BODY COMPOSITION: CONCEPTS, ASSESSMENT, CLASSIFICATIONS AND APPLICATION FOR ATHLETES

GATORADE SPORTS SCIENCE INSTITUTE

OVERVIEW

- Body Composition Concepts
- Methods of Assessing Body Composition
- Body Composition Classifications
- Practical Applications for Athletes

BODY COMPOSITION CONCEPTS

WHAT IS BODY COMPOSITION?

The body's relative amounts of fat and lean body tissue (or fat-free mass – FFM)

Components of FFM include:


Muscle


Bone


Water


Organ tissues

COMPONENTS OF BODY FAT

Total Body Fat =

Essential Fat + Storage Fat

ESSENTIAL FAT

Required for normal physiological function

Consists of fat within:

- **Major organs**
- **Muscles**
- **Central nervous system**

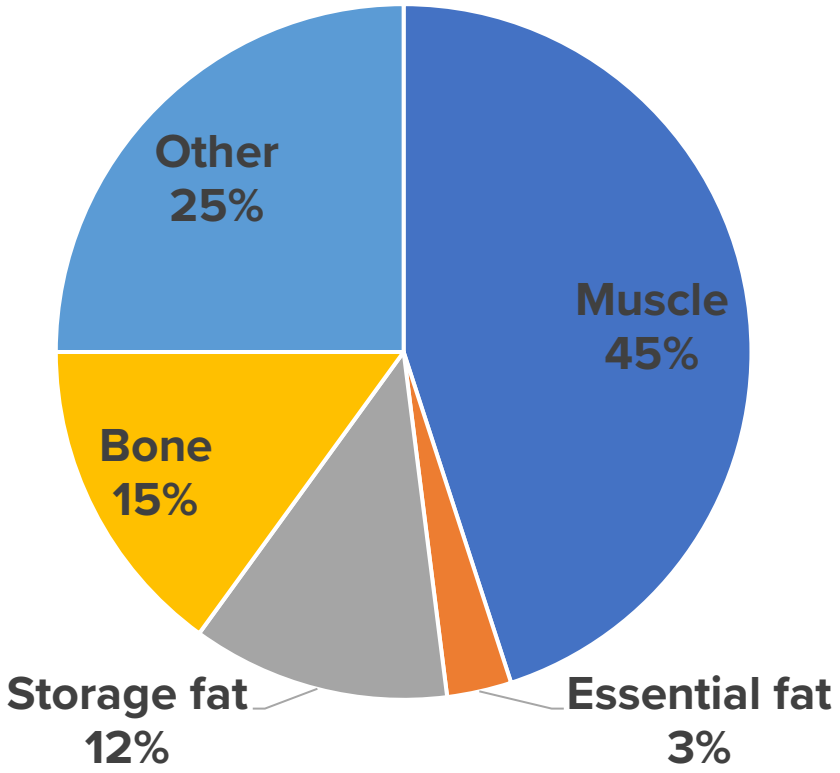
ESSENTIAL FAT

Accounts for:

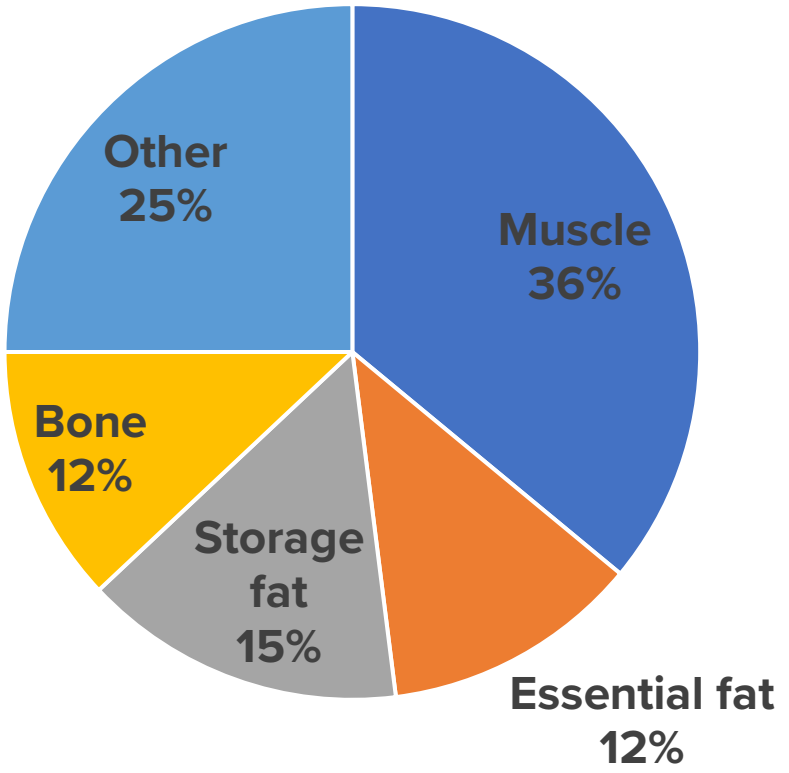
- **3-5%** total body weight **in males**
- **8-12%** total body weight **in females**

