# Physiology of Sport and Exercise

# Assessing Body Composition

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# Learning Objectives

- Concept of body composition
- Methods for assessing body composition
- Practical approach

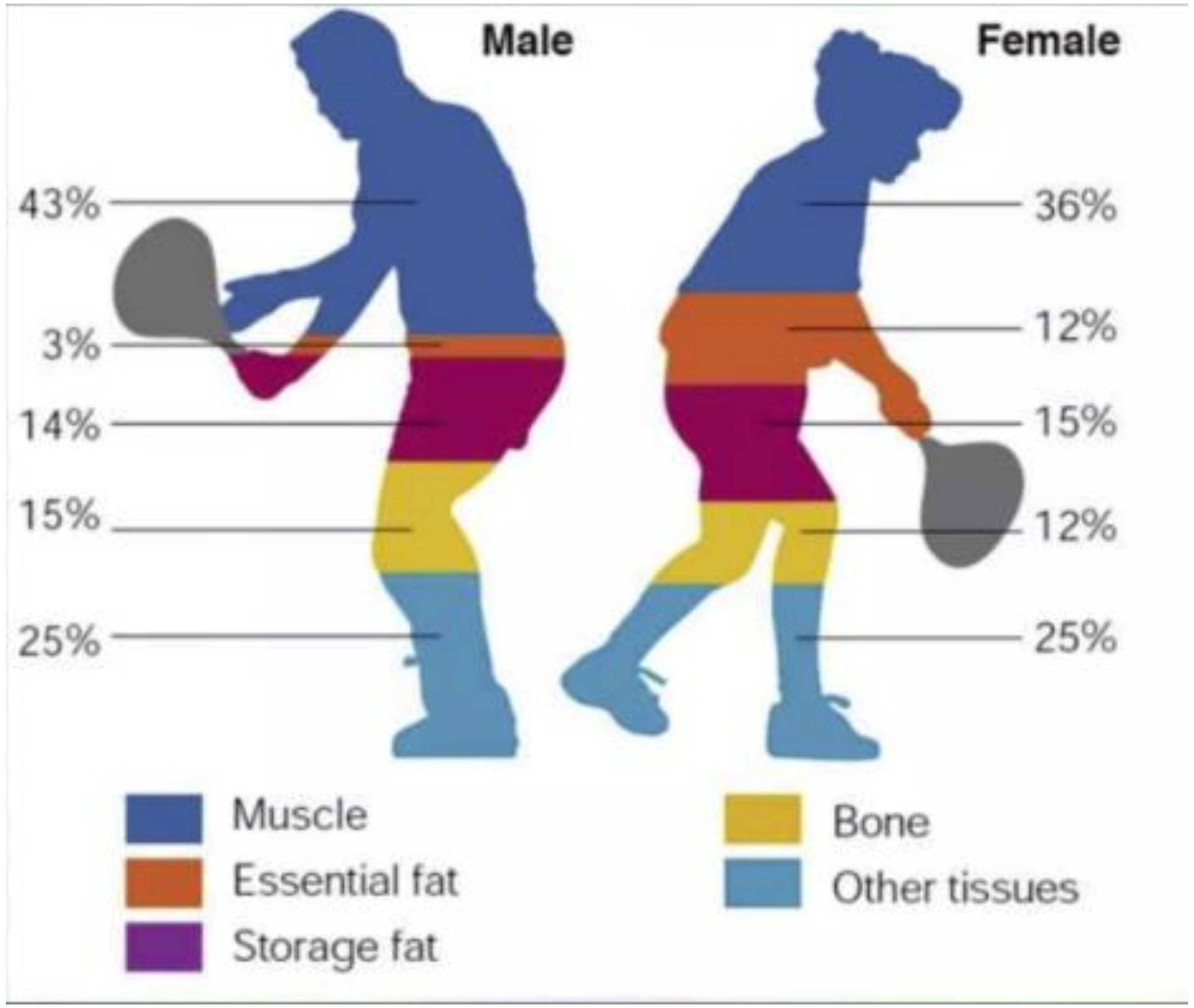
