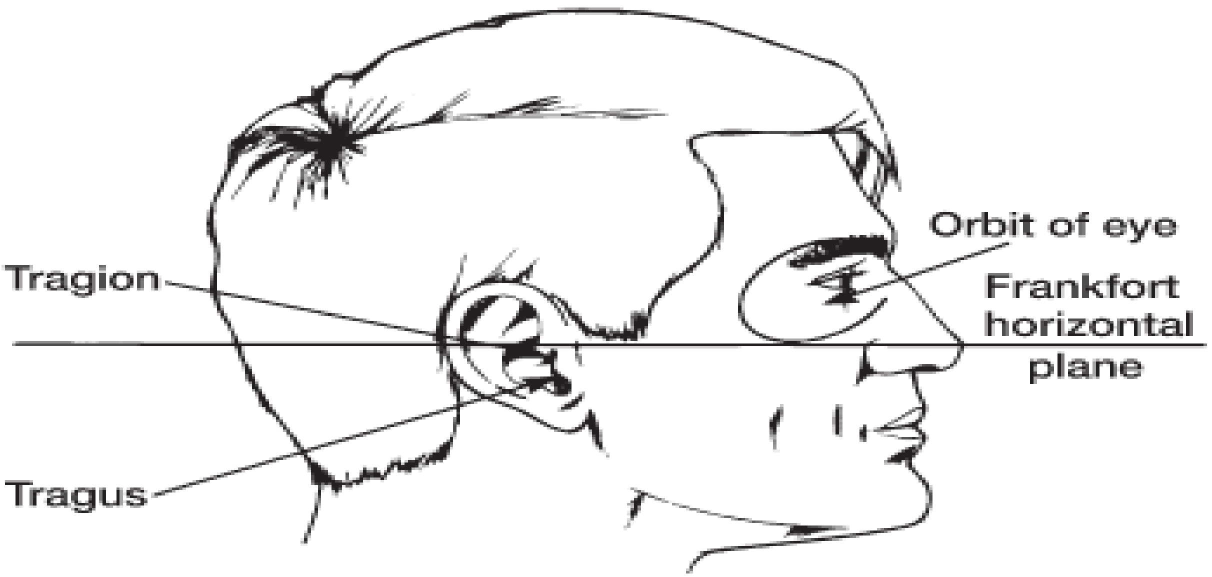


Figure 6.1
Length and stature are measured with the head in the Frankfort horizontal plane. This plane is represented by a line between the lowest point on the margin of the orbit (the bony socket of the eye) and the tragion (the notch above the tragus, the cartilaginous projection just anterior to the external opening of the ear).