BODY COMPOSITION BREAKDOWN BY GENDER

Men ♂

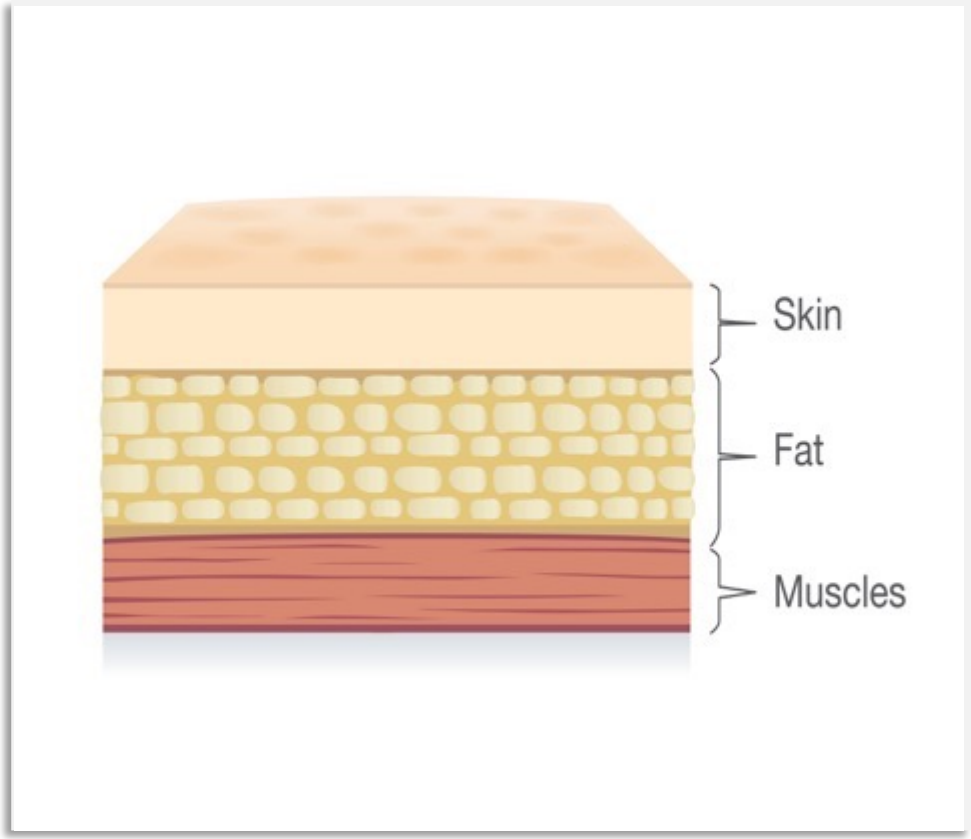


Women ♀



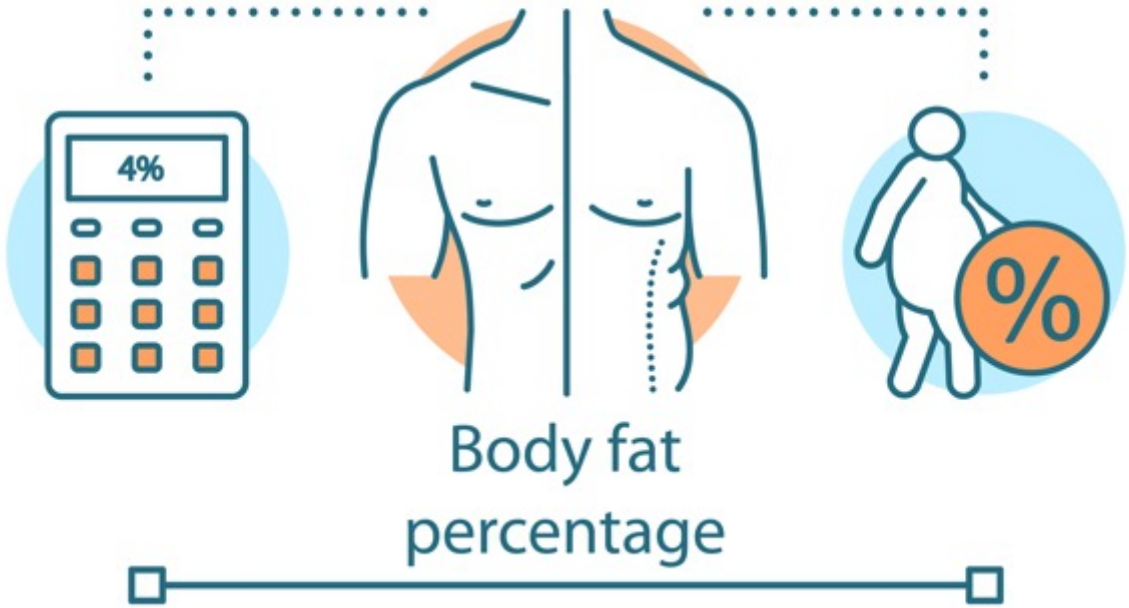
STORAGE FAT

Nonessential fat stored as adipose tissue near the body's surface.



PERCENT BODY FAT (% BF)

- Percentage of total body weight represented by fat
- Primary index used to evaluate body composition
- Several methods are used to measure it



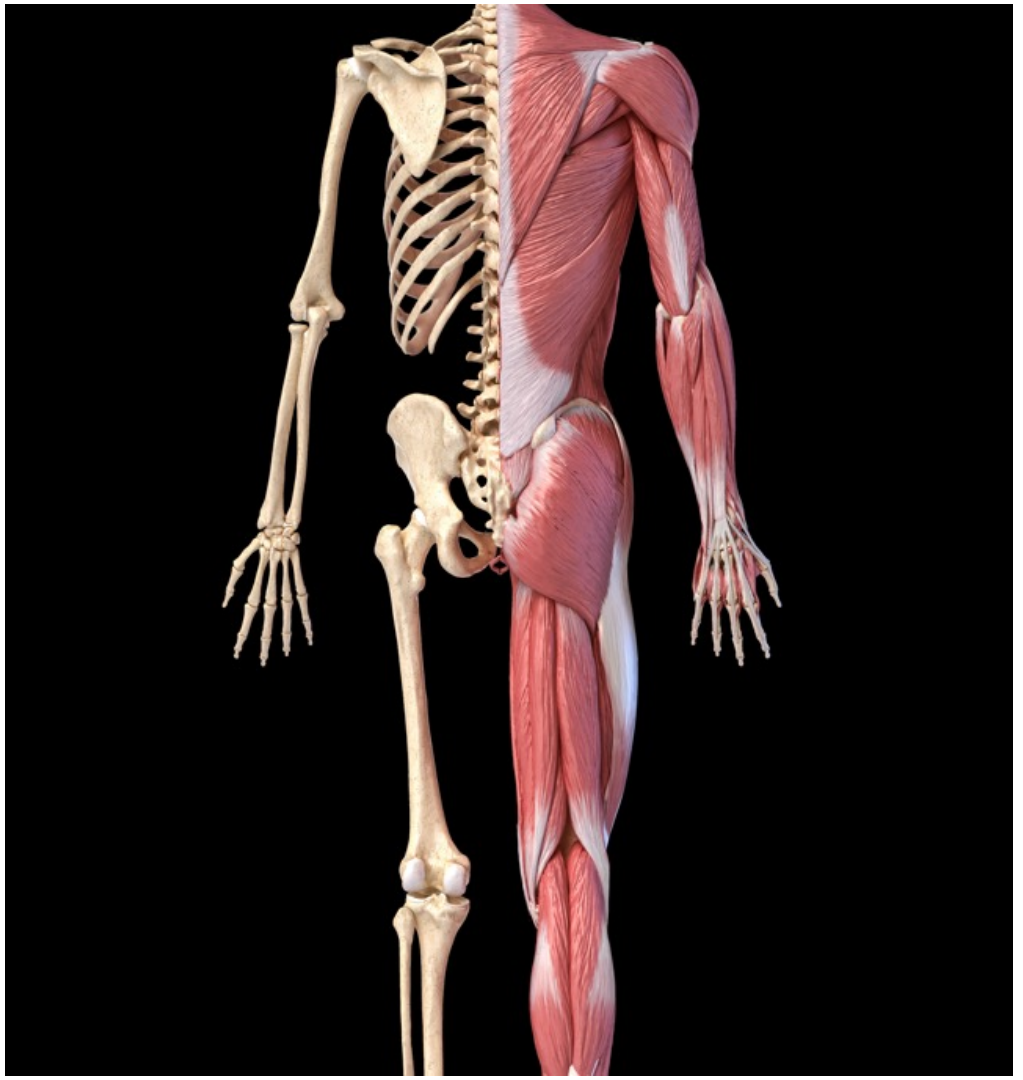
FAT-FREE MASS (FFM)

Defined as body mass minus all extractable fat

Fat-Free Mass =

Body Mass - **Fat Mass**

(%BF x Body Mass)



FAT-FREE MASS (FFM)

Baseball Athlete Example

Body mass = 80 kg (~177 lbs)

% BF = 15%

Fat mass = 80 x 15% = 12 kg

FFM = 80 – 12 = 68 kg (~150 lbs)

PURPOSES OF EVALUATING BODY COMPOSITION

1. To help assess health risks and determine needed behavior changes for optimal health.
2. To help athletes determine the best body composition for performance in their respective sport.