# Human Body Composition

**Typical body composition of and adult man and woman**

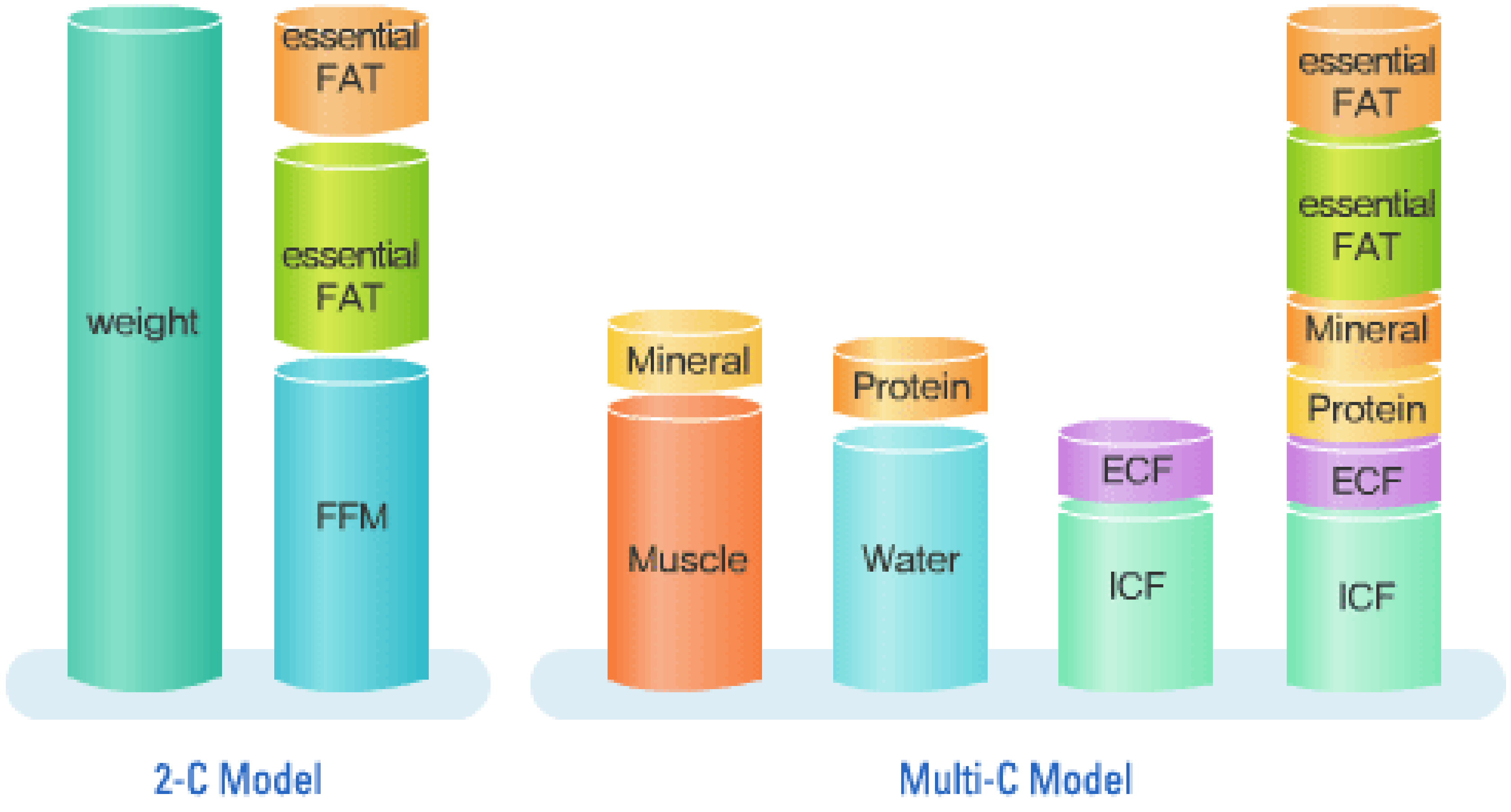
**Body Composition:** the body's relative amounts of fat mass and fat-free mass (bone, water, muscle, connective and organ tissue, teeth)

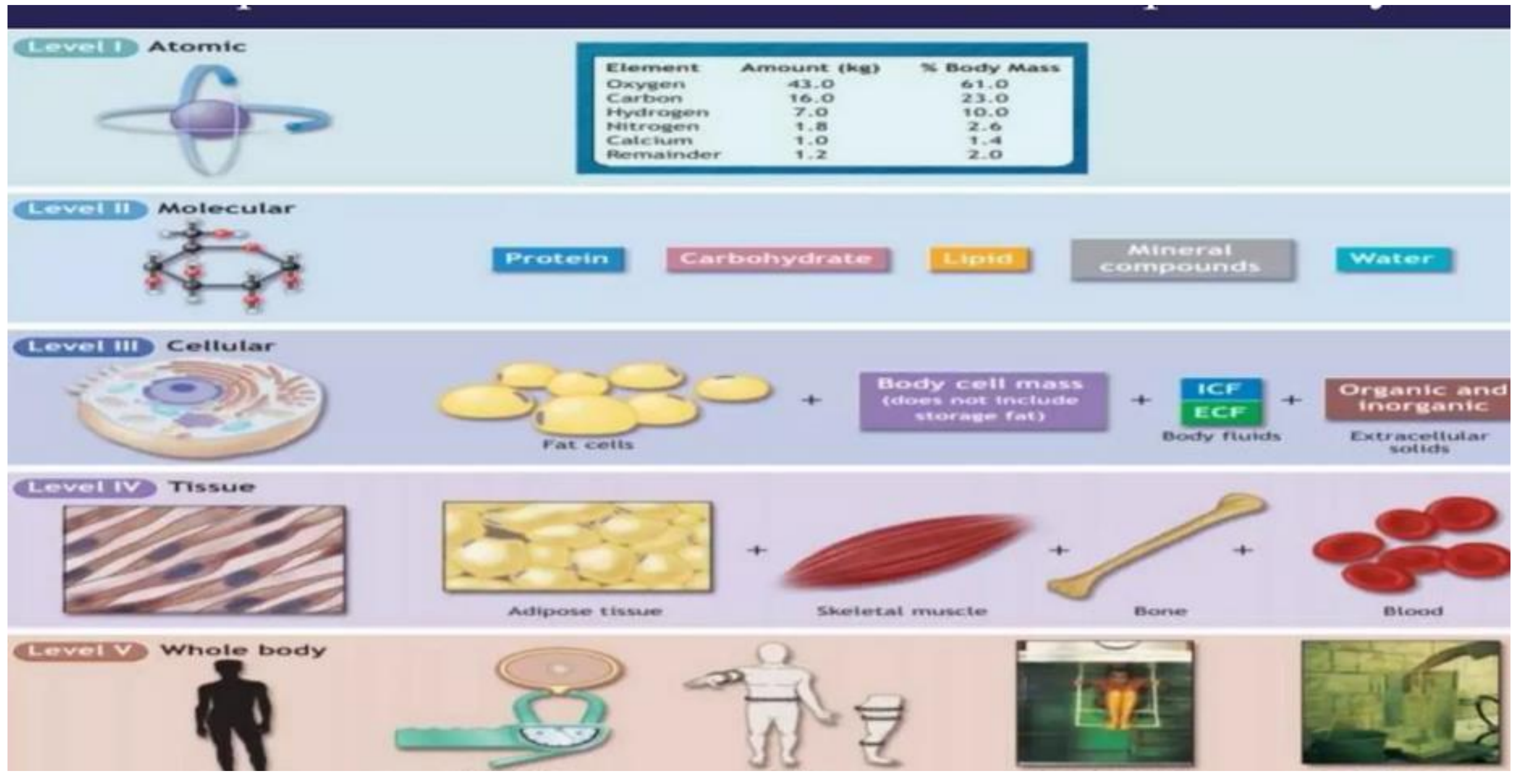
**Essential fat:** crucial for normal body functioning