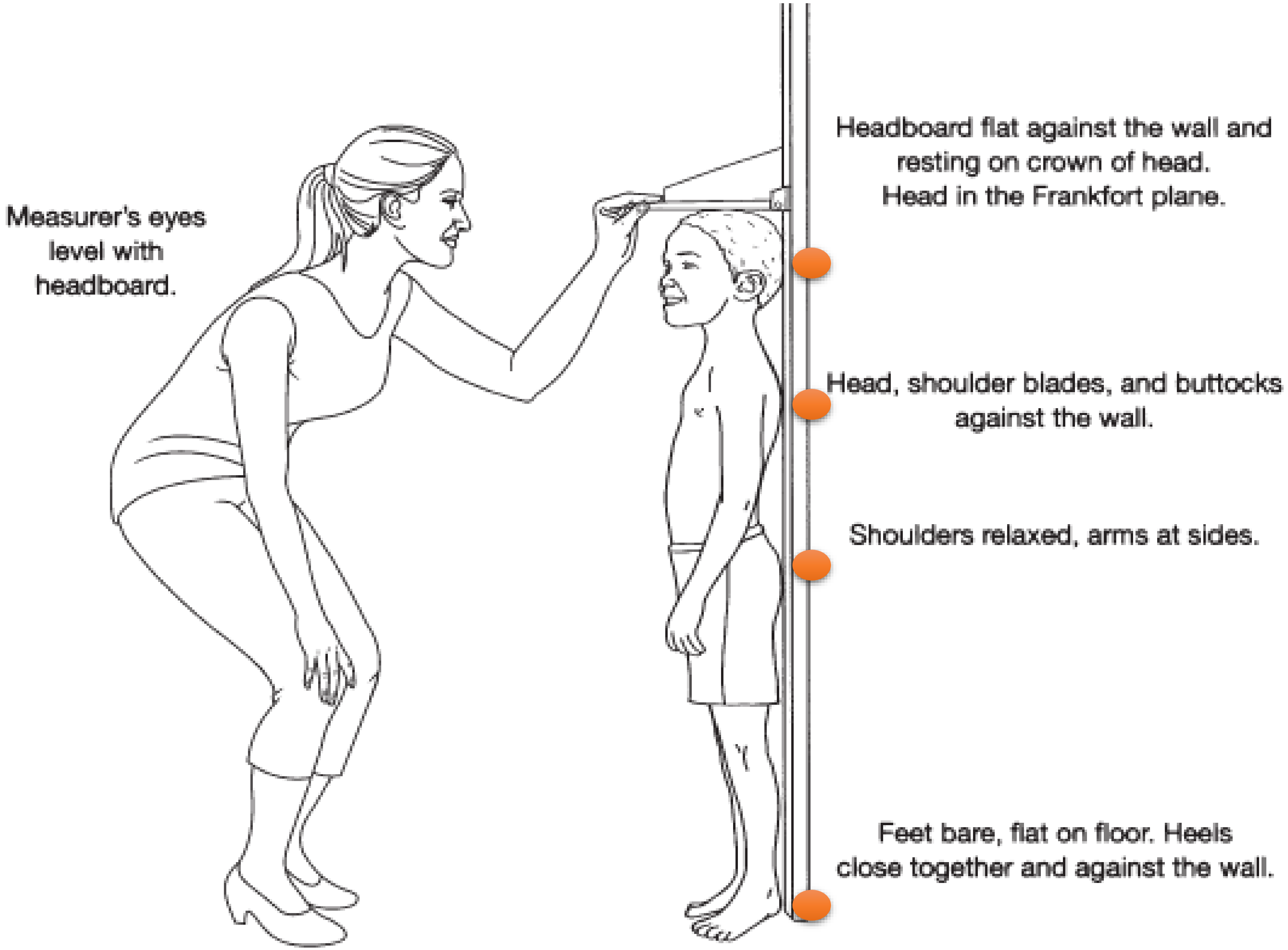


Figure 6.3 **Body position when measuring stature.**


seca
219
220

Length and stature

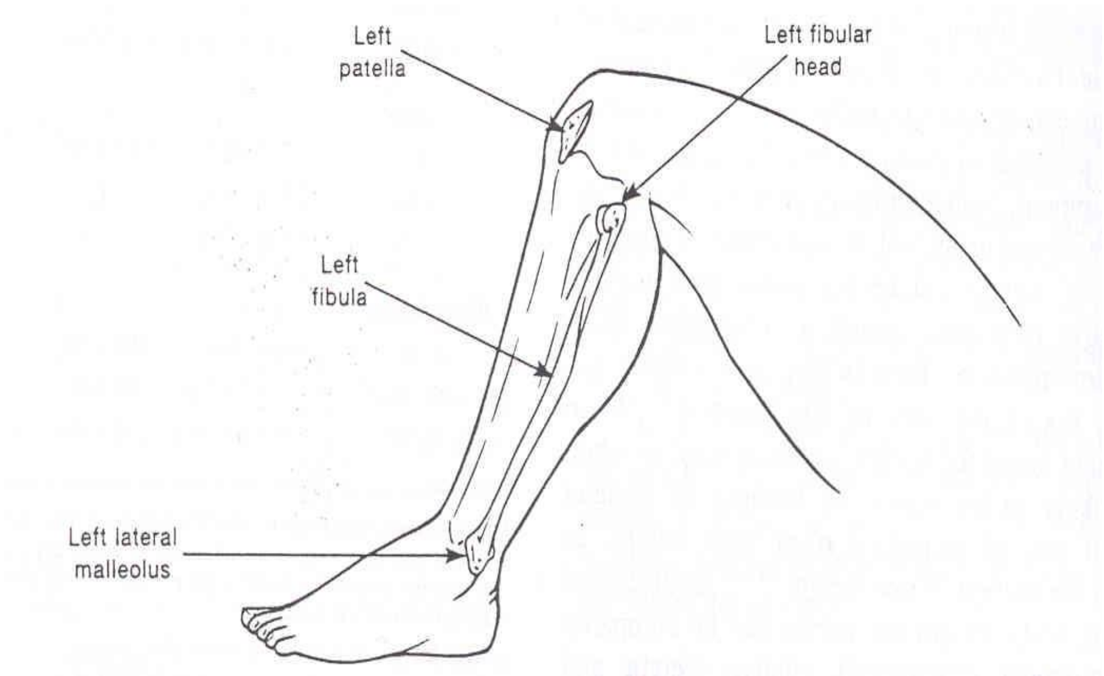
- The growth charts used for persons birth to 36 months of age are based on recumbent length

- Whereas the growth charts for those age 20 to 20 years are based on stature

  - Now , using the WHO growth charts for all age groups

Nonambuatory person

- Knee height :Used to estimate height when unable to stand straight (severe spinal curvature)



Body Measurement

- **Body Weight**
  - **Sum of fat, water, lean protein and mineral mass.**
  - **Predicts calorie expenditure and body composition**
  - **May be compared to a reference standard, usual B.W or baseline**

Weighing infants

- Using “pan-type” pediatric electronic or balance beam scale
- Average of 2-3 weighings
- Digital scales can record a subject’s weight quickly (important advantage in weighing infants)
- If too active infant???

Weighing children & adults

- **Weight is measured by:**
  - **electronic scale**
  - **balance-beam scale**
- **Electronic scales are:- lighter in wt, more portable, faster and easier to use**

Nonambulatory persons

- Can be weighed in a bed scale

- Or body weight can be computed from :
  - knee height
  - Calf circumference
  - Mid-arm circumference
  - Subscapular skinfold thickness

Weight Standards

- **Overweight:-**
  - **A body weight above some reference point of acceptable weight that usually is defined in relation to height .**

- **Obesity:-**
  - **An excess of body fat in relation to lean body mass .**

Hamwi Equation

- **Determination of a person's recommended body weight.**
- **For females-:**
  - **100lb (45.5kg) for the first 60in. (152cm) of stature and then add 5lb (2.3kg) for each additional 1in (2.54cm)**
- **For males-:**
  - **106lb (48kg) for the first 60in. (152cm) of stature 6 lb (2.7kg) for each additional 1 in (2.54cm)**
- **For both genders create ± 10%, allowance for the effect of frame size .**

Height-Weight Tables

- Published by The metropolitan life Insurance Company

- Are convenient, quick, easy to use, and understood by practically every adult.

- See book page 167

Strengths of Ht –Wt tables

- **Weight is an important distinguishing feature of identification.**
- **Weight and Height can be accurately measured .**
- **Height and Weight tables are easily understood and used by many .**

Limitations of Ht –Wt tables

- **The data on which Height Weight tables are based on a not representative sample of the entire population.**
- **Quality of the data is variable**
- **Some of the data are cross- sectional and do not allow association between weight and mortality to be drawn .**
- **There is inadequate control of potentially confounding variables, especially smoking .**
- **It is not always clear how frame size was determined .**
- **Tables don't provide information on body composition .**

How to measure frame size

- There are several methods including:

1. Elbow breadth

Look table 6.2 page 169

2. Ratio of body height to wrist circumference

$$\text{Ratio (r)} = \frac{H\ body\ height\ in\ centimeters}{C\ circumferance\ of\ the\ right\ wrist}$$

Table 6.3 Determining Frame Size from the Ratio of Body Height to the Circumference of the Right Wrist

Frame Size	r Value	
	Women	Men
Small	> 10.9	> 10.4
Medium	10.9–9.9	10.4–9.6
Large	< 9.9	< 9.6

Adapted from Grant JP, Custer PB, Thurlow J. 1981. Current techniques of nutritional assessment. *Surgical Clinics of North America* 61:437–463.