EFFECTS OF TOO MUCH/LITTLE BODY FAT

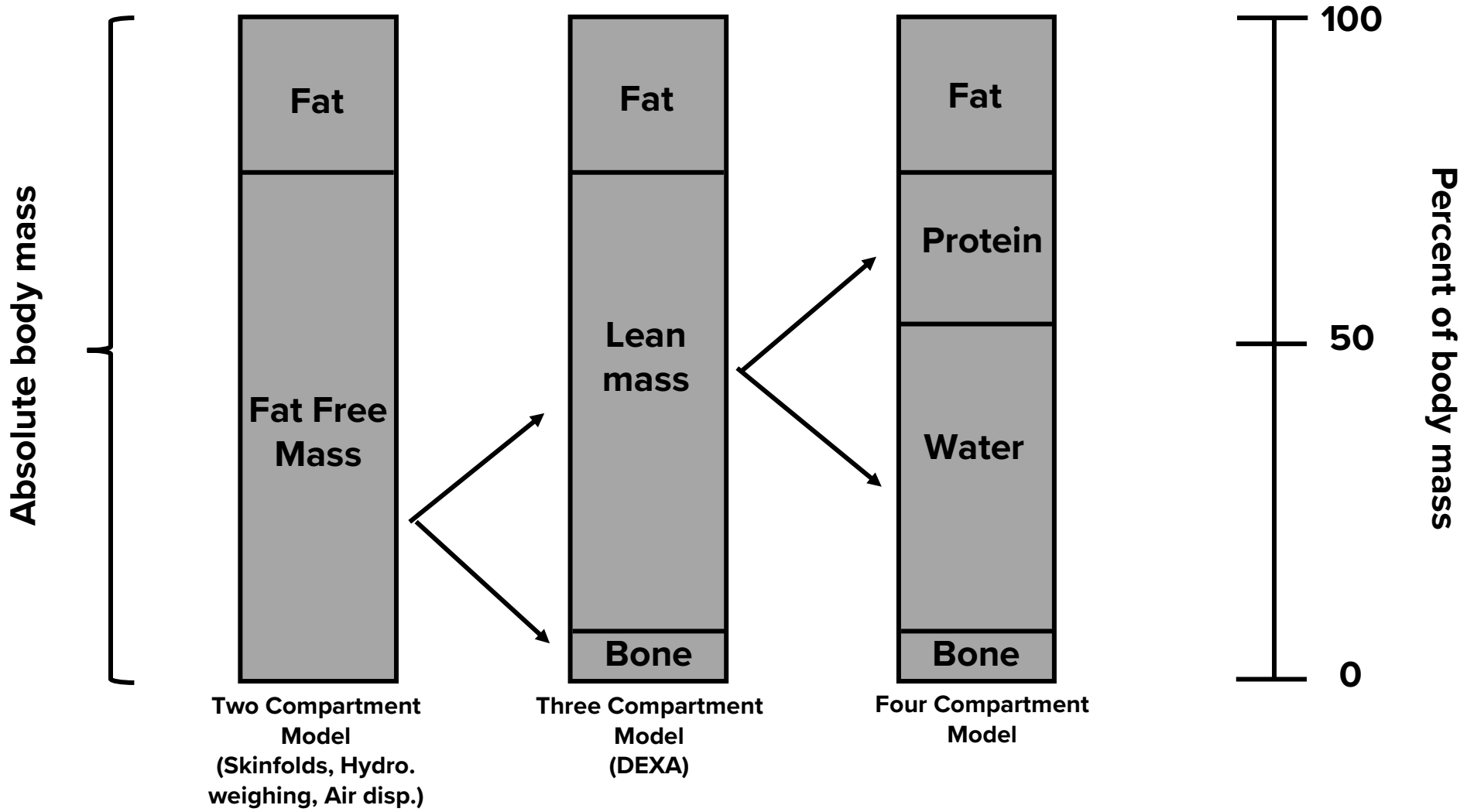
Excessive body fat can increase risk of chronic diseases, such as:

- Cardiovascular disease
- Hypertension
- Type 2 diabetes
- Cancer

Extremely low levels of body fat can result in reproductive, circulatory, and immune disorders.