**Nonessential fat:** adipose tissue



# Body Composition Models

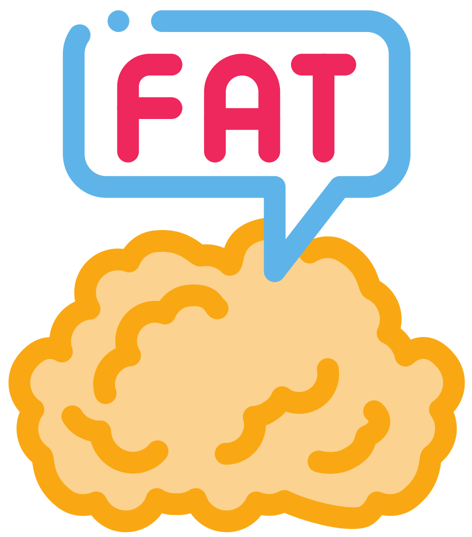



**Two-Compartment model:** divides the human body into fat and fat-free mass.

**Multi-component model:** divide the human body into the atomic model, molecular model, cellular model, and tissue system model.

# Why assessing body composition?




**Information about the % of body fat and fat distribution**

The most important consideration is the proportion of total body weight that is fat

Estimating a healthy body weight and formulating nutritional recommendations/ exercise prescriptions (over and underweight/fatness)

Estimating competitive body weight for athletes participating in sports that use body weight classification

Monitoring the growth of children and adolescents and identifying those at risk ( under or overweight/fatness)

Body changes associated with aging, malnutrition or obesity

# Two Method Body Composition Assessment

**Direct**

- Chemical solution dissolves
- Physical dissection

**Indirect**

- Height, weight and BMI
- Hydro densitometry
- Air displacement plethysmograph
- Skin fold method
- Bioelectrical impedance analysis (BIA)
- Dual-energy X-ray absorptiometer (DEXA)

# Height, weight and BMI

Body Height: measured by stadiometer

Body weight: measured by weighing scale

Body Mass Index (BMI): estimated by equation BMI= Weight (kg)/ Height (cm)2

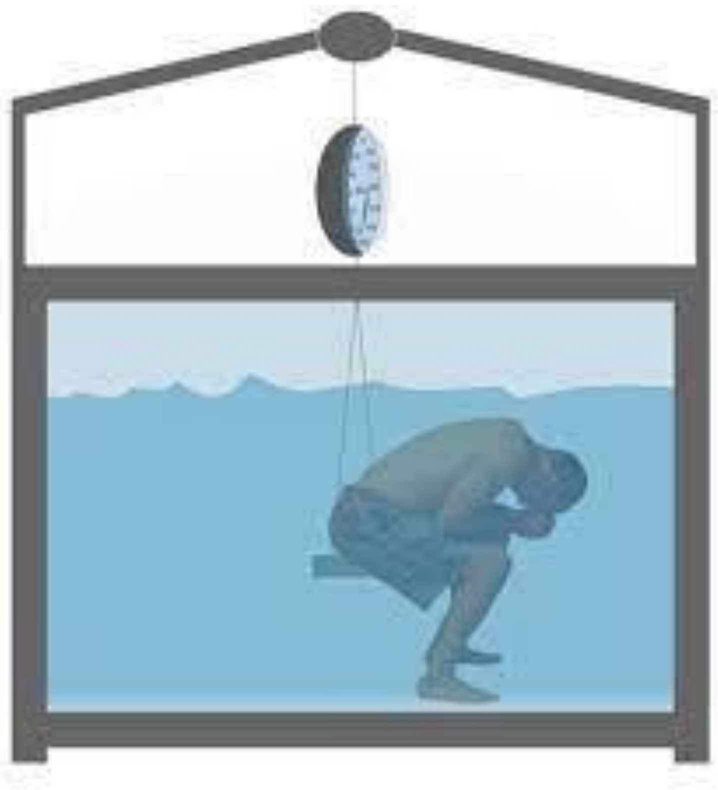
| Classification | BMI (kg/$m^2$) | Risk of comorbidities |
|---|---|---|
| Underweight | <18.5 | Low (but risk of other clinical problems increased) |
| Normal range | 18.5–24.9 | Average |
| Overweight (preobese) | 25.0–29.9 | Mildly increased |
| Obese | ≥30.0 | |
| Class 1 | 30.0–34.9 | Moderate |
| Class 11 | 35.0–39.9 | Severe |
| Class 111 | ≥40.0 | Very severe |