Height – Weight Indices

- Ht-Wt tables are unable to provide information on actual body composition .
  - This had lead to the development of various height-weight indices or body mass indices.

Height – Weight Indices

- **Two types**
  - **1)Relative Wt = .-:**
    - Actual wt/Reference wt x 100%
    - Reference weight can be taken from several approaches
    - 90% to 120% is acceptable

  - **2)Power- Type indices-:**
  - Wt/ht ratio: Wt/Ht
  - **Quetlets index (BMI) = wt (kg) / ht^2 (m^2)**
  - Khosla- Lowe index =wt/ht^3
  - Ponderal index = height/weight $^{1/3}$ (for infants and newborns)
  - Benn's index = wt/ht^a
    - **a**: population specific factor derived from ht-wt data of the population sample .... Changes from sample to sample

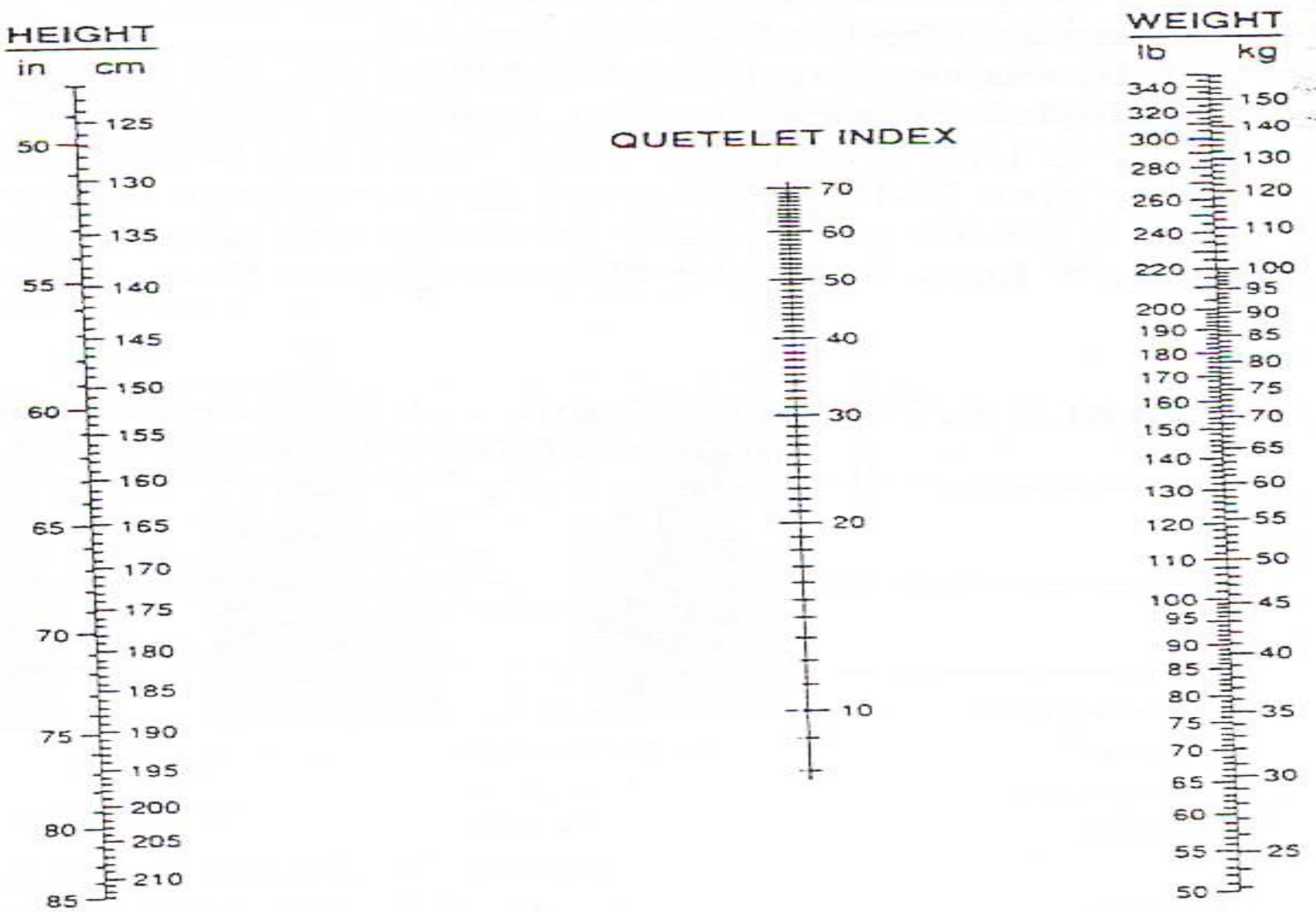
Table 6.4 Height-Weight Indices*

Relative weight:	$\frac{\text{Actual weight}}{\text{Reference weight}} \times 100$
Weight/height ratio:	$\frac{\text{Weight}}{\text{Height}}$
Quetelet's index:	$\frac{\text{Weight}}{\text{Height}^2}$
Khosla-Lowe index:	$\frac{\text{Weight}}{\text{Height}^3}$
Ponderal index:	$\frac{\text{Height}}{\text{Weight}^{1/3}}$
Benn's index:†	$\frac{\text{Weight}}{\text{Height}^p}$

Quetlete index (BMI)

- Has high correlation with estimates of body fatness, and low correlation with stature
- Nomogram (use with caution) or table
- Best to be used in conjunction with waist circumference → marker for increased risk of type 2 diabetes, hypertension, CVDs.
  - Not a standard approach to use in children

The Nomogram



BMI and disease risk

appears to be the optimal BMI range for adults.[16] Every additional 5 kg/m^2 of BMI greater than 25.0 kg/m^2 was associated with a 30% greater risk of death from all causes, a 40% greater risk of death from cardiovascular diseases, a 60% to 120% greater risk of death from diabetic, renal, and hepatic diseases, and a 10% increased risk of death from neoplastic diseases. Compared to those in the optimal BMI range, those whose BMI was in the 30.0 to 35.0 kg/m^2 range died two to four years earlier and those whose BMI was in the 40.0 to 45.0 kg/m^2 died eight to ten years earlier (which is comparable to the effects of cigarette smoking). Those having a BMI less than this optimal range of 22.5 to 25.0 kg/m^2 are also at increased risk of death compared to those whose BMI is in the optimal range, but much of the excess mortality seen in this group is primarily due to cigarette smoking.[16] This relationship between BMI and risk of death is illustrated in Figure 6.9.

