# Nutritional Status Assessment

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# Outline, main points

- Background, basics, definitions, objectives, indications
- Malnutrition

*Techniques (in assessing nutritional status)*:

- History
- Anthropometry
- Physical (clinical) examination - general appearance
- Biochemical and immunological examinations
- Dynamometry tests (muscle strength)
- Validated screening tools
- Children (specifics)

# Definitions, scope

- Nutritional status:

  - The resulting status of health and nutrition given and influenced by diet, dietary intake and uptake, factors influencing uptake (including malfunctions and diseases), energy output, heredity, environmental factors, lifestyle (physical activity, smoking, alcohol…)

- Nutritional assessment – differentiate:

  - Dietary assessment, (Food consumption, Dietary habits …)

    v.s.

  - Nutritional status assessment

- Malnutrition

  - Nutritional status, which is characterized by a deficit or excess of energy or individual nutrients

  - This imbalance results in measurable changes in the tissues, the body's form, the functions of the organism, and the clinical condition of the individual

## Malnutrition by deficiency - undernutrition

- Energy, energy-protein deficiency malnutritions:
  - ⇒ Underweight
  - ⇒ Cachexia
  - ⇒ Marasmus
  - ⇒ Kwashiorkor
  - ⇒ Marasmic kwashiorkor
- Specific deficiencies
  - ⇒ Iodine deficiency - endemic goitre (Struma)
  - ⇒ Vit. A deficiency - xeroftalmia
  - ⇒ Nutritional anaemia
  - ⇒ Nutritional osteopenia
  - ⇒ B1 (Thiamine) deficiency - Beri beri
  - ⇒ B2 (Riboflavin) deficiency
  - ⇒ B3 (Niacin, vit. PP) - Pellagra
  - ⇒ Vit C deficiency) - Scurvy
  - ⇒ Sarcopenia

## Malnutritions by excess, overnutrition

- ⇒ Overweight
- ⇒ Obesity
- ⇒ Micronutrient excess

*Classification of nutritional concepts according to ESPEN*

***Human nutrition:***

- *Preventive nutrition*
  - Population based public health nutrition
- *Clinical nutrition*

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*Classification of clinical nutrition concepts; i.e. nutrition disorders and nutrition related conditions*

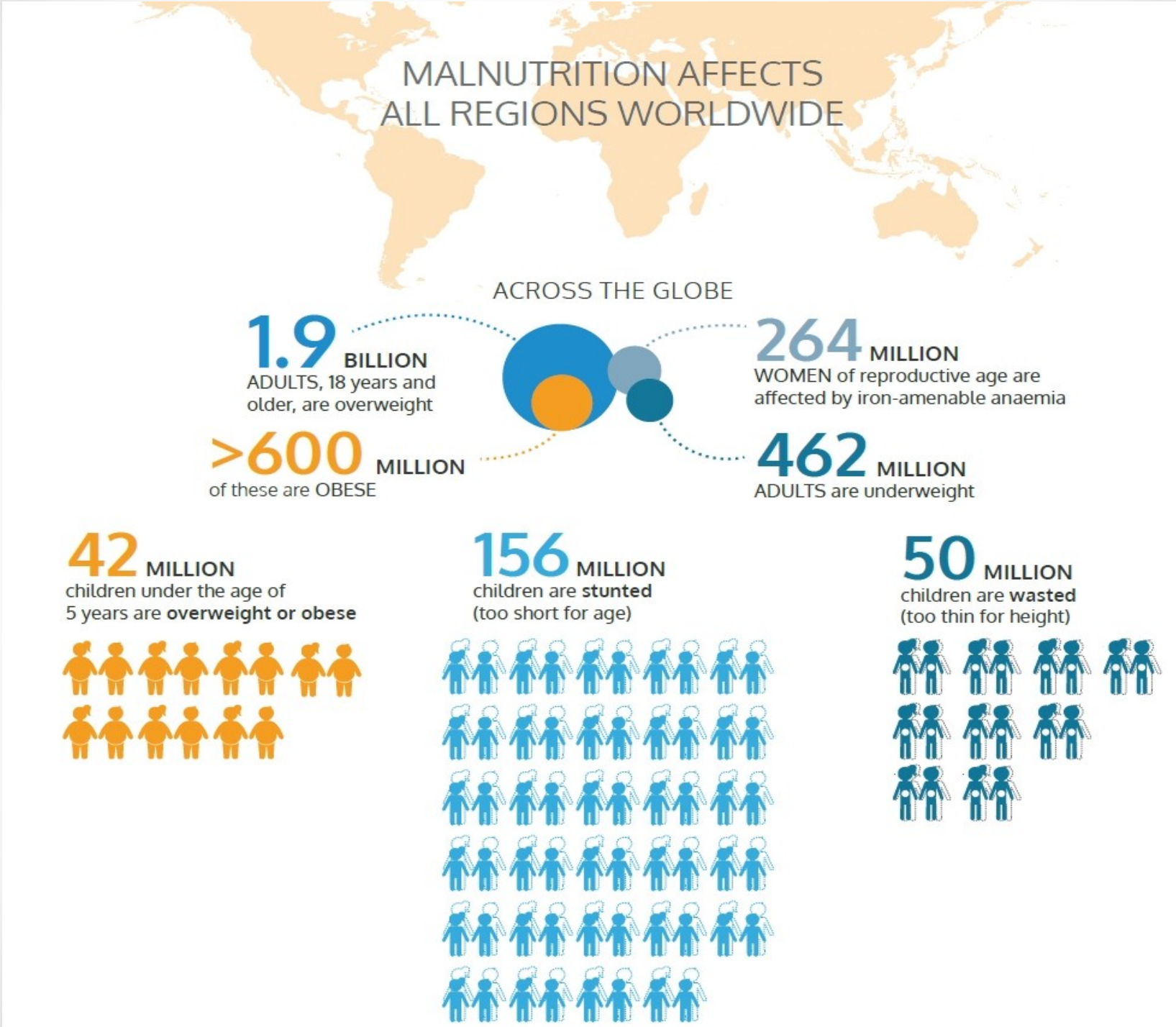
- *Clinical nutrition*
  - **Malnutrition**; Synonym: Undernutrition
    - Disease-related malnutrition (DRM) with inflammation
      - Chronic DRM with inflammation; Synonym: Cachexia
        - A Cancer cachexia and other disease-specific forms of cachexia
      - Acute disease- or injury-related malnutrition
    - DRM without inflammation. Synonym: Non-cachectic DRM
    - Malnutrition/undernutrition without disease. Synonym: Non-DRM
      - Hunger-related malnutrition
      - Socioeconomic or psychologic related malnutrition
  - **Sarcopenia**
  - **Frailty**
  - **Over-nutrition**
    - Overweight
    - Obesity
      - Sarcopenic obesity
      - Central obesity
  - **Micronutrient abnormalities**
      - Deficiency
      - Excess
  - **Refeeding syndrome**

*Source: ESPEN guidelines on definitions and terminology of clinical nutrition, Clinical nutrition 2016*

# Burden of malnutrition

- Malnutrition affects people in every country.
- Around 1.9 billion adults worldwide are overweight, while 462 million are underweight.
- An estimated 41 million children under the age of 5 years are overweight or obese, while some 159 million are stunted and 50 million are wasted.
- Adding to this burden are the 528 million or 29% of women of reproductive age around the world affected by anaemia, for which approximately half would be amenable to iron supplementation.
- Many families cannot afford or access enough nutritious foods like fresh fruit and vegetables, legumes, meat and milk, while foods and drinks high in fat, sugar and salt are cheaper and more readily available, leading to a rapid rise in the number of children and adults who are overweight and obese, in poor as well as rich countries.
- It is quite common to find undernutrition and overweight within the same community, household or even individual – it is possible to be both overweight and micronutrient deficient, for example.