# BMI postive and negative factors

- A significant predictor of cardiovascular disease and type 2 diabetes.
- Is widely used in population-based and prospective studies

- Does not differentiate fat from lean body mass
- Athletes with a large amount of muscle mass can be wrongly classified into the 'moderate or high-risk' categories

# Hydro densitometry



Based on the density of the body

**D= Mass/volume**

Mass= measured by scale weight

Volume= 1. hydrostatic weighing (underwater weighing)

2. volume by air displacement

**Archimedes' Principle**: weight loss underwater is directly proportional to the volume of water displaced by the body volume.

# Hydro densitometry - Calculation

Body density = Wa / (((Wa - Ww) / Dw) - (RV + 100cc))

Wa = body weight in the air (kg),
Ww = body weight in water (kg),
Dw = density of water (according to temperature)
RV = residual lung volume
100cc is the correction for air trapped in the gastrointestinal tract.

NEXT

**Siri (1956): Fat % = [4.950 /Density - 4.500]×100**

**Brozek et al. (1963): Fat % = [4.570 /Density - 4.142]×100**

# Hydrostatic Weighing

- A most common technique used for decades
- The majority of indirect techniques have been validated against hydrostatic weighing

- Time-consuming
- Difficult to perform on the aquaphobic
- Requires measurement of residual lung volume
- Impractical to measure a large number of people

# Air displacement plethysmograph

- Measure the body volume and density using air displacement instead of water to estimate the volume.
- Body volume is calculated by subtracting the air volume of the person inside the chamber from the volume of the empty chamber.
- The individual sits inside the small chamber (Bod Pod)
- Computerized pressure sensors determine the amount of air displaced by the person.
- After estimating the body volume is possible to predict the body density and body fat.
- Take around 5-10 minutes.

# Air displacement plethysmograph

Factors to consider:

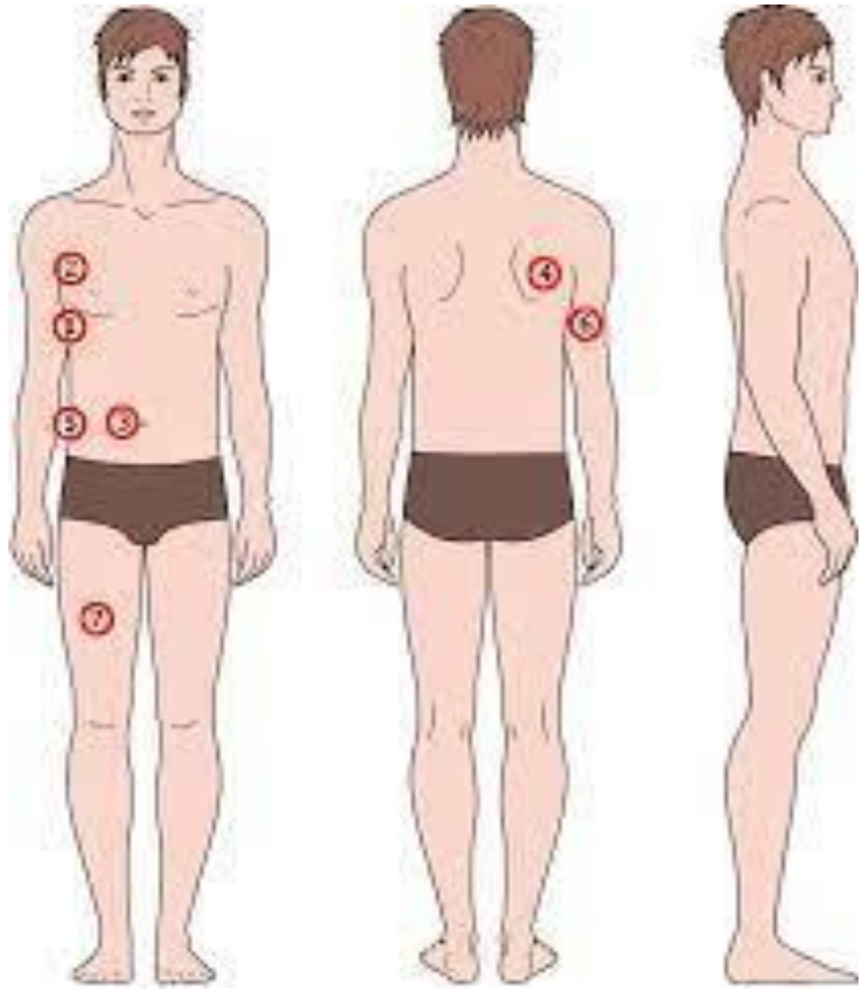
- Individuals are tested wearing minimal clothing (a swimsuit) and a swim cap to compress the hair.
- Individuals with excess body hair may affect the results (underestimating).