TABLE 6.6	Classification of Overweight and Obesity by Body Mass Index (BMI), Waist Circumference, and Associated Disease Risk* in Adults			
			Disease Risk* Relative to Normal Weight and Waist Circumference	
	BMI (kg/m^2)	Obesity Class	Men ≤ 40 in. (≤ 102 cm); Women ≤ 35 in. (≤ 88 cm)	Men > 40 in. (> 102 cm); Women > 35 in. (> 88 cm)
Underweight	< 18.5		———	———
Normal †	18.5–24.9		———	———
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very high
	35.0–39.9	II	Very high	Very high
Extreme obesity	≥ 40.0	III	Extremely high	Extremely high

**Disease risk for type 2 diabetes, hypertension, and cardiovascular disease.

Even with normal BMI , high waist circumference could be a risk

Limitation of BMI

- BMI overestimates total body fat in persons who are very muscular or who have clinically evident edema

- underestimates body fat in persons who have lost muscle mass such as the frail and elderly

Body Fat Distribution

- Is an important concept in considering the health implications of obesity

- **Where fat is distributed** within the body may actually be more important than **quantity of fat .**

Body Fat Distribution

- ***Classification of fat distribution:***
  - Upper body
    - Android
    - male type
      - e.g. abdomen
  - Lower body
    - Gynoid
    - Female type
      - e.g. hips of thighs

Body Fat Distribution

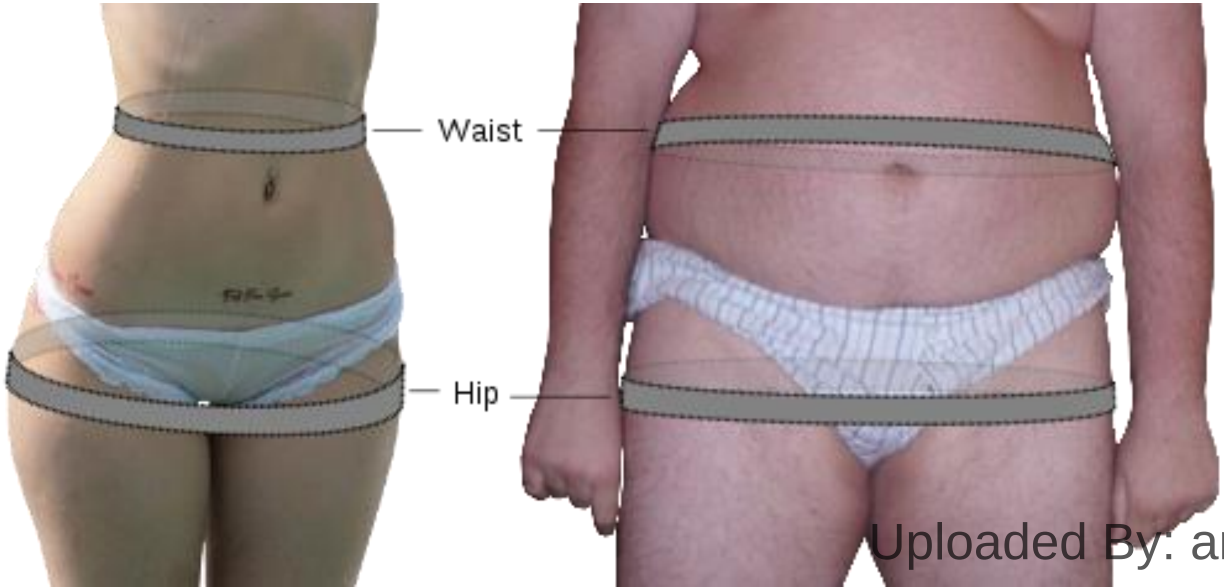
- Studies showed that fat distribution is a more important risk factor for morbidity and mortality than is obesity.

- Android obesity is a risk factor to:-
  - Insulin resistance
  - Non-insulin dependent diabetes mellitus
  - Hypertension
  - Hyperlipidemia
  - CVD
  - Death.

- Even when **BMI is not markedly increased** !!

Body Fat Distribution

- To assess total abdominal fat :
  - –Waist to hip ratio
    - Less than 1 (<0.9 for males, <0.8 for females)
  - –Waist circumference
    - Better indicator than WHR
      - » < 102 cm for males
      - » < 88 cm for females
    - » Also useful for evaluating the success of weight loss treatment


Waist
Hip

Sagittal abdominal diameter (SAD)

- It is an index of visceral adiposity
- Well correlated with obesity related metabolic disturbances.

- https://youtu.be/Av2r_rP1DAg

- Interpretation of result (appendix H)

Body Composition

Two compartment model

- Total body mass-composed of two chemically distinct compartments:
  1. Adipose fat + Lean body mass

(includes small % fat (1-3% in tissue)

OR

2. Fat mass + Fat free mass:-
   - **Fat mass** includes all the solvent-extractable lipids contained in both adipose tissue and other tissues.
   - **Fat free mass**:- composed of muscle, water, bone and other non-fat tissues

Body Composition

- **Four compartments model**

- Total Body Mass-composed of four chemically distinct compartments:
  - Water
  - Protein
  - Mineral
  - fat

Estimate of Body Composition Using the Two Compartment Model

- ✓ **Anthropometry**
  - ✓ **Measures of skin fold thickness**
  - ✓ **Bone dimension**
  - ✓ **Limb circumference**
- ✓ **Determination of whole body density**
  - ✓ **Underwater weighing**
  - ✓ **Plethysmograph**

Estimate of Body Composition Using the four Compartment Model

- Total body electrical conductivity
- Bioelectrical impedance
- Absorptiometry
- And others

Estimating body composition

- All of the methods are **indirect** measures.