# MALNUTRITION AFFECTS ALL REGIONS WORLDWIDE



World Health Organization

# THE DOUBLE BURDEN OF MALNUTRITION

## WHAT

THE DOUBLE BURDEN OF MALNUTRITION IS CHARACTERISED BY THE COEXISTENCE OF:

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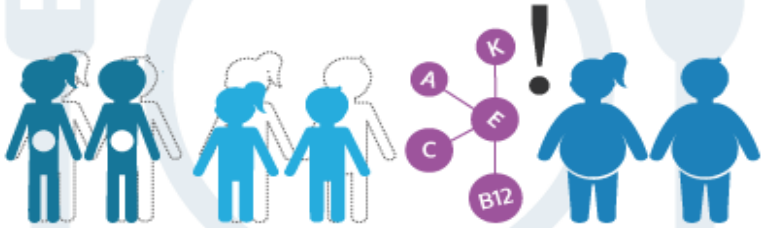



Undernutrition (wasting, stunting & micronutrient deficiencies) along with overweight and obesity

2

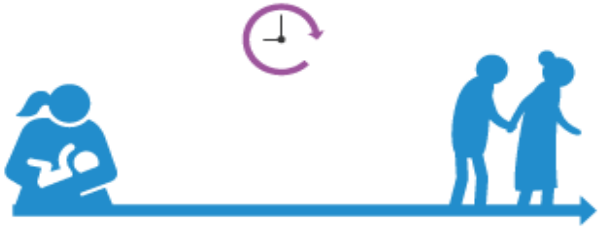
and diet-related noncommunicable diseases

3

within individuals, households and populations

4

throughout life



# Types of Protein-Energy Malnutrition (PEM)

- Underweight - adults low BMI, children low weight for age
- Starvation – pure caloric deficiency, conserve lean mass, increase fat metabolism
- Wasting – gradual loss of body mass (getting thinner). In children: Low weight for height.
- Stunting – low height for age
- Kwashiorkor – edematous PEM by protein deficiency
- Marasmus – severe wasting due to energy deficiency
- Marasmic kwashiorkor
- Cachexia –associated with inflammatory or neoplastic condition
- Sarcopenia - skeletal muscle wasting by ageing

The most common:

For infants – Marasmus , for older infants: Kwashiorkor

For elderly: Sarcopenia and cachexia (regarding undernutrition)

**Normal Height for age (WHO Growth Standards)**

**Normal**
Normal weight and height

**Wasted**
Thinner than normal

**Stunted**
Shorter than normal

**Wasted & Stunted**
Thinner and shorter than normal

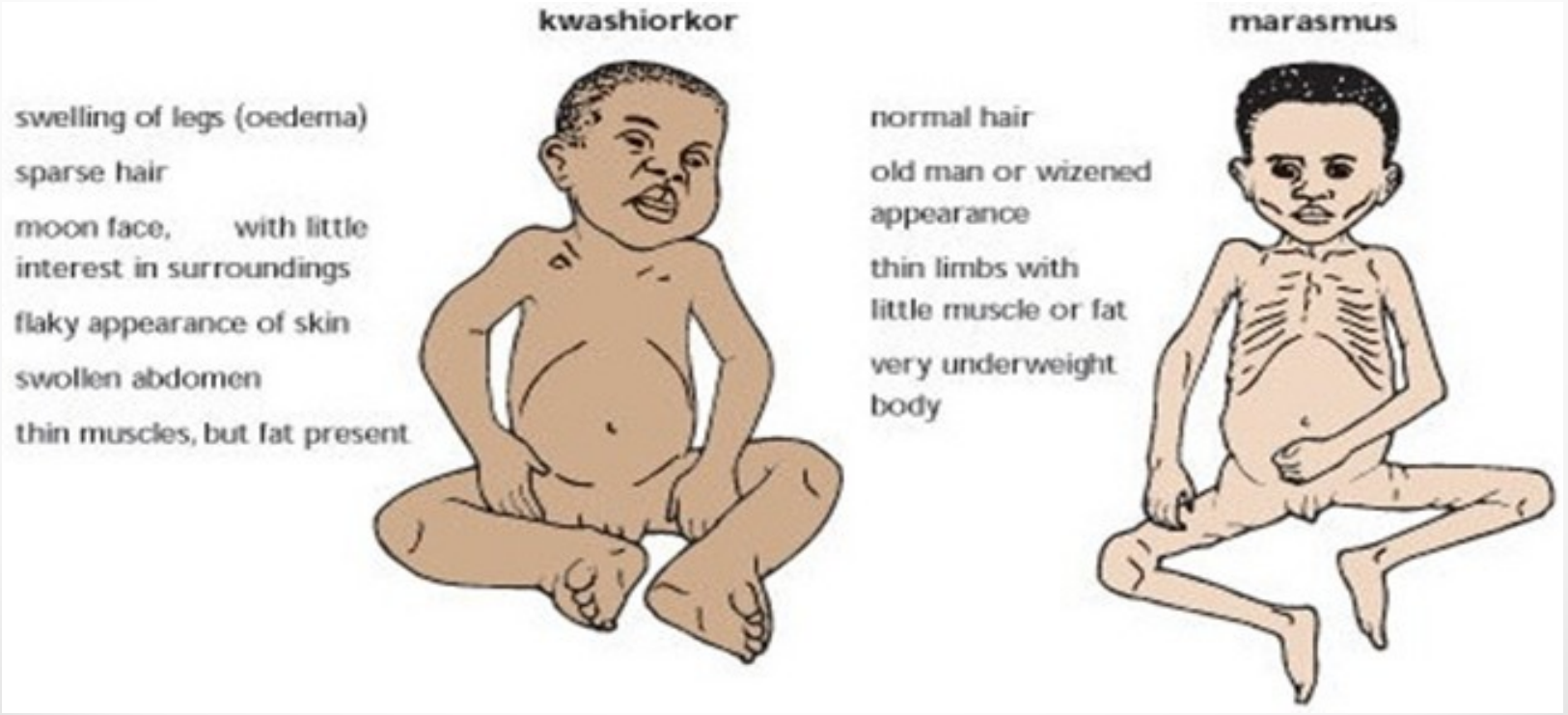
# Marasmus vs Kwashiorkor

- Marasmus

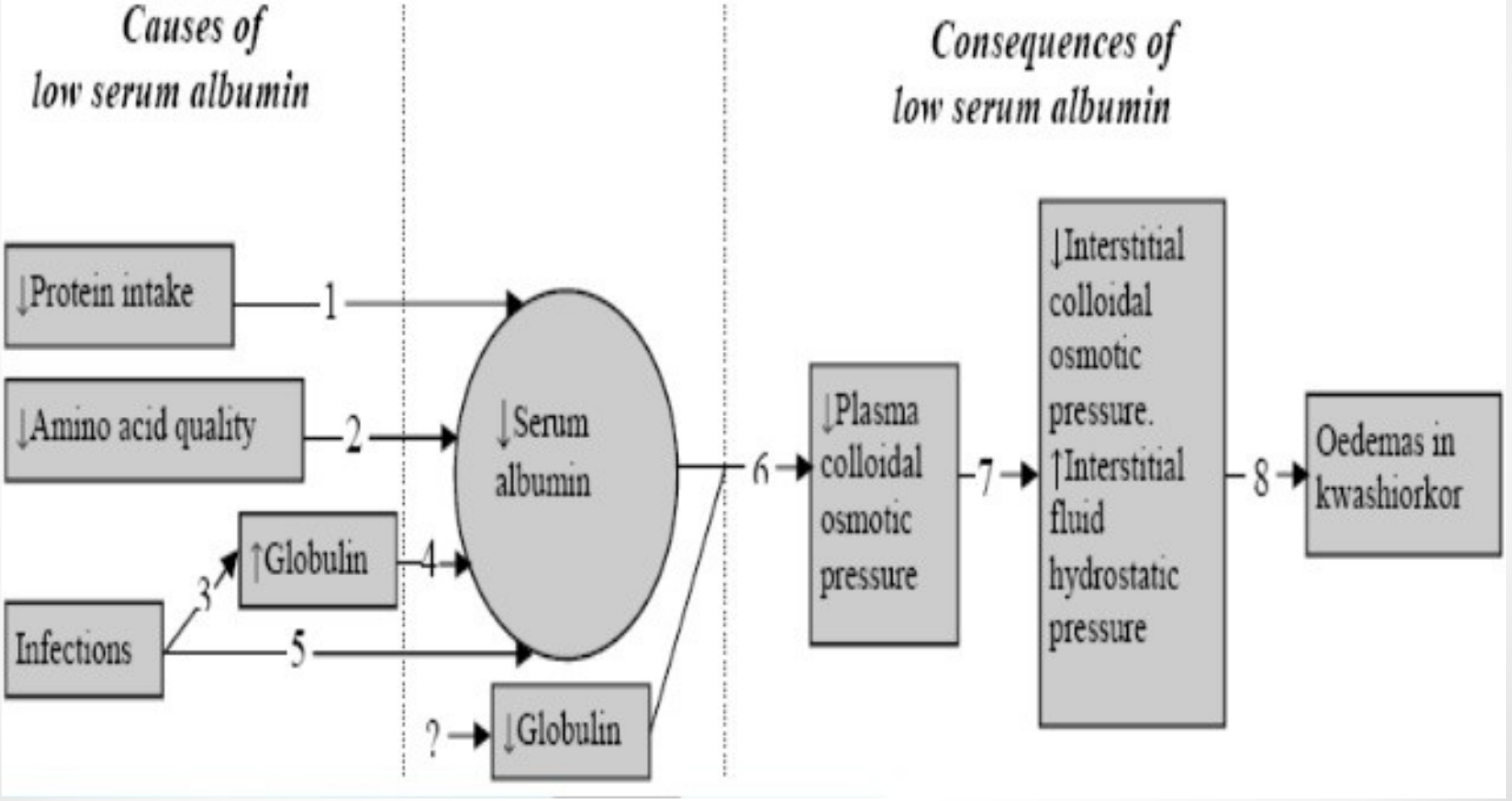
Marasmus is caused by a severe deficiency of nearly all nutrients, especially protein, carbohydrates, and lipids.