METHODS OF ASSESSING BODY COMPOSITION

MODELS OF BODY COMPOSITION



ASSESSMENT METHODS

- Height, Weight, BMI
- Waist-to-Hip ratio (and body girth measurements)
- Skinfold measurements
- Hydrostatic (underwater) weighing
- Air displacement plethysmography
- Bioelectrical impedance analysis (BIA)
- Dual energy X-ray absorptiometry (DEXA)

ASSESSMENT METHODS: HEIGHT

Best measured using a stadiometer

Ensure the subject:

- Removes shoes
- Stands straight up with heels together
- Holds deep breath during measurement

ASSESSMENT METHODS: WEIGHT/MASS

Best measured on a calibrated scale at a set time of day

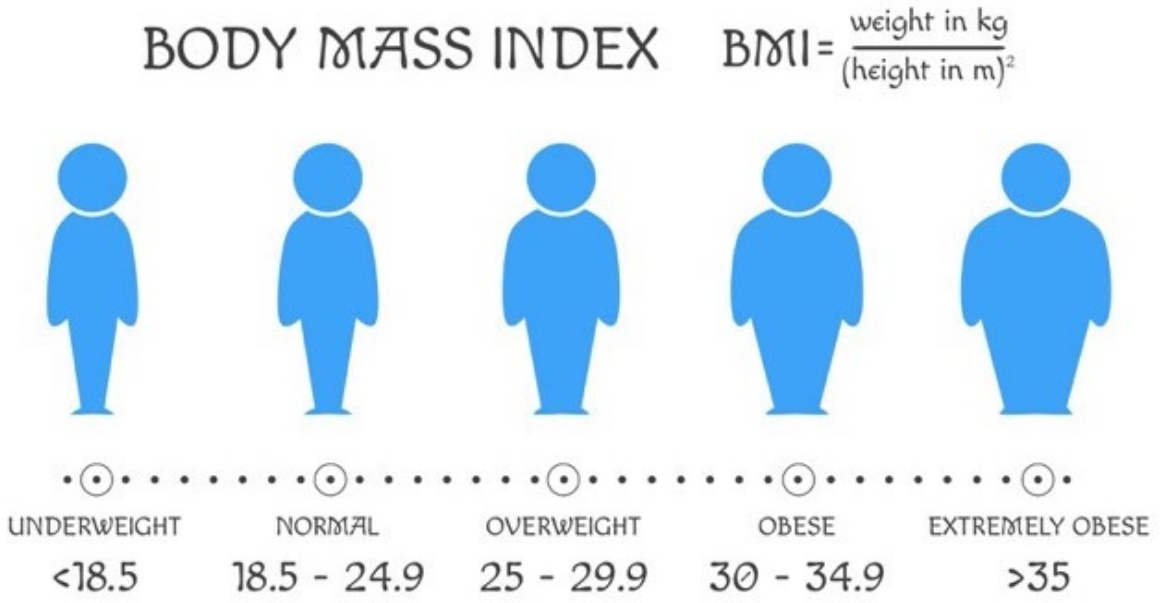
Ensure the subject:

- Removes shoes
- Wears minimal clothing (if nude weight isn't possible)

*BW = lbs; BM = kg (1kg = 2.21 lbs)

ASSESSMENT METHODS: BODY MASS INDEX (BMI)

- Based on the concept that a person's weight should be proportional to height
- Used to estimate degree of obesity in large populations
- Does not take into account % of fat or FFM (not very useful measure for athletic populations)



BMI = BM (kg) ÷ Height (m^2)

ASSESSMENT METHODS: WAIST-TO-HIP RATIO

Provides evaluation of body fat distribution:

Waist circumference

- Should be measured at the narrowest point below the ribs.

Hip circumference

- Should be measured at the widest point (around the gluteus maximus)

ASSESSMENT METHODS: CIRCUMFERENCE

All circumference measurements are in inches. The values in [square brackets] are used if the individual participates in more than 240 minutes of vigorous activity per week.

Younger Women (17-26 years): % body fat = (abdominal x 1.34) + (thigh x 2.08) – (forearm x 4.31) – 19.6 [or 22.6]

Older Women (over 26 years): % body fat = (abdominal x 1.19) + (thigh x 1.24) – (calf x 1.45) – 18.4 [or 21.4]

Younger Men (17-26 years): % body fat = (upper arm x 3.70) + (abdominal x 1.31) – (forearm x 5.43) – 10.2 [or 14.2]

Older Men (over 26 years): % body fat = (buttock x 1.05) + (abdominal x 0.90) – (forearm x 3.00) – 15.0 [or 19.0]

Katch FI, McArdle WD. Lea & Febiger: Philadelphia. PA. 1983

ASSESSMENT METHODS: SKINFOLD

- Highly correlated with other methods of measuring % BF (including DEXA and hydrostatic weighing)
- Multiple sites are measured and % BF is calculated using the sum of the sites **(3-site, 4-site, and 7-site methods are used)**
- Measurements should be taken on the right side of the body