# Skinfold Thickness

- Based on the principle that the amount of fat beneath the skin is proportional to total body fat
- Reliable measurement of the tissue gives a good indication of the percent body fat.
- A simple anthropometric procedure that estimates body fat from the close relationship between three factors:

1. Subcutaneous fat in adipose tissue deposits directly beneath the skin
2. Body's internal fat store
3. Body density of the intact human body

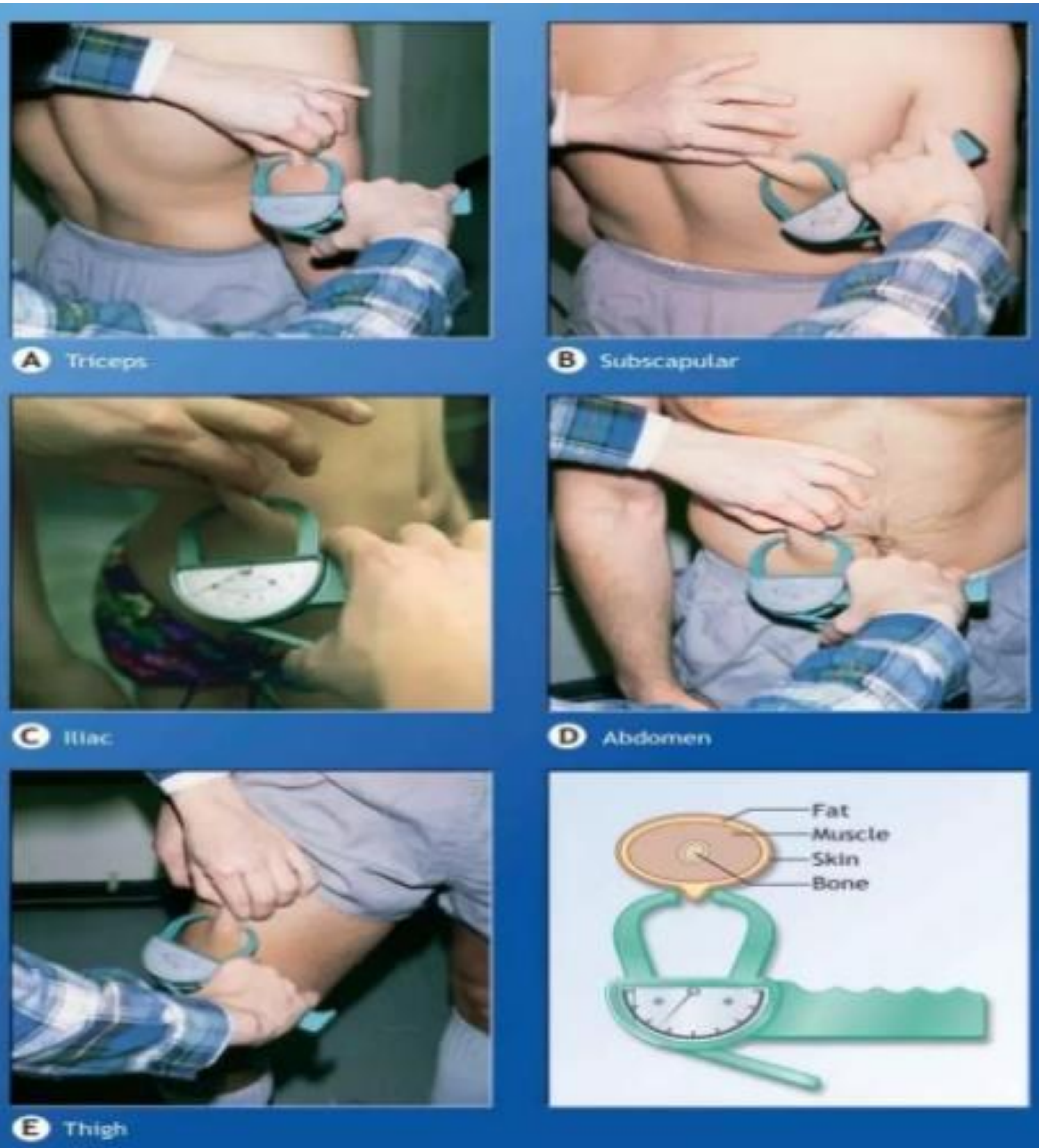
# Skinfold Thickness Measurement



- Skinfold measurement is done with pressure calipers
- Specific anatomical sites are measured, on the right side of the body, three times (average or repeated number is taken)
- The values are applied in predictive equations to estimate body fat.