- Kwashiorkor

Sufficient calorie intake, but with insufficient protein consumption.



# Role of albumin



# Malnutrition - symptoms

- Lack of appetite or interest in food or drink
- Tiredness and irritability
- Inability to concentrate
- Always feeling cold
- Loss of fat, muscle mass, and body tissue
- Higher risk of getting sick and taking longer to heal
- Longer healing time for wounds
- Higher risk of complications after surgery
- Depression
- Reduced sex drive and problems with fertility
- Breathing becomes difficult
- Skin may become thin, dry, inelastic, pale, and cold
- The cheeks appear hollow and the eyes sunken, as fat disappears from the face
- Hair becomes dry and sparse, falling out easily

# Malnutrition - causes

- **Low intake of food**

  This may be caused by symptoms of an illness, for example, dysphagia, when it is difficult to swallow. Badly fitting dentures may contribute.

- **Mental health problems**

  Conditions such as depression, dementia, schizophrenia, anorexia nervosa, and bulimia can lead to malnutrition

- **Social and mobility problems**

  Some people cannot leave the house to buy food or find it physically difficult to prepare meals. Those who live alone and are isolated are more at risk. Some people do not have enough money to spend on food, and others have limited cooking skills.

- **Digestive disorders and stomach conditions**

  If the body does not absorb nutrients efficiently, even a healthful diet may not prevent malnutrition. People with Crohn's disease or ulcerative colitis may need to have part of the small intestine removed to enable them to absorb nutrients. Celiac disease may result in damage to the lining of the intestines and poor food absorption. Persistent diarrhea, vomiting, or both can lead to a loss of vital nutrients

- **Alcoholism**

  Alcohol can lead to gastritis or damage to the pancreas. These can make it hard to digest food, absorb certain vitamins, and produce hormones that regulate metabolism. Alcohol contains calories, so the person may not feel hungry. They may not eat enough proper food to supply the body with essential nutrients.

- **Lack of breastfeeding**

  Not breastfeeding, especially in the developing world, can lead to malnutrition in infants and children.

# Worldwide most frequent micronutrient deficiencies

- **Iron deficiency**
  - The world's most widespread micronutrient deficit (2 billion people)
  - Anaemia, reduced mental and physical performance, susceptibility to infections
- **Vitamin A deficiency**
  - In adult individual pool for 2 years
  - In developing countries, babies are born with small supplies and do not receive vitamin A by breastfeeding either
  - First, reversible night blindness
  - Later, irreversible blindness (annually 1.5 million children)
  - Decrease in immune functions, pneumonias, infectious diarrhea, death
- **Iodine**
  - The second most common deficit, very serious manifestations for the population
  - The world's most prevalent, yet easily preventable, cause of brain damage
  - "Iodine Deficiency Disorders" (IDD) - goiter, hypothyroidism, retardation of psychomotor development, cretinism
  - The best prevention: iodised salt
  - Natural content in food outside marine products depends on the geological basement - mountain deficiency
  - The urinary excretion shows the saturation (<100 ug / l = deficiency)

# The spectrum of iodine deficiency disorders, IDD

| | |
|---|---|
| Fetus | Miscarriage<br>Stillbirths<br>Congenital anomalies<br>Increased perinatal morbidity and mortality<br>Endemic cretinism |
| Neonate | Neonatal goiter<br>Neonatal hypothyroidism<br>Endemic neurocognitive impairment<br>Increased susceptibility of the thyroid gland to nuclear radiation |
| Child and adolescent | Goiter<br>(Subclinical) hypothyroidism<br>Impaired mental function<br>Retarded physical development<br>Increased susceptibility of the thyroid gland to nuclear radiation |
| Adult | Goiter with its complications<br>Hypothyroidism<br>Impaired mental function<br>Spontaneous hyperthyroidism in the elderly<br>Iodine-induced hyperthyroidism<br>Increased susceptibility of the thyroid gland to nuclear radiation |

# METHODS

# Methods, techniques

- History
- Physical, (clinical) examination – general appearance
- Anthropometry
- Laboratory – biochemical and immunological examinations
- Dynamometry tests (muscle strength)*

*Rather rare use

- Validated screening tests
- Children

# History and Physical Examination

- Comprehensive nutritional assessment begins with a history and physical examination. History should consist of medical diagnoses, hospitalizations, changes in appetite, availability and preparation of food, medications, and details regarding weight change. Weight loss is perhaps the most validated parameter of nutritional status.

- Following the history, a thorough physical examination may be performed. Attention should be directed toward findings of soft-tissue wasting, hydration status, evidence of vitamin and mineral deficiencies, height, weight, and body mass index (BMI). See table for a description of physical examination findings and related nutrient deficiencies.

# History

*To a large extent, it overlaps with the „Dietary assessment" , or "Nutritional history". Directly within the Nutritional Status assessment,we focus especially on the factors that can influence the nutritional status:*

- Dietary habits, possible alternative diets, social status..
- Lifestyle – physical activity, alcohol…
- Chronic and current diseases of the examined person

⇒ Focus on gastrointestinal problems

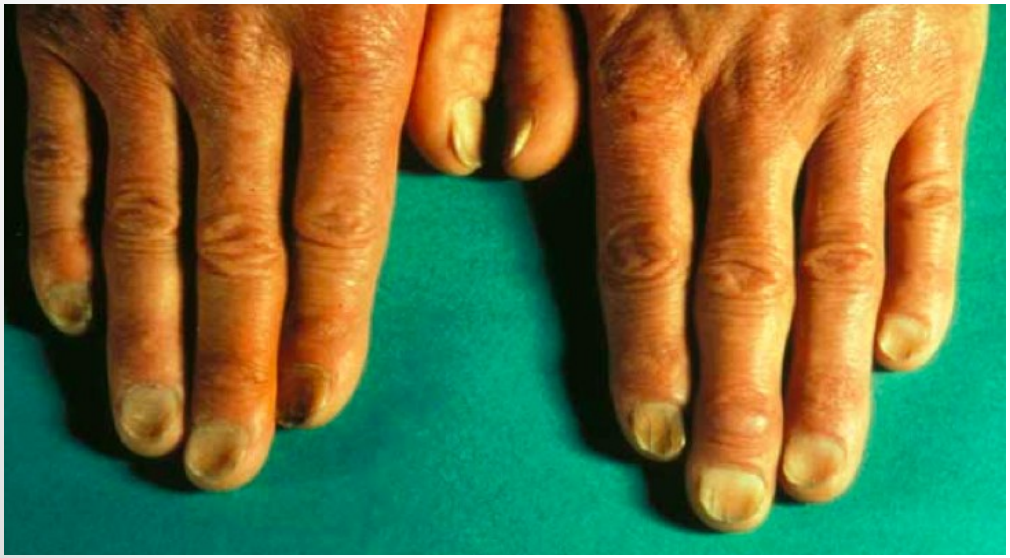
⇒ Using drugs that can interact with the digestion and uptake of nutrients