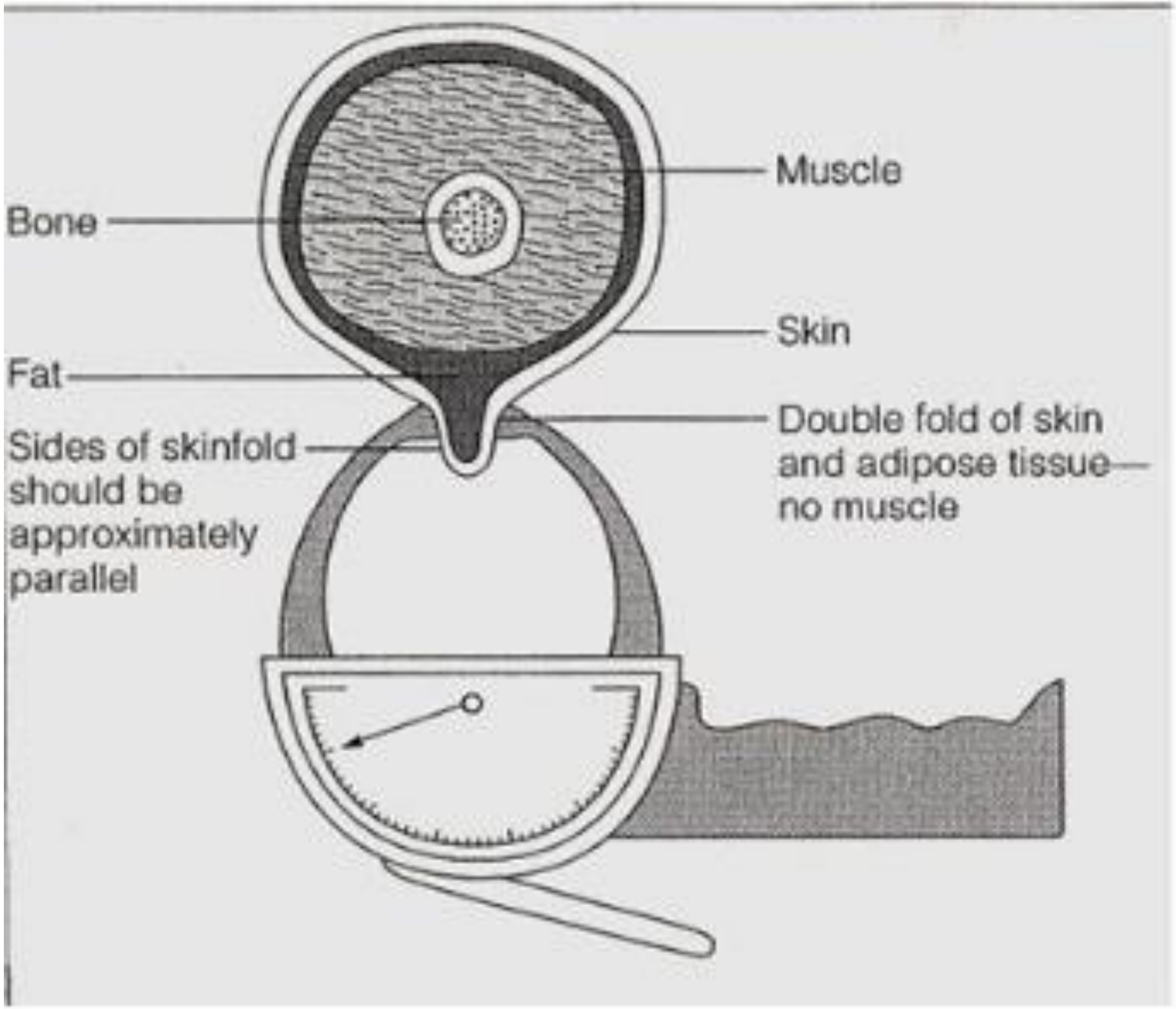
- The only **direct** measurement for body composition is by analyzing cadavers !

Skin Fold Measurements

- **By measuring the thickness of a double of skin and compressed subcutaneous fat .**

- **This method is widely used as an indirect method for estimation of body fat percent.**
  - By skinfold caliper ,in different sites.

–Figure 6-15


Muscle
Bone
Skin
Fat
Double fold of skin
and adipose tissue
no muscle
Sides of skinfold
should be
approximately
parallel

Skin Fold Measurements

- **The equipment needed is inexpensive**
- **It requires little space**
- **Measurements are easily and quickly obtained**
- **When correctly done it provides estimates of body composition**
  - **Assumptions involved p 189 (old version)**
- **Read techniques p189 and fig. 6-16 (old version)**

Box 6.3 Assumptions Involved in Using Skinfold Thickness Measurements to Predict Body Fat

1. The double thickness of skin and subcutaneous adipose tissue has a constant compressibility
2. Thickness of the skin is negligible or a constant fraction of the skinfold
3. The thickness of subcutaneous adipose tissue is constant or predictable within and between individuals
4. The fat content of adipose tissue is constant
5. The proportion of internal to external fat is constant
6. Body fat is normally distributed

Adapted from Martin AD, Ross WD, Drinkwater DT, Clarys JP. 1985. Prediction of body fat by skinfold caliper: Assumptions and cadaver evidence. *International Journal of Obesity* 9(suppl 1):31–39.