ASSESSMENT METHODS: SKINFOLD

3-Site Technique for Skinfold Measurements

Measure all skinfolds in millimeters

Men

Body Density = 1.10938 – (0.0008267 x sum of skinfolds) + (0.0000016 x square of the sum of skinfolds) – (0.0002574 x age)

Body Fat Percentage (%) = (495 / Body Density) – 450

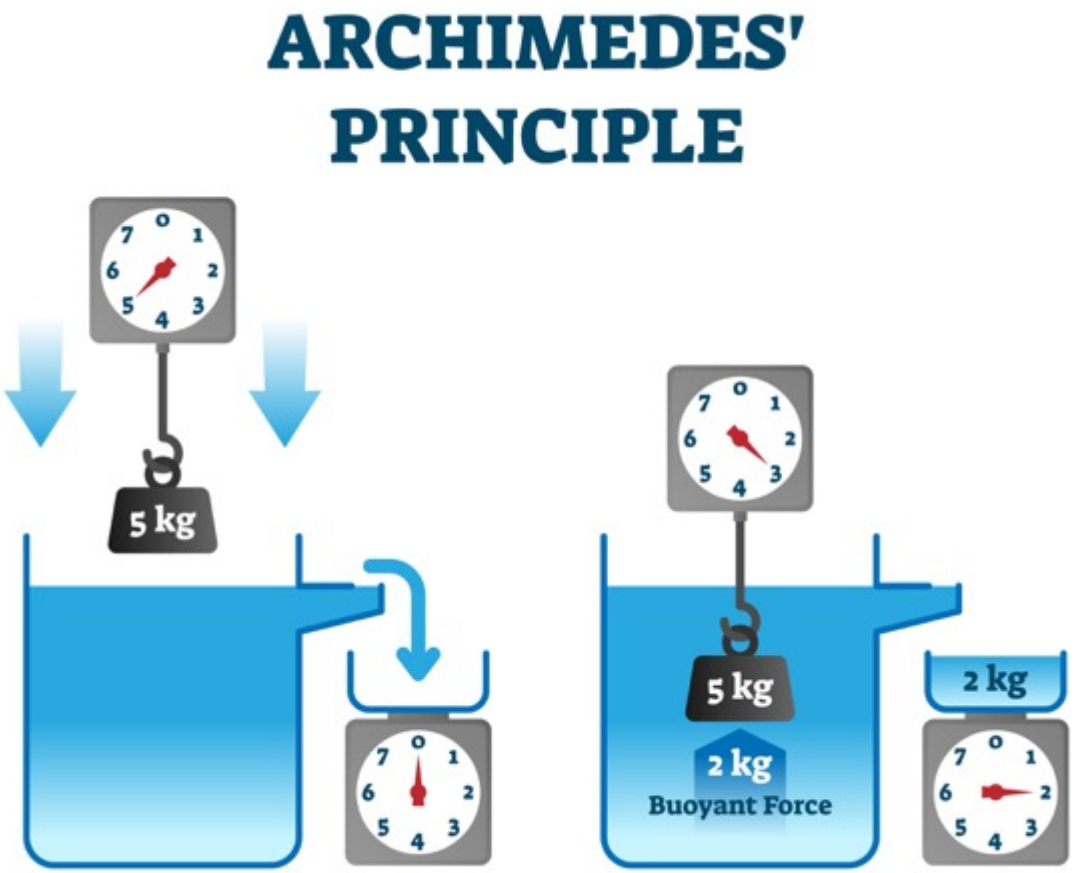
Women

Body Density = 1.0994921 – (0.0009929 x sum of skinfolds) + (0.0000023 x square of the sum of skinfolds) – (0.0001392 x age)

Body Fat Percentage (%) = (495 / Body Density) – 450

Jackson AS & Pollock ML. *Phys Sports Med.* 1985;13:76-90

ASSESSMENT METHODS: UNDERWATER WEIGHING



Hydrostatic (Underwater) Weighing

- Historically the most commonly used lab technique for measuring % BF
- Uses whole-body density to calculate body comp. based on Archimedes' principle **(fat more buoyant than lean tissue)**
- Cons: time-consuming, not feasible to test large numbers of athletes

ASSESSMENT METHODS: BOD POD

Air Displacement Plethysmography (Bod Pod)

- Calculates % BF from body density (similar to hydrostatic weighing).
- Uses computerized air pressure sensors to determine amount of air displaced.
- Bod Pod device used for this method.