# Symptoms and signs of undernutrition and micronutrient deficiency

| Area/System | Symptom or Sign | Deficiency |
|---|---|---|
| **Skin** | • Pallor - especially palms<br>• Bruising, ecchymosis, petechiae, hematomas<br>• Hypo or hyperpigmentation, desquamation, ulceration<br>• Hyperpigmentation exposed areas (Pellagra)<br>• Perifollicular hyperkeratosis | Anaemia from iron or folate<br>Vitamin. C, vitamin K<br>Zinc or protein<br>Niacin (vitamin PP, B3)<br>Vitamin A |
| **Eye** | • Impaired night vision<br>• Xerotic conjuntivae, xerotic cornea, Bitot's spot, keratomalacia (corneal drying and clouding), corneal scars | Vitamin A |
| **Hair** | • Thinning or loss of hair, Depigmentation, pluckability, sparsity | Protein - Kwashiorkor |
| **Nails** | • Koilonychia, spooning of nails | Iron |
| **Mouth** | • Cheilosis, glossitis, loss of papillae, magenta tongue<br>• Glossitis, scarlet tongue<br>• Bleeding gums | Riboflavin (B2)<br>Niacin<br>Vitamin C |
| **Subcutaneous tissue** | • Reduced subcutaneous tissue and fat<br>• Oedema<br>• Muscle wasting, weakness | Energy<br>Hypalbuminaemia, Na and K disturbances<br>Undernutrition, protein |
| **Bones** | • Bone deformities - Craniotabes, prominent costochondral junctions, widening of metaphyses (wrists and ankle), frontal bossing, wide anterior fontanelle, rickety rosary, delayed dentition, bow legs.<br>• Joint pain or swelling<br>• Inadequate bone mass or osteoporosis | Vitamin D<br><br>Vitamin C<br>Calcium |
| **Abdomen** | • Hepatomegaly | Kwashiorkor |
| **Central nervous system, neurologic** | • Apathy<br>• Peripheral neuropathy – paresthesias or numbness in stocking-glove distribution<br>• Tetany<br>• Cognitive and sensory deficits<br>• Dementia | Kwashiorkor, iron deficiency<br>Thiamine (B1) – beri beri, or pyridoxine (B6)<br>Calcium, magnesium<br>Thiamine, niacin, pyridoxine, vitamin B12<br>Thiamine, niacin, B12 |
| **Cardiac** | • Cardiac failure or enlargement | Thiamine (B1) |
| **Endocrine - Thyroid** | • Goitre (thyromegaly) | Iodine |
| **Musculoskeletal** | • Wasting of muscle | Protein |
| **GI** | • Diarrhoea<br>• Diarrhoea and dysgeusia<br>• Dysphagia or odynophagia (Plummer-Vinson syndrome) | Protein, niacin, folate, vitamin B12<br>Zinc<br>Iron |

# Nails

- Nails
  - Anémie z nedostatku železa – suché, lomivé, ploché až lžičkovitého tvaru (koilonychie)
  - Nedostatek bílkovin – příčné bílé proužky



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# Eyes

- Oči
  - Blefaritis – nedostatek riboflavinu, příp. vitamínu A
  - Xeróza spojivek – nedostatek vitamínu A
  - Korneální skleróza, keratomalacie – nedostatek vitamínu A
  - Bitotovy skvrny – nedostatek vitamínu A
  - Korneální vaskularizace – nedostatek riboflavinu nebo vitamínu A
  - Angulární palpebritis – nedostatek riboflavinu, pyridoxinu, železa
  - Šeroslepost – nedostatek vitaminu A, retinolu a β-karotenu

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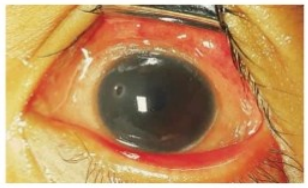

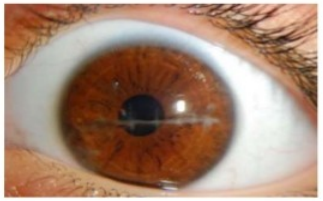

Corneal xerosis with corneal ulcer

Corneal Scar

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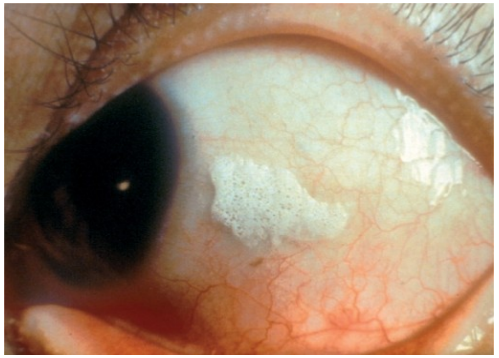

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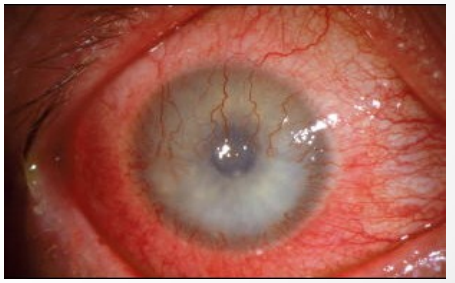

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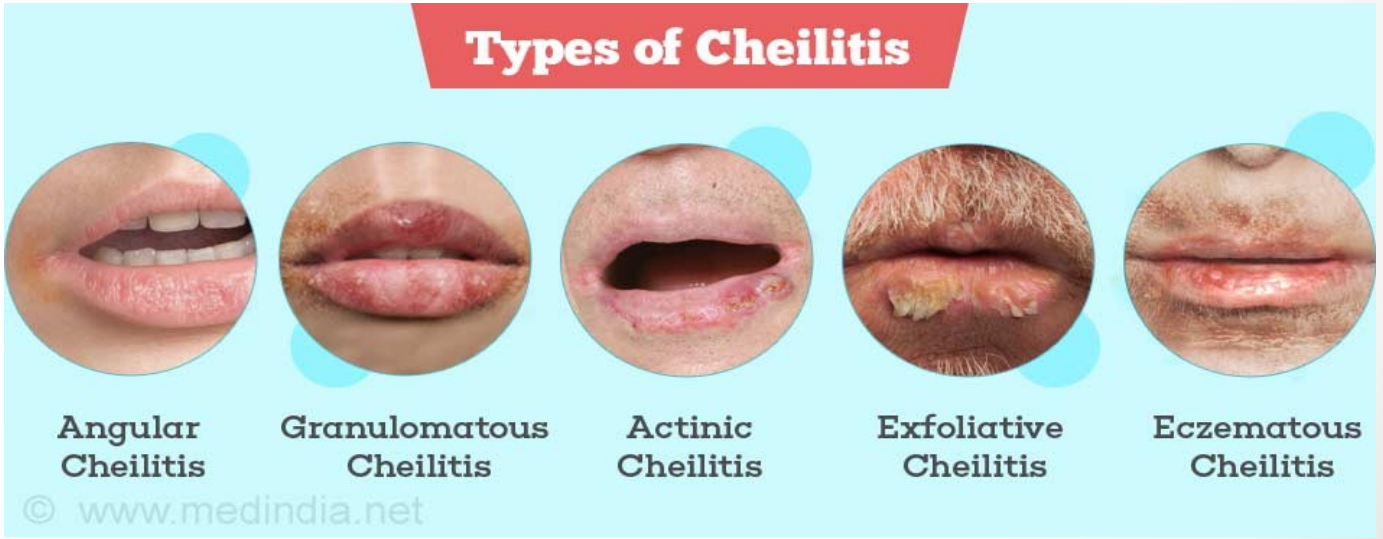
# Mouth, lips

- Rty
  - Angulární stomatitis – nedostatek riboflavinu, pyridoxinu, železa
  - Angulární jizvy – nedostatek riboflavinu, pyridoxinu
  - Cheilitis – nedostatek riboflavinu

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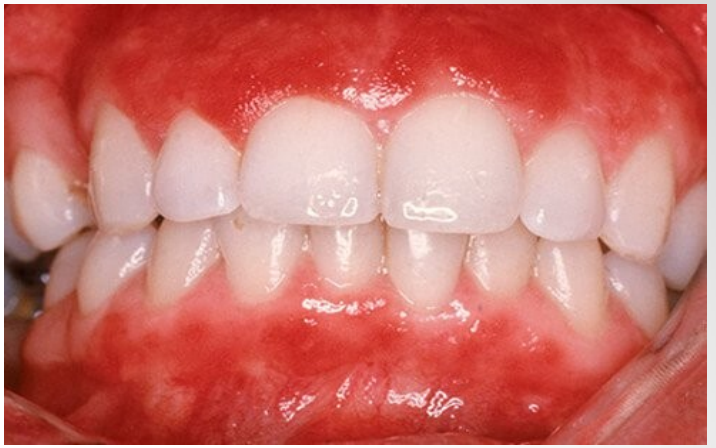
# Teeth, gums