- American studies: right hands
- European studies: left hand

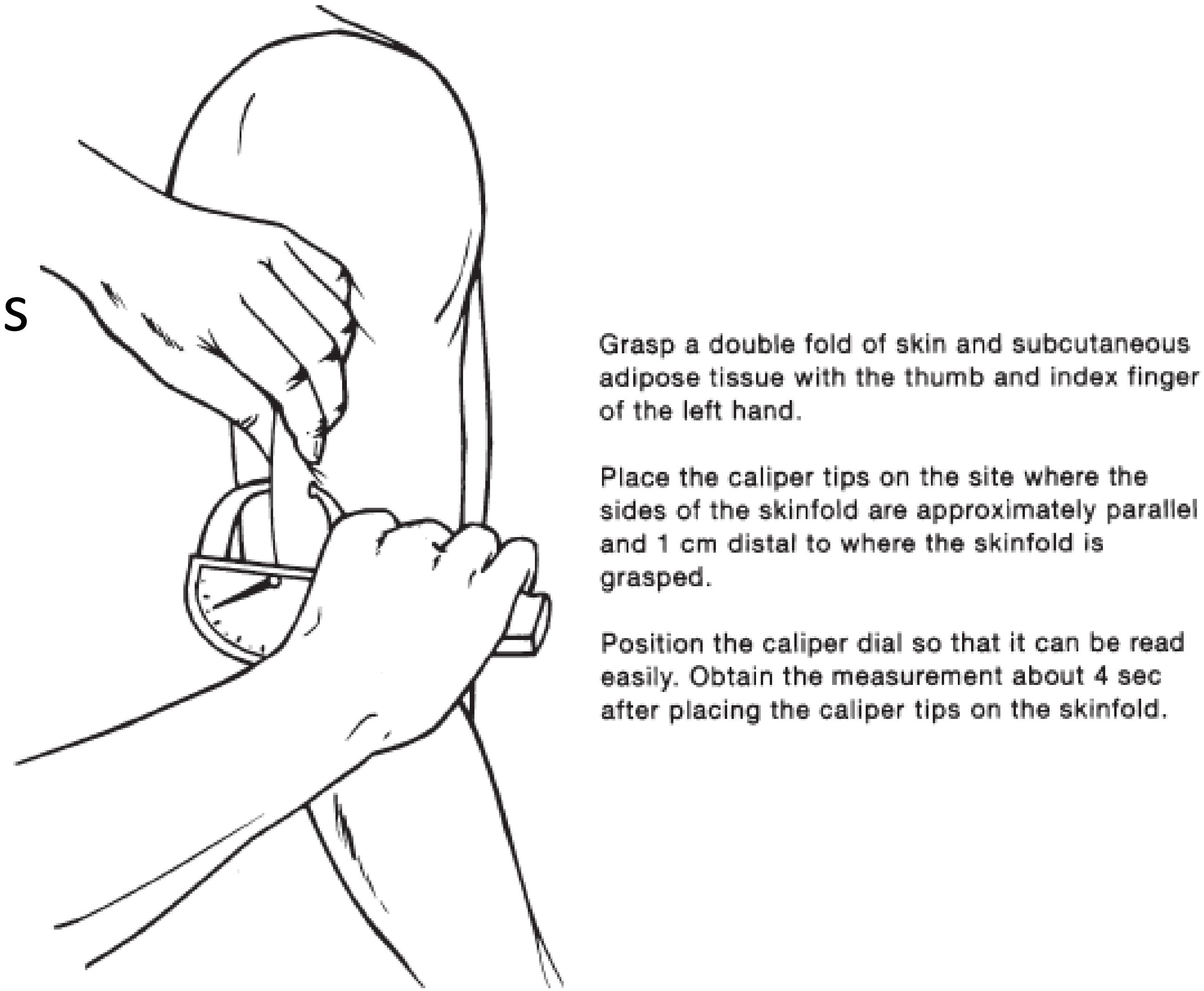
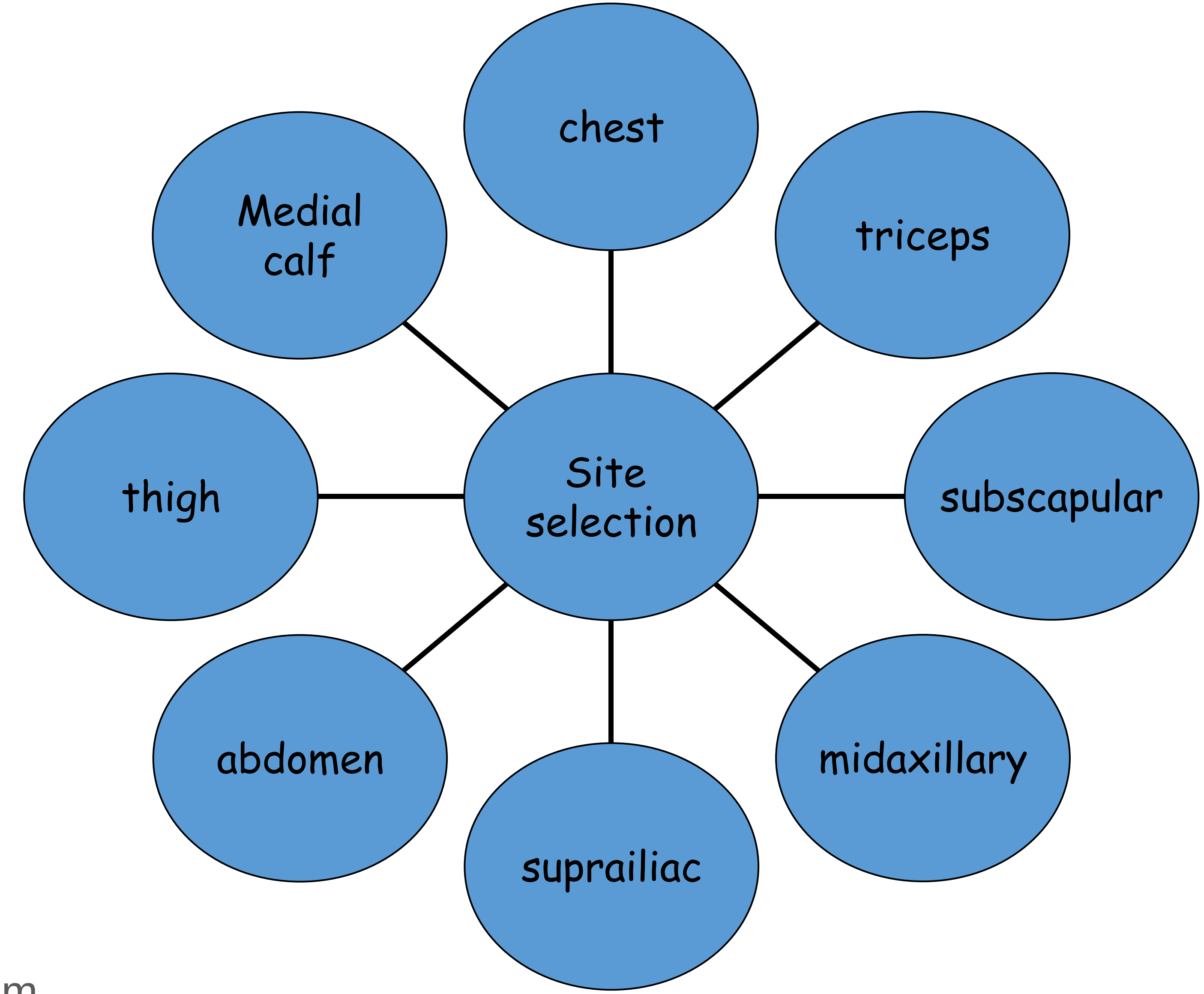