ASSESSMENT METHODS: BIA

Bioelectrical Impedance Analysis (BIA)

- Rapid, non-invasive, and inexpensive method of measuring body comp.
- Sends electrical current through the body to estimate body fat (based on the principle that fat is less conductive than lean tissue)
- Cons: possesses a higher degree of measurement error (measurements may be affected by subject's hydration status)

ASSESSMENT METHODS: DEXA

Dual Energy X-ray Absorptiometry (DEXA)

- Uses a series of low-dose, transverse radiation scans, providing high degree of accuracy
- Provides measurements of bone mineral, fat, and nonbone lean tissue (able to measure visceral fat as well)
- Cons: very expensive

SUMMARY OF ASSESSMENT METHODS

Method	Pros	Cons
BMI	• Costless (requires no equipment) • Noninvasive • Easy for assessing large populations	• Does not account for % fat and FFM (not useful for athletic populations)
Waist-to-Hip / Body Girth	• Very low cost • Easy to measure/calculate	• Prediction equation possesses high degree of error
Skinfolds	• Low cost • Easy to use • Time efficient	• Slightly invasive • Requires certain degree of skill to measure accurately
Hydrostatic Weighing	• High degree of accuracy	• Time consuming • Requires pool/water tank • Requires certain degree of skill to use
Air Displacement (BodPod)	• Easy to use • Time efficient • High degree of accuracy	• Very expensive
Bioelectrical Impedance Analysis (BIA)	• Fairly low cost • Easy to use (can be self-administered) • Time efficient	• Sensitive to subject's hydration status (therefore has high degree of error)
DEXA	• Very high degree of accuracy • Noninvasive • Includes measure of bone density	• Very expensive • May require trained personnel to operate

BODY COMPOSITION NORMS & CLASSIFICATIONS

BMI REFERENCE CHART

BMI Reference Chart	
Weight Range	**BMI Category**
Underweight	<18.5
Normal weight	18.5 – 24.9
Overweight	25.0 – 29.9
Grade I Obesity	30.0 – 34.9
Grade II Obesity	35.0 – 39.9
Grade III Obesity	>40

WAIST TO HIP RATIO

Waist-to-Hip Ratio Norms				
Gender	Excellent	Good	Average	At Risk
Males	<0.85	0.85 – 0.89	0.90 – 0.95	>0.95
Females	<0.75	0.75 – 0.79	0.80 – 0.86	>0.86

PERCENT BODY FAT

Fitness Categories for % Body Fat for Men by Age							
		Age					
%		20-29	30-39	40-49	50-59	60-69	70-79
99	Very lean*	4.2	7.3	9.5	11.1	12	13.6
95		6.4	10.3	13	14.9	16.1	15.5
90	Excellent	7.9	12.5	15	17	18.1	17.5
85		9.1	13.8	16.4	18.3	19.2	19
80		10.5	14.9	17.5	19.4	20.2	20.2
75	Good	11.5	15.9	18.5	20.2	21	21.1
70		12.6	16.8	19.3	21	21.7	21.6
65		13.8	17.7	20.1	21.7	22.4	22.3
60		14.8	18.4	20.8	22.3	23	22.9
55	Fair	15.8	19.2	21.4	23	23.6	23.6
50		16.7	20	22.1	23.6	24.2	24.1
45		17.5	20.7	22.8	24.2	24.9	24.5
40		18.6	21.6	23.5	24.9	25.6	25.2
35	Poor	19.8	22.4	24.2	25.6	26.4	25.7
30		20.7	23.2	24.9	26.3	27	26.3
25		22.1	24.1	25.7	27.1	27.9	27.1
20		23.3	25.1	26.6	28.1	28.8	28
15	Very poor	25.1	26.4	27.7	29.2	29.8	29.3
10		26.6	27.8	29.1	30.6	31.2	30.6
5		29.3	30.2	31.2	32.7	33.5	32.9
1		33.7	34.4	35.2	36.4	37.2	37.3
n =		1,938	10,457	16,032	9,976	3,097	571

Total *n* = 42,071

*Very lean: no less than 3% body fat is recommended for men.

Adapted with permission from *Physical Fitness Assessmenits and Noms for Adults and Law Enforcement* (The Cooper institute, Dallas, Texas, 2013)