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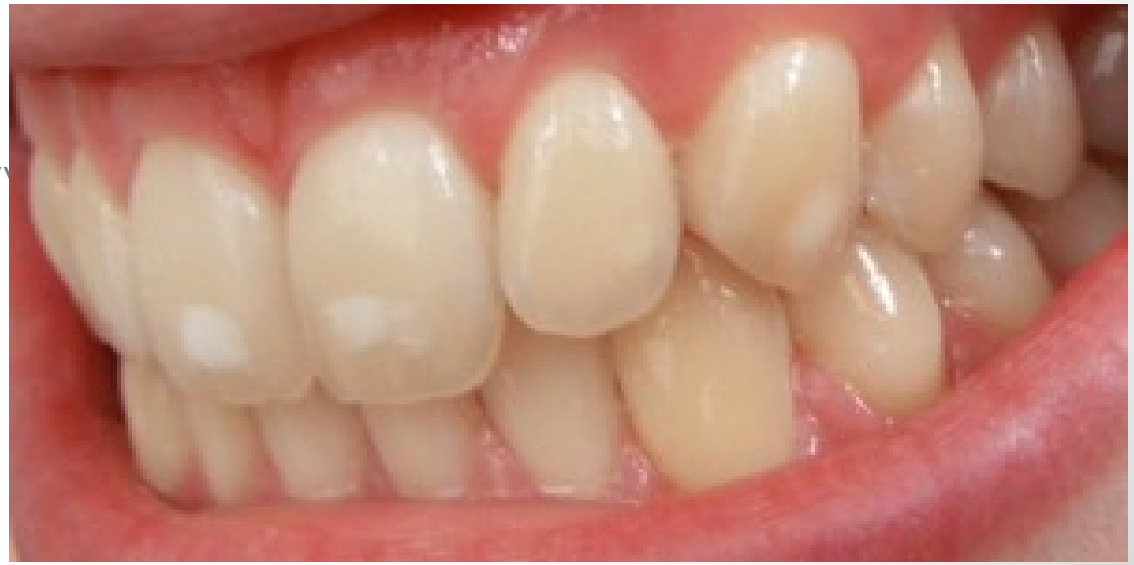
- Dásně
  - Gingivitis – nedostatek vitamínu C
- Jazyk
  - Nedostatek riboflavinu, k. nikotinové, pyridoxinu, kobalaminu, k. listové a železa – akutní zánět, glossodynie, pukliny, vyhlazení povrchu jazyka
- Zuby
  - Zubní kaz
    - Nedostatek fluoru – zv
  - Skvrnitá sklovina
    - Nadbytek fluoru



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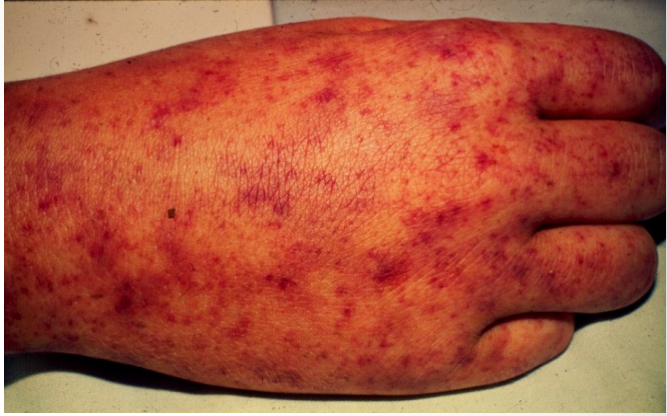
# Skin

- Kůže
  - Folikulární hyperkeratóza – nedostatek vitamínu A, nedostatek esenciálních mastných kyselin, nedostatek pyridoxinu
  - Xeroderma – nedostatek vitamínu A
  - Nasolabiální seborrhoea – nedostatek riboflavinu
  - Folikulární petechie – avitaminóza C
  - Petechiální hemorrhagie – avitaminózy C, K



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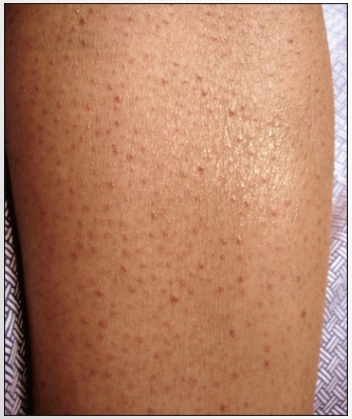

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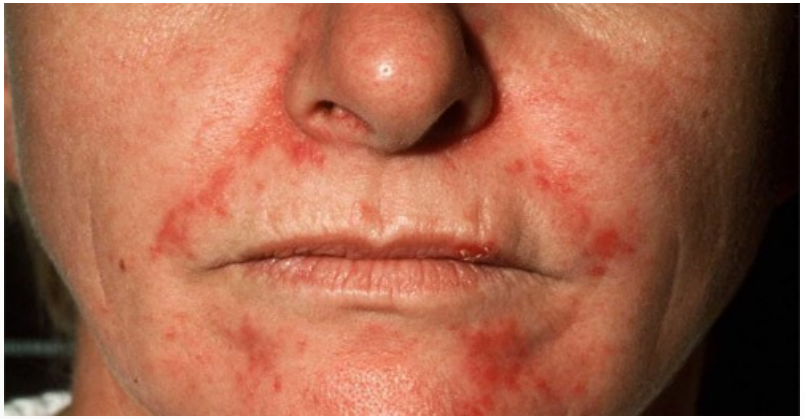

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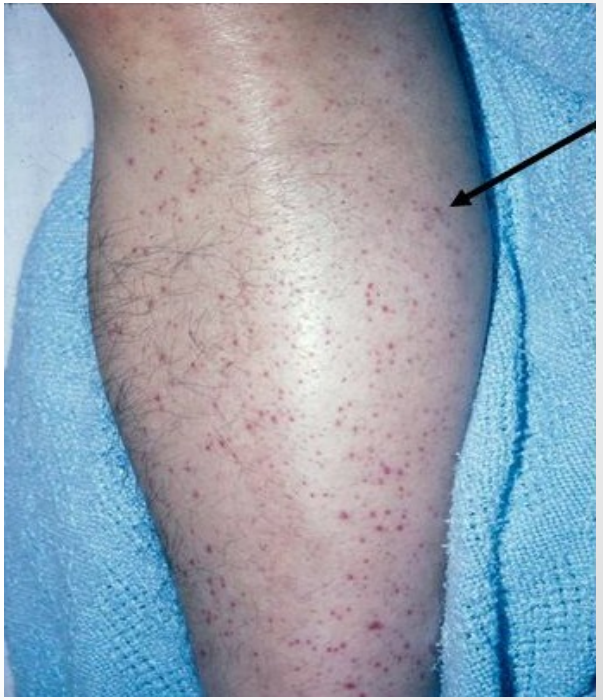

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# Skin

- Kůže
  - Změny pigmentace
    - Špinavě hnědé skvrny – chronická podvýživa
    - Depigmentace – kwashiorkor
    - Erytém, svědění, pálení – puchýřky – hrubnutí kůže – pellagra
    - Bledá kůže - chudokrevnost