Figure 6.16
Accurate skinfold measurements require careful site selection and proper technique in placing and reading the caliper.

Site Selection



Two-Site Skinfold Measurements

- Single site measurement is not enough for estimating boy fat!
  - Only comparison with reference data

- The 2 sites : Most commonly the triceps and subscapular
- Accessible and easy to measure
- Reference data to compare with (appendix I)
  - 50th percentile represent the median value for each age/sex group.

Estimating body fat from multiple sites (table 6.7 p185)

TABLE 6.8	Generalized Body Composition Equations for Male and Female Adults*

Males

Body density = $1.11200000 - 0.00043499(X_1) + 0.00000055\,(X_1)^2 - 0.00028826\,(X_8)$

Percent body fat = $0.29288\,(X_2) - 0.00050\,(X_2)^2 + 0.15845\,(X_8) - 5.76377$

Body density = $1.1093800 - 0.0008267\,(X_3) + 0.0000016\,(X_3)^2 - 0.0002574\,(X_8)$

Body density = $1.1125025 - 0.0013125\,(X_4) + 0.00000055\,(X_4)^2 - 0.0002440\,(X_8)$

Percent body fat = $0.39287\,(X_5) - 0.00105\,(X_5)^2 + 0.15772\,(X_8) - 5.18845$

Females

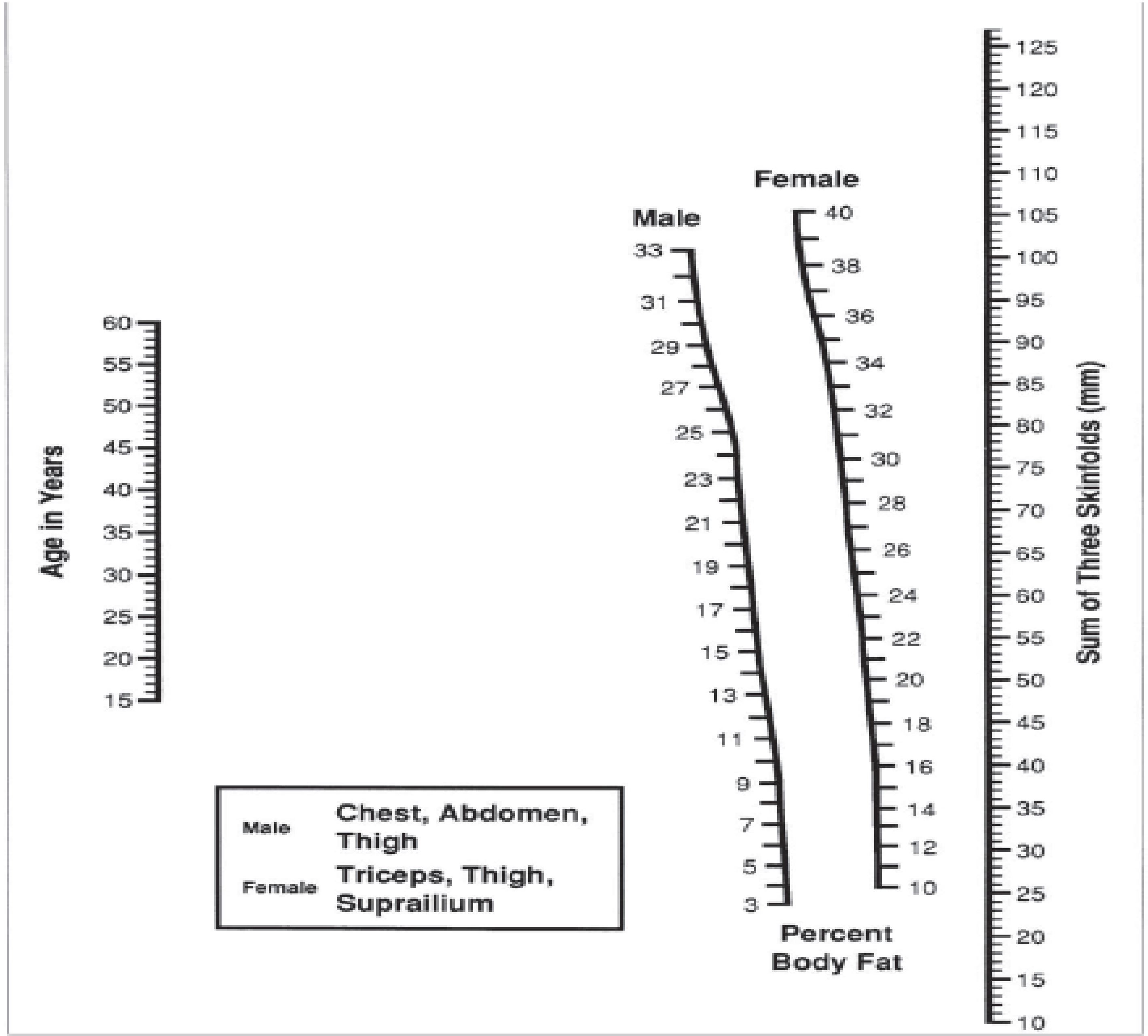
Body density = $1.0970 - 0.00046971\,(X_1) + 0.00000056\,(X_1)^2 - 0.00012828\,(X_8)$