- Skin fold sites

1. triceps – vertical
2. Subscapular – oblique
3. Iliac crest – oblique
4. Abdomen – vertical
5. Thigh – vertical
6. Biceps - vertical



# Skinfold Thickness Formulas

| *Authors* | *Population* | *Equations* |
|---|---|---|
| Siri (1961) | Adults | M and F: Fat (%) = 495/D – 450 |
| Lohman *et al* (1984) | Prepubescent children | M and F: Fat (%) = 530/D – 489 |
| Weststrate and Deurenberg (1989) | 10–18 y (modification of Siri equation) | F: Fat (%) = [553–7.3 (Age – 10)] / D – [514–8 (Age –10)]<br>M: Fat (%) = [562–4.2 (Age – 2)] / D – [525–4.7 (Age –2)] |
| Brook (1971) | 1–11 y (predicted from equations for adolescents) | F: *D* = 1.2063–0.0999 (LOG sum of 4 skinfolds)<br>M: *D* = 1.1690–0.0788 (LOG sum of 4 skinfolds) |
| Durnin and Rahaman (1967);<br>Durnin and Womersley (1974) | 13–15.9 y<br>16–19.9 y | F (13–15.9 y): *D* = 1.1369–0.0598 (LOG sum of 4 skinfolds)<br>M (13–15.9 y): *D* = 1.1533–0.0643 (LOG sum of 4 skinfolds)<br>F (16–19.9 y): *D* = 1.1549–0.0678 (LOG sum of 4 skinfolds)<br>M (16–19.9 y): *D* = 1.162–0.063 (LOG sum of 4 skinfolds) |
| Johnston *et al* (1988) | 8–14 y | F: *D* = 1.144–0.06 (LOG sum of 4 skinfolds)<br>M: *D* = 1.166–0.07 (LOG sum of 4 skinfolds) |
| Deurenberg *et al* (1990) | Pubertal F: 13.1 $\pm$ 0.15 y<br>Pubertal M: 13.8 $\pm$ 0.21 y<br>Post-pubertal F: 16.8 $\pm$ 0.36 y<br>Post-pubertal F: 17.5 $\pm$ 0.39 y | F pubertal: *D* = 1.1074–0.0504 (LOG sum of 4 skinfolds) + 1.6 (age $10^{-3}$)<br>M pubertal: *D* = 1.0555–0.0352 (LOG sum of 4 skinfolds) + 3.8 (age $10^{-3}$)<br>F post-pubertal: *D* = 1.183–0.0813 (LOG sum of 4 skinfolds)<br>M post-pubertal: *D* = 1.1324–0.0429 (LOG sum of 4 skinfolds) |
| Sarría *et al* (1998) | 11–16.9 y | M (11–13.9): D = 1.1516–0.0658 (LOG sum of 4 skinfolds)<br>M (14–16.9): D = 1.169–0.0693 (LOG sum of 4 skinfolds) |
| Sloan *et al* (1962) | Young women | F: D = 1.0764–0.00081 suprai – 0.00088 tric |
| Wilmore and Behnke (1970) | Young women | F: D = 1.06234–0.00068 subsc – 0.00039 tric – 0.00025 thigh |

# Bioelectrical Impedance Analysis (BIA)


- Based on the principle that the fat tissue is a less-efficient conductor of an electrical current (1-10 uA).
- The easier the conductance, the leaner the individual
- Low-level electrical current is passed through the individual body and the impedance or the opposition to the flow of the current is measured with a BIA analyzer.
- It is possible to estimate body fat, lean body mass and body water

# Bioelectrical Impedance Analysis (BIA)

- BIA devices are considered safe for most people

CAUTIONS:

- Anyone with an electronic medical implant
- Pregnant women


Factors that may affect the measurement

- Body weight: less accurate in obese people
- Hydration: dehydration may cause the fat-free mass (muscle and bone) to be underestimated
- Exercise: a recent exercise in high intensity may affect the accuracy
- Food and drink: recent food and drink intake may affect the accuracy. Overnight fasting is more accurate

# Dual-Energy X-Ray Absorptiometey

- A high-technology procedure that quantifies fat and muscle around bone areas of the body, including regions without the bone present.
- Consists of a short exposure with low radiation dosage penetrates into the bone and soft tissue areas to a depth of about 30cm. Specialized computer software reconstructs an image of the underlying tissue.
- The computer generates a report that quantifies bone mineral content, total fat mass, and fat-free mass.

# A COMPARISON OF COMMON BODY COMPOSITION METHODS IN SPORT

**REFERENCE:** Larson-Meyer et al. (2018); *International Journal of Sport Nutrition And Exercise Metabolism*
Slater et al. (2018); *Best Practice Protocols for Physique Assessment in Sport*