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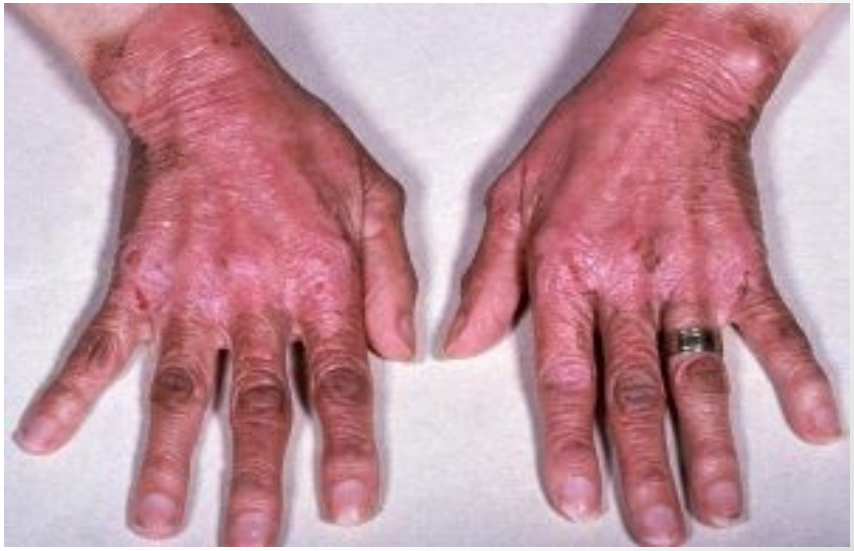

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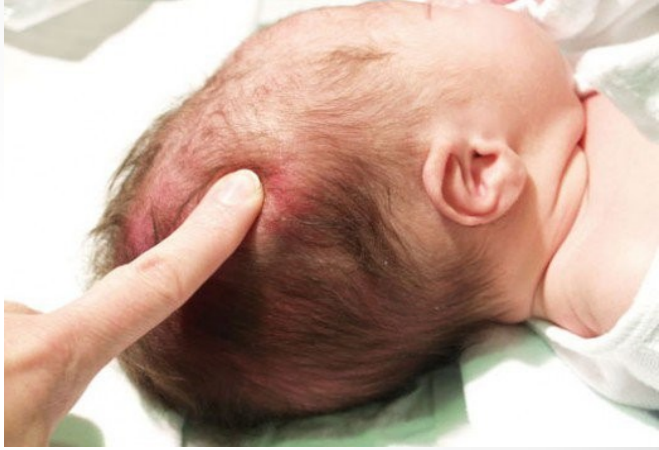
# Bones, skeleton

- Kostra – nedostatek vito
  - Craniotabes
  - Caput quadratum
  - Pozdní uzávěr velké fontanely
  - Rachitický růženec
  - Pectus carinatum
  - Harrisonova rýha
  - Deformace dlouhých k
  - Nohy do „X“ nebo do „



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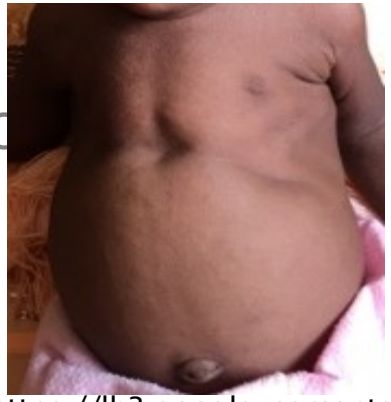

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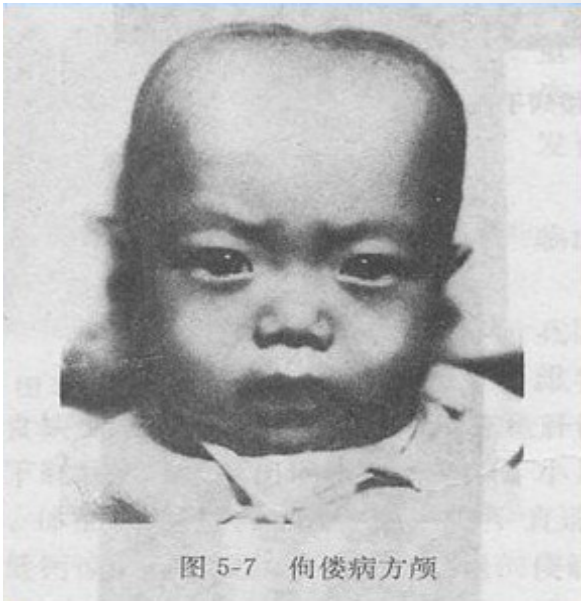


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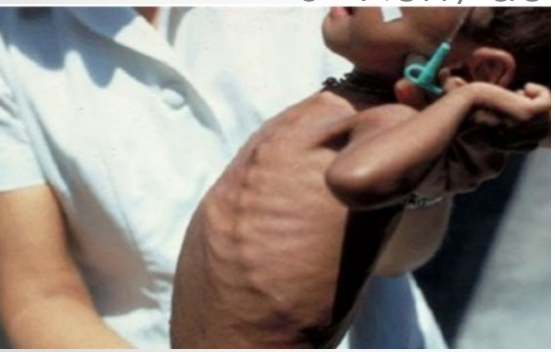

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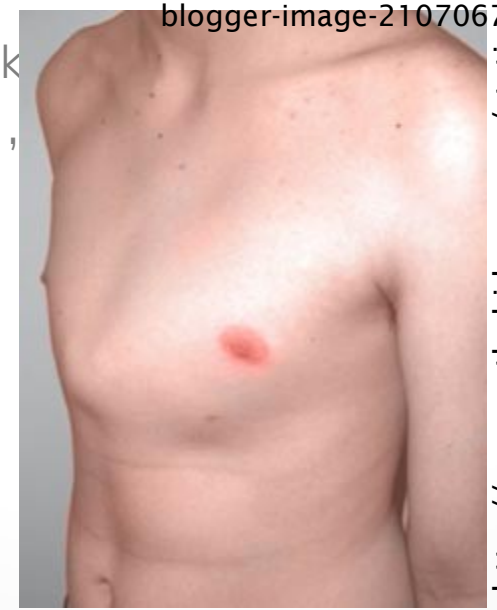
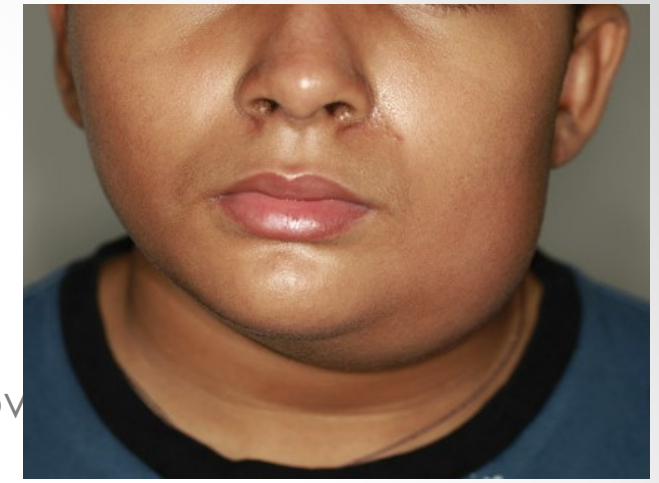


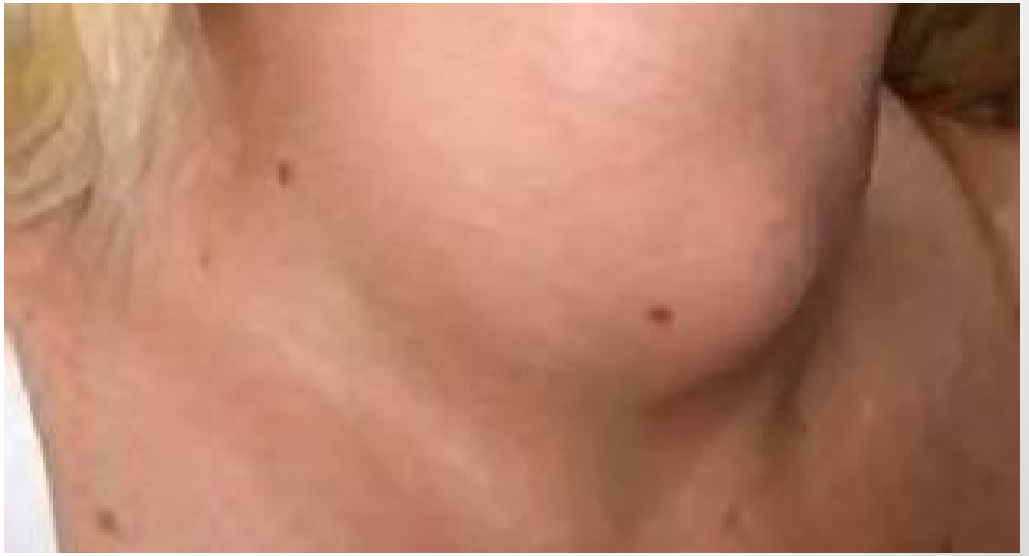
http://www.orthokids.com.au/static/uploads/images/pectus-carinatum-patient-wfwwhgzwmqop.jpg