Fitness Categories for % Body Fat for Women by Age							
		Age					
%		20-29	30-39	40-49	50-59	60-69	70-79
99	Very lean*	11.4	11	11.7	13.8	13.8	13.7
95		14.1	13.8	15.2	16.9	17.7	16.4
90	Excellent	15.2	15.5	16.8	19.1	20.1	18.8
85		16.1	16.5	18.2	20.8	22	21.2
80		16.8	17.5	19.5	22.3	23.2	22.6
75	Good	17.7	18.3	20.5	23.5	24.5	23.7
70		18.6	19.2	21.6	24.7	25.5	24.5
65		19.2	20.1	22.6	25.7	26.6	25.4
60		20	21	23.6	26.6	27.5	26.3
55	Fair	20.7	22	24.6	27.4	28.3	27.1
50		21.8	22.9	25.5	28.3	29.2	27.8
45		22.6	23.7	26.4	29.2	30.1	28.6
40		23.5	24.8	27.4	30	30.8	30
35	Poor	24.4	25.8	28.3	30.7	31.5	30.9
30		25.7	26.9	29.5	31.7	32.5	31.6
25		26.9	28.1	30.7	32.8	33.3	32.6
20		28.6	29.6	31.9	33.8	34.4	33.6
15	Very poor	30.9	31.4	33.4	34.9	35.4	35
10		33.8	33.6	35	36	36.6	36.1
5		36.6	36.2	37	37.4	38.1	37.5
1		38.4	39	39	39.8	40.3	40
n =		1,342	4,376	6,392	4,496	1,576	325

Total *n* = 18,507

*Very lean: no less than 10-13% body fat is recommended for women.

Adapted with permission from *Physical Fitness Assessmenits and Noms for Adults and Law Enforcement* (The Cooper institute, Dallas, Texas, 2013)

PERCENT BODY FAT BY SPORT

Sport	Male	Female	Sport	Male	Female
Baseball	12-15%	12-18%	Rowing	6-14%	12-18%
Basketball	6-12%	20-27%	Shot Putters	16-20%	20-28%
Body Building	5-8%	10-15%	X-Country Skiing	7-12%	16-22%
Cycling	5-15%	15-20%	Sprinters (T&F)	8-10%	12-20%
American Football (Backs)	9-12%	No data	Soccer*	6-18%	13-18%
American Football (Lineman)	15-19%	No data	Swimming	9-12%	14-24%
Gymnastics	5-12%	10-16%	Tennis	8-18%	16-24%
High/Long Jumpers (T&F)	7-12%	10-18%	Triathlon	5-12%	10-15%
Ice/Field Hockey	8-15%	12-18%	Volleyball	11-14%	16-25%
Marathon Running	5-11%	10-15%	Weightlifters	9-16%	No data
Racquetball	8-13%	15-22%	Wrestlers	5-16%	No data

**Research on male soccer athletes has found percentage of body fat varies from 6.1-19.5%, with midfielders showing higher fat levels than either forwards or backs.*

% BF Norms by Sport – *Sport Nutrition, 2nd edition (Jeukendrup & Gleeson, 2010)*

BODY COMPOSITION EXAMPLE

Sport-Specific Example: Changes in NFL Football Player Body Composition over Time

	1972[1] (OL/TE)	1976[2] (OL/TE)	1984[3] (OL/DL)	1998[4] (OL/TE)	2005[5] (OL)	2013[6] (OL)
Height (cm/in)	193.5/ 76.2	193.0/ 76.0	191.2/ 75.3	194.1/ 76.4	193.3/ 76.1	192.8/ 75.9
BM (kg/lb)	113.2/ 249.6	112.6/ 248.2	117.6/ 259.3	135.7/ 299.2	140.0/ 308.6	140.9/ 310.6
% Body Fat	15.5	15.6	17.0	24.7	25.1	28.8

Table 1: Mean Body Composition Values for an Offensive Lineman Over Recent Decades

[1] (Wilmore & Haskell, 1972), [2] (Wilmore et al., 1976), [3] (Gleim, 1984), [4] (Snow et al., 1998), [5] (Kraemer et al., 2005), [6] (Dengel et al., 2013). BM, body mass. OL, offensive linemen. TE, tight end. DL, defensive linemen.

Learning Check: How do these values compare to the norms?

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PRACTICAL APPLICATIONS FOR ATHLETES

ASSESSING BODY COMPOSITION IN ATHLETES

Factors to Consider When Assessing Body Composition in Athletes

1. Needs/goals of the athlete (e.g. an athlete looking to increase lean mass)
2. The most appropriate method for your situation, based on:
    - The resources (time, cost, etc.) and equipment available to you
    - Validity, accuracy, and reliability of the methods

TRAINING & NUTRITION

- Body composition does not directly determine performance
- However, it may be relevant to measure depending on the athlete/sport type.
- Measurements can be used to help inform appropriate training and nutrition strategies (see additional lecture in this series for more information.)

KEY TAKEAWAYS

- ✓ Evaluation of body composition is relevant to:
  1. help determine behavior changes for optimal health
  2. help athletes determine what's optimal for performance in their respective sport.
- ✓ Numerous body composition assessment methods are available. Practitioners should consider the needs/goals of their athletes, and the resources/equipment available to them when deciding the most appropriate method to use.

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