**MORE INFO:** Designed by Adam Virgile
Learn more here: https://blog.shakebot.co/ @shakebotapp

| Assessment Method | Cost | Technician Skill | Accuracy % Error | Reliability | Subject Comfort | Regional Assessment | Time Required | Common Sources of Error |
|---|---|---|---|---|---|---|---|---|
| **Skinfolds Assessment** Compressed subcutaneous fat thickness via skinfold calipers | $ | Med | Med 3-7% | High | Body touched by practitioner | Yes | <10 min | • Formula used • Inconsistent site locations • Population-specific prediction equation |
| **Bioelectrical impedance analysis** Fat mass, fat-free mass, body water via imperceptible electric current thru body | $ to $$$$$ | Low | Low 3-11% | Low | Non-invasive | Yes; but invalid | <5 min | • Hydration status • Body temperature • Recent exercise • Food intake |
| **Underwater weighing** Fat mass, fat-free mass, total body volume via water displacement | $$$$$ | High | Med 2-3% | High | Involves full water submersion | No | 10-20 min | • Fat-free mass fluctuations (water, minerals, proteins) • Air in lungs |
| **Air displacement plethysmography** Fat mass, fat-free mass, total body volume via air displacement | $$$$$ | High | Med 2-3% | High | May involve sitting in small spaces | No | <10 min | • Moisture on skin • Hydration status • Inconsistent clothing • Breathing patterns |
| **Dual energy x-ray absorptiometry** Bone, fat mass, non-osseous lean mass via X-ray beams thru body | $$$$$ | High | Med 2-3% | High | Non-invasive | Yes | <10 min | • Muscle glycogen stores • Inconsistent clothing • Changes in technology & software |
| **Ultrasound** Uncompressed subcutaneous fat thickness via imperceptible high-frequency sound waves | $$$ to $$$$$ | High | High 1-3% | Med | Body indirectly touched with device | Yes | <10 min | • Inconsistent site locations • Technician inexperience • Inconsistent interpretation |

# Practical application - Sport

## Maximizing Fat-Free Mass


Desirable for athletes involved in strength, power and muscular endurance types of modalities in which the body weight is moved through space.

## Severe weight loss

Dehydration: impairs kidney and cardiovascular function; impairing performance

Chronic fatigue: similar symptoms of overtraining

# Practical application - Sport

## Problems associate with very low levels of body fat

Too little body fat is associated with impairment in reproductive health (low levels of testosterone and estrogen); disorders in the immune system; lower bone mineral density; increase risk of injuries.

In female athletes, increase the chance of the Female Triad Syndrome: interrelationship of menstrual dysfunction, low energy availability and decrease of bone mineral

# Orthorexia Nervosa:
*When healthy eating goes wrong*

The foods we eat should fuel our body.
But if nutrition disrupts your life, it could be orthorexia.

| POSITIVE NUTRITION | PATHOLOGICAL NUTRITION |
| --- | --- |
| Nourishes our body | Excludes certain foods |
| Promotes social bonds | Harms our health |
| Gives us pleasure | Controls our thoughts and behaviors |
| Allows for flexibility | Interferes with relationships |

Source: Jessica Setnick, MS, RD, CEDRD-S

OhioHealth

Eating disorders are serious medical conditions.
If you need help, seek care from a physician quickly.
*Visit ohioHealth.com/FindADoctor.*

*Cabre HE[1,2], Moore SR[1,2], Smith-Ryan AE[1,2,3], Hackney AC[2,3]*

# Relative Energy Deficiency in Sport (RED-S): Scientific, Clinical, and Practical Implications for the Female Athlete

*Relativer Energiemangel im Sport (RED-S): Wissenschaftliche, klinische und praktische Implikationen für die Sportlerin*