# Thyroid - goitre

- Žlázy
  - Zvětšení příušních žláz – nedostatek kvalitních bílkov
  - Struma – nedostatek jódu



https://www.wikidoc.org/images/a/aa/Parotitis01.jpg



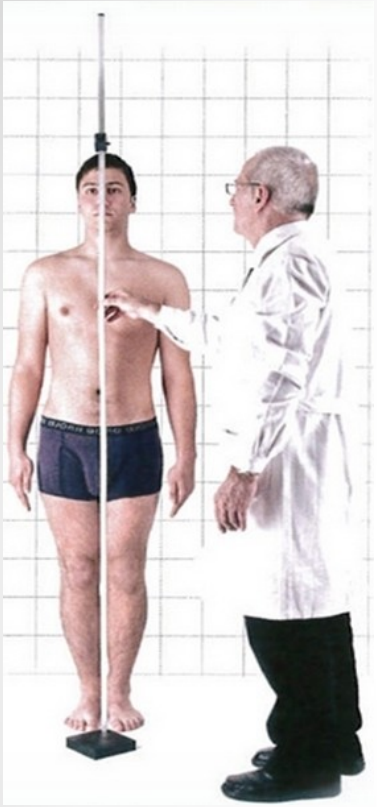
https://i.iinfo.cz/images/414/struma-vole-zvetsena-stitna-zlaza-2-thumb.jpg

# ANTHROPOMETRY

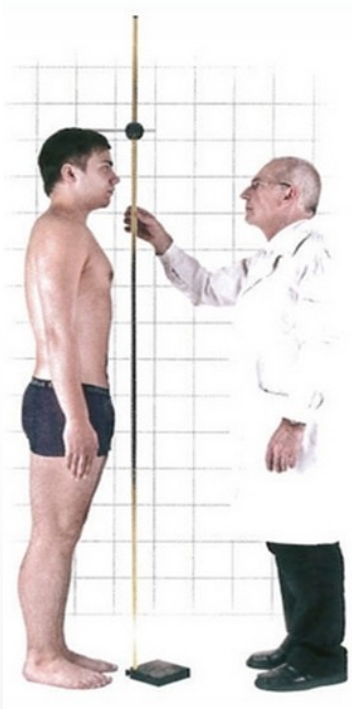
# Anthropometric (somatometric) measurements used in nutritional status assessment

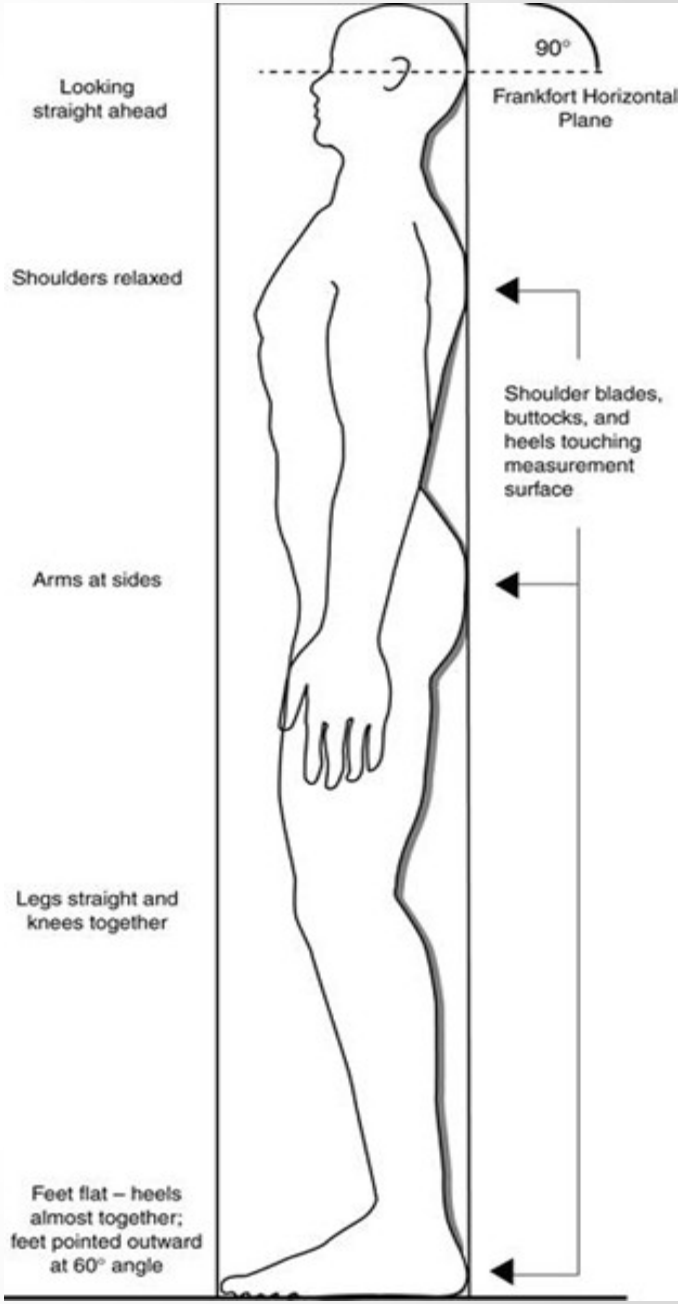
- Directly measured simple parameters:
  - ⇒ Height
  - ⇒ Weight
  - ⇒ Waist
  - ⇒ Hip
  - ⇒ Arm (MUAC)
  - ⇒ Skinfolds
- Anthropometric indexes:
  - ⇒ BMI
  - ⇒ WHR
- Body composition analysis:
  - ⇒ BIA
  - ⇒ Hydrodensitometry (hydrostatic weighing)
  - ⇒ DEXA
  - ⇒ MRI
  - ⇒ Plethysmography (BodPod) (whole body air displacement plethysmography)
  - ⇒ 3D-scanning

# Height




seca




90°
Looking straight ahead
Frankfort Horizontal Plane
Shoulders relaxed
Shoulder blades, buttocks, and heels touching measurement surface
Arms at sides
Legs straight and knees together
Feet flat – heels almost together; feet pointed outward at 60° angle

# Weight

**Box 3. Weighing a patient**

- Ensure the scales are balanced, or display zero before weighing the patient
- When weighing a baby, if a protective covering is placed in the weigh pan ensure this is allowed for by pressing the appropriate "tare" or "zero" key
- Ensure that no part of the weigh platform or load receptor is touching a fixed object, such as a wall
- Ensure the patient's clothing is not touching any fixed part of the scales or surroundings
- When using chair scales, ensure the patient's feet are not touching the ground and that their arms are not brushing against an adjacent fixture
- When monitoring periodical weight change ensure the patient always wears clothing of similar weight
- Do not weigh young children on scales of high capacity designed for adults. The weighing interval may be too coarse, resulting in a higher-than-acceptable percentage error

Source: UK Weighing Federation (2002)

- Alternatives to weighing patients:
  - Ask the patient about their latest recorded weight;
  - Check their medical records;
  - Ask their relatives for their last recorded weight;
  - Undertake a visual assessment - does the patient "look" thin? For example, are rings obviously loose on fingers;
  - Use a weighing bed.

# BMI

- BMI = weight (kg) / height$^2$ ($m^2$)

**Body mass Index (BMI) =** $\dfrac{\text{weight (kg)}}{\text{Height (m) x Height (m)}}$

e.g.

Weight = 62kgs Height =1.72m BMI = $62 / (1.72)^2 = 20.95 kgs/m^2$

| Classification: | Underweight | Normal range | Overweight | Obesity |
|---|---|---|---|---|
| BMI | < 18.5 | 18.5 – 24.9 | 25.0 -29.9 | ≥ 30.0 |

# BMI – Diagnostic criteria (cut-offs)

| Classification | BMI Kg/m² | |
|---|---|---|
| | Principal cut off points | Additional cut off points |
| Underweight | <18.50 | <18.50 |
| Severe thinness | <16.00 | <16.00 |
| Moderate thinness | 16.00 - 16.99 | 16.00 - 16.99 |
| Mild thinness | 17.00 - 18.49 | 17.00 - 18.49 |
| Normal range | 18.50 - 24.99 | 18.50 - 22.99<br>23.00 - 24.99 |
| Overweight | ≥25.00 | ≥25.00 |
| Pre-Obese | 25.00 - 29.99 | 25.00 - 27.49<br>27.50 - 29.99 |
| Obese | ≥30.00 | ≥30.00 |
| Obese class I | 30.00 - 34-99 | 30.00 - 32.49<br>32.50 - 34.99 |
| Obese class II | 35.00 - 39.99 | 35.00 - 37.49<br>37.50 - 39.99 |
| Obese class III | ≥40.00 | ≥40.0 |

Source: WHO website (http://www.who.int/bmi).