Percent body fat = $0.29699\,(X_2) - 0.00043\,(X_2)^2 + 0.02963\,(X_8) + 1.4072$

Percent body fat = $0.41563\,(X_6) - 0.00112\,(X_6)^2 + 0.03661\,(X_8) + 4.03653$

Body density = $1.0994921 - 0.0009929\,(X_7) + 0.0000023\,(X_7)^2 - 0.0001392\,(X_8)$

*X_1 = sum of chest, midaxillary, triceps, subscapular, abdomen, suprailiac, and thigh skinfolds; X_2 = sum of abdomen, suprailiac, triceps, and thigh skinfolds; X_3 = sum of chest, abdomen, and subscapular skinfolds; X_4 = sum of chest, triceps, and subscapular skinfolds; X_5 = sum of abdomen, suprailiac, and triceps skinfolds; X_6 = sum of triceps, abdomen, and suprailiac skinfolds; X_7 = sum of triceps, suprailiac, and thigh skinfolds; X_8 = age in years.



Age in Years
60
55
50
45
40
35
30
25
20
15
Male
Female
33
31
29
27
25
23
21
19
17
15
13
11
9
7
5
3
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
Percent Body Fat
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
Sum of Three Skinfolds (mm)
Male
Chest, Abdomen, Thigh
Female
Triceps, Thigh, Suprailium

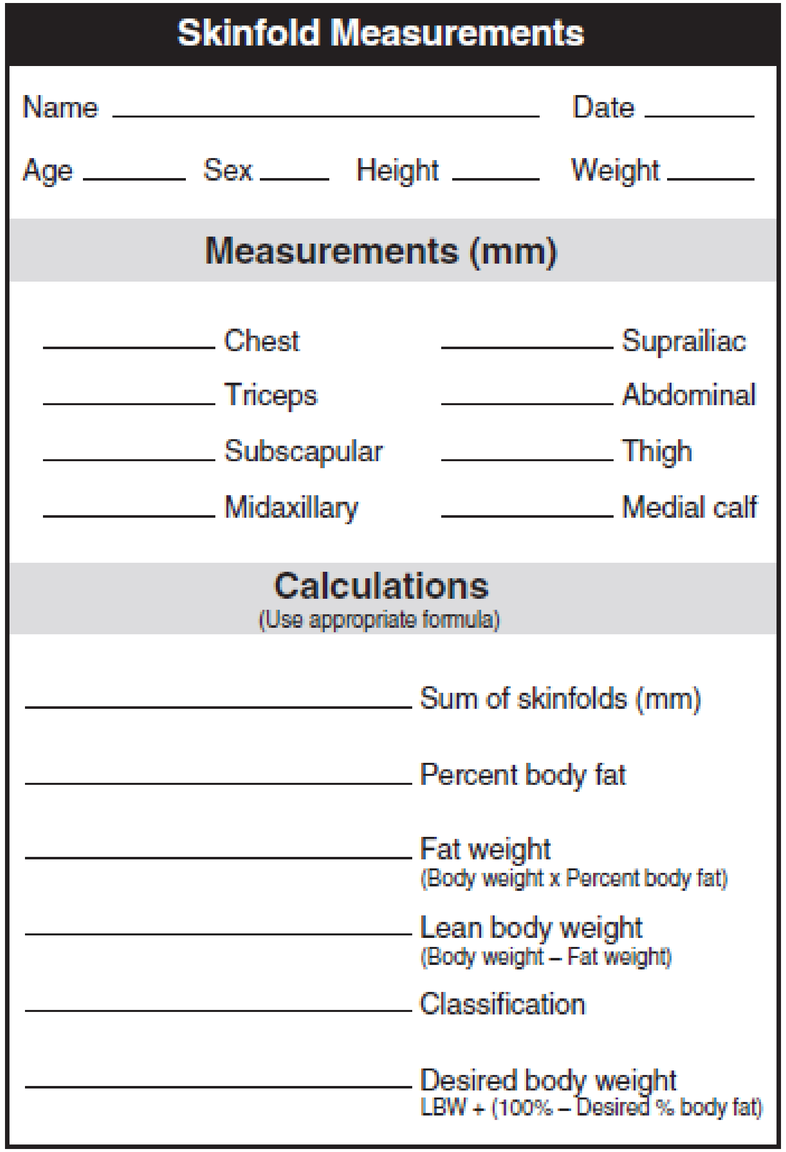
What Is a Desirable Level of Fatness?

TABLE 6.10 Percent Body Fat and BMI Classifications for Males and Females by Age Group

Gender and Age	Normal *Equal to BMI < 24.9 kg/m²*	Overweight/Fat *Equal to BMI 25 to 29.9 kg/m²*	Obese *Equal to BMI ≥ 30 kg/m²*
Males	**% Body Fat**	**% Body Fat**	**% Body Fat**
3–10 y	< 20	20–29.9	≥ 30
11–17 y	< 22	22–31.9	≥ 32
18–49 y	< 24.9	25–29.9	≥ 30
50–84 y	< 27.9	28–31.9	≥ 32
Females			
3–6 y	< 21	21–25.9	≥ 26
7–10 y	< 25	25–34.9	≥ 35
11–17 y	< 34	34–44.9	≥ 45
18–49 y	< 36.9	37–41.9	≥ 42
50–84 y	< 39.9	40–43.9	≥ 44

Calculating target weight necessary to achieve a certain body fat

- Using the pervious table, this table and equations in page 187



Skinfold Measurements

Name ____________ Date ______

Age ______ Sex ______ Height ______ Weight ______

Measurements (mm)

______ Chest	______ Suprailiac
______ Triceps	______ Abdominal
______ Subscapular	______ Thigh
______ Midaxillary	______ Medial calf

Calculations
(Use appropriate formula)

______ Sum of skinfolds (mm)

______ Percent body fat

______ Fat weight
(Body weight x Percent body fat)

______ Lean body weight
(Body weight – Fat weight)

______ Classification

______ Desired body weight
LBW + (100% – Desired % body fat)

Figure 6.35 Skinfold recording and calculation form.