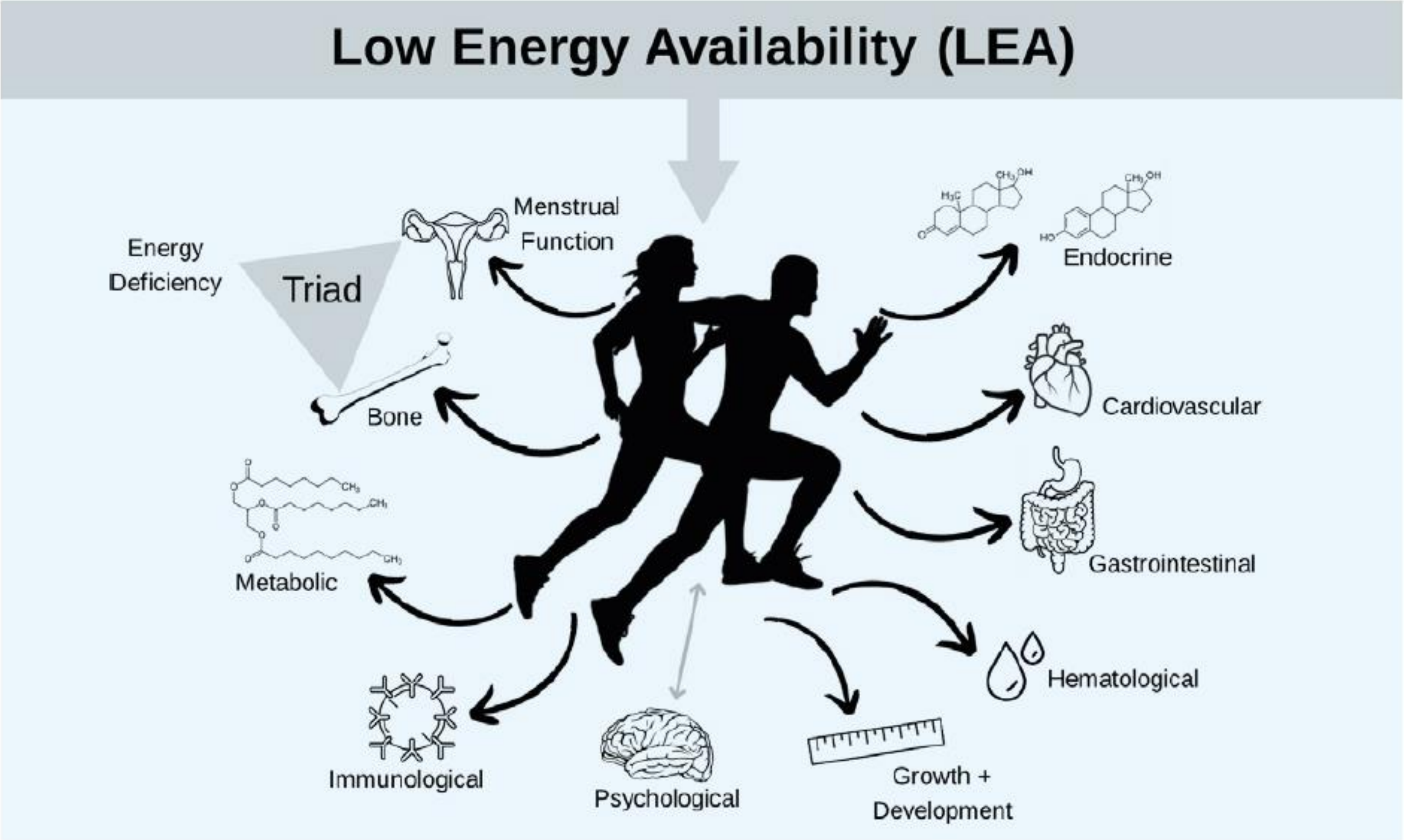



**Figure 2**

A summary of the physiological effects of low energy availability (LEA).

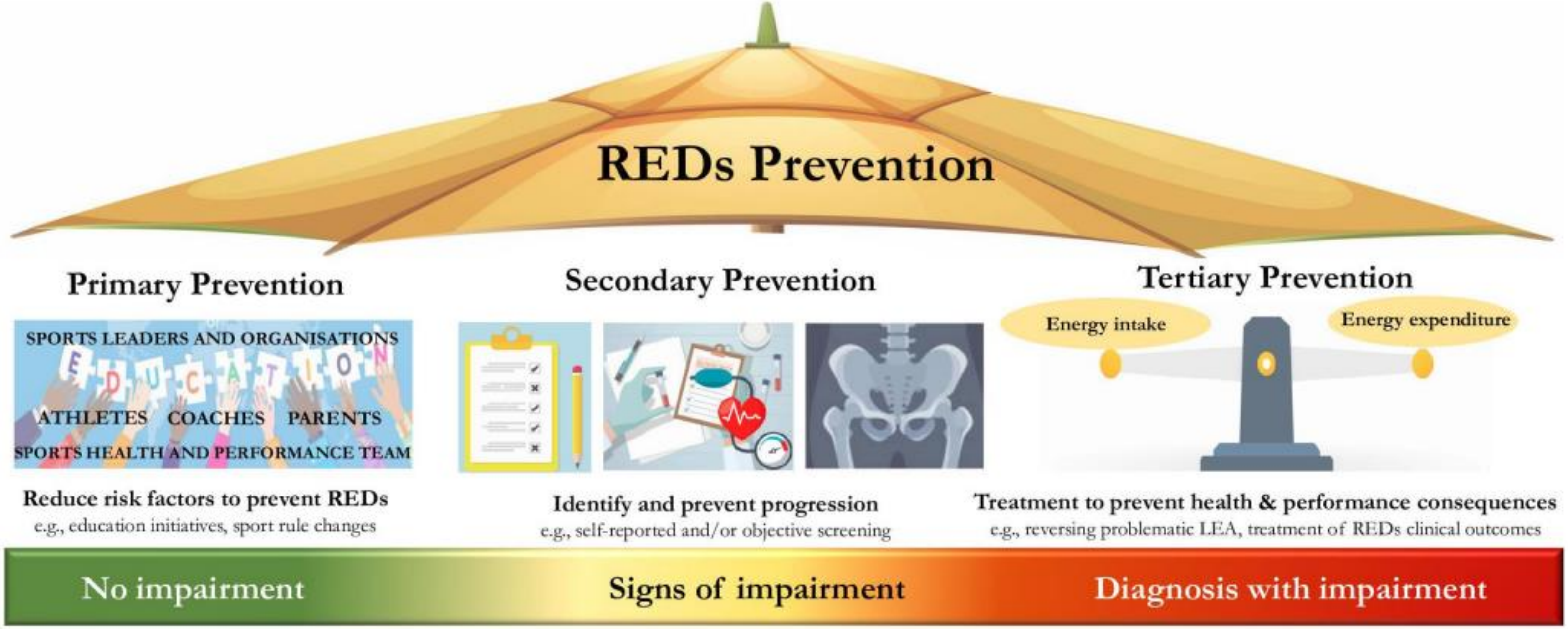



**Figure 1** A primary, secondary and tertiary prevention model of Relative Energy Deficiency in Sport (REDs). Pictures from pixabay.com.

# Practical application - Sport

To consider in sport settings:

- Prioritize the body composition instead of weight
- Specific sport modality
- Sex and individual differences should be considered
- Methodological errors in body composition measurement should be considered
- A combination of diet and exercise is the best approach for optimal weight loss, for athletes with no more than 0.5 -1.0kg per week until reaching the desired body composition range.


Obrigada

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