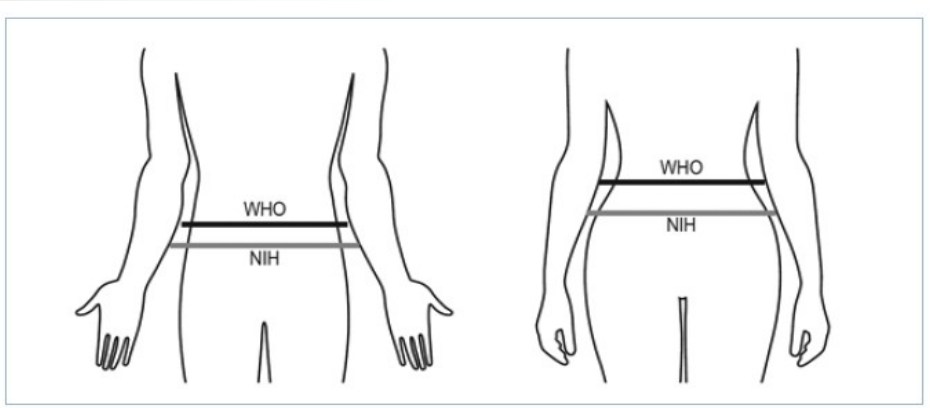
# Circumferences

*Possible circumferences in nutritional status assessment*:

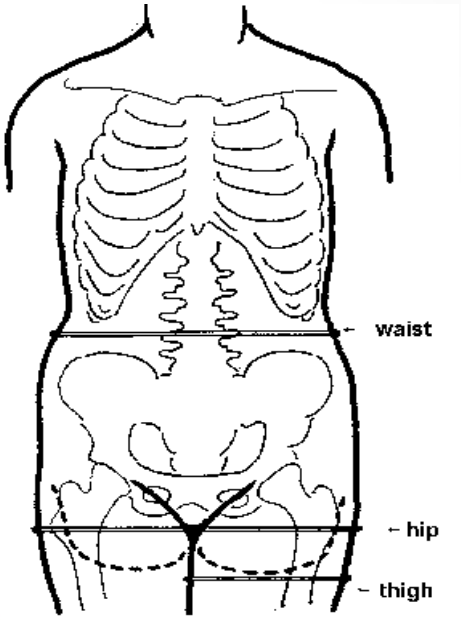
- Waist
- Hip
- Arm
- Calf

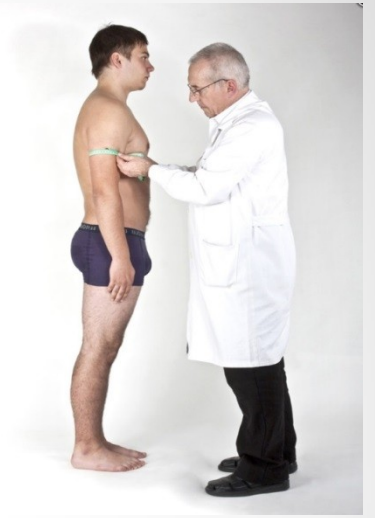
# Circumferences – measuring sites:

- Waist – taken in level of the umbilicus (navel)
- Hip - measurement is taken at the widest lateral extension of the hips
- Arm – mid upper arm, relaxed

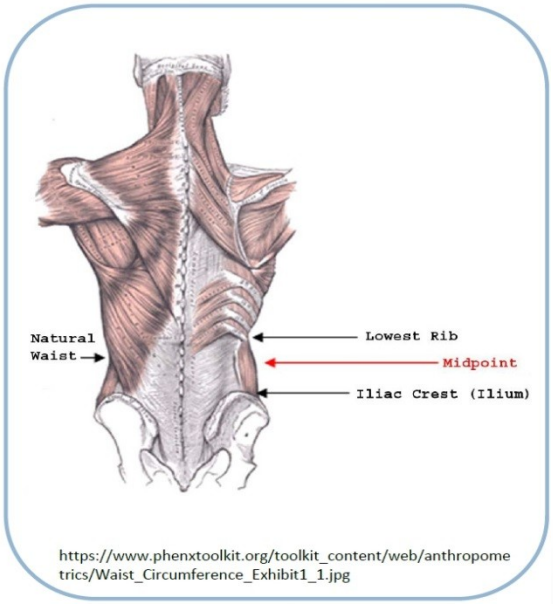



http://www.statcan.gc.ca/pub/82-003-x/2012003/article/11707/c-g/fig1-eng.gif

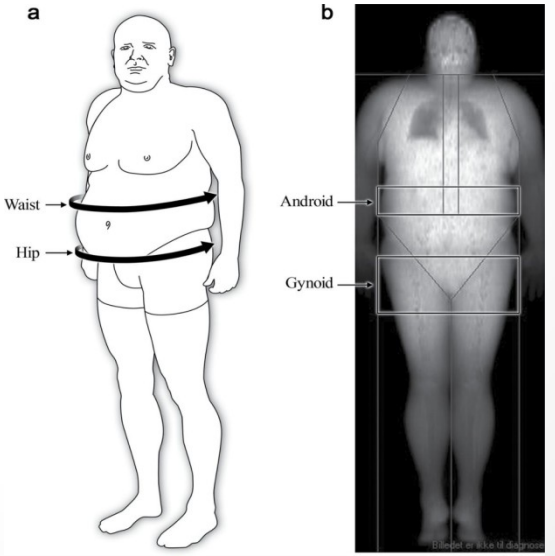


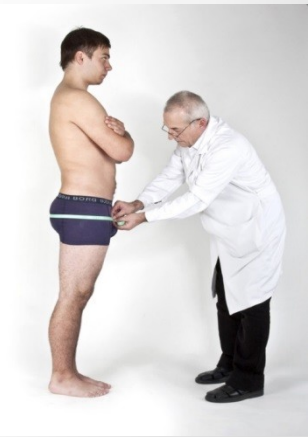



- NHANES: top of the iliac crest
- WHO: midpoint between the last palpable rib and top of the iliac crest
  - Requires palpation
  - Difficult landmarks to identify in obese children
- Natural waist (minimum)
- NIH Multi-Ethnic Study of Atherosclerosis (MESA) study: level of the umbilicus or navel




https://www.phenxtoolkit.org/toolkit_content/web/anthropometrics/Waist_Circumference_Exhibit1_1.jpg



# Waist circumference – diagnostic criteria

- WHO – risk of metabolic complications:

| | OK | Risk increased | Substantially increased |
|---|---|---|---|
| Men | < 94 | 94.1 - 102 | > 102 |
| Women | < 80 | 80.1 - 88 | > 88 |

**Table 2: Ethnic specific values for waist circumference**

| Country/Ethnic group | | Waist circumference |
|---|---|---|
| **Europids*** In the USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes | Male | ≥ 94 cm |
| | Female | ≥ 80 cm |
| **South Asians** Based on a Chinese, Malay and Asian-Indian population | Male | ≥ 90 cm |
| | Female | ≥ 80 cm |
| **Chinese** | Male | ≥ 90 cm |
| | Female | ≥ 80 cm |
| **Japanese**** | Male | ≥ 90 cm |
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| **Ethnic South and Central Americans** | Use South Asian recommendations until more specific data are available | |
| **Sub-Saharan Africans** | Use European data until more specific data are available | |
| **Eastern Mediterranean and Middle East (Arab) populations** | Use European data until more specific data are available | |

** In future epidemiological studies of populations of Europid origin, prevalence should be given using both European and North American cut-points to allow better comparisons.*

*** Originally different values were proposed for Japanese people but new data support the use of the values shown above.*

# Waist circumference – correlation with abdominal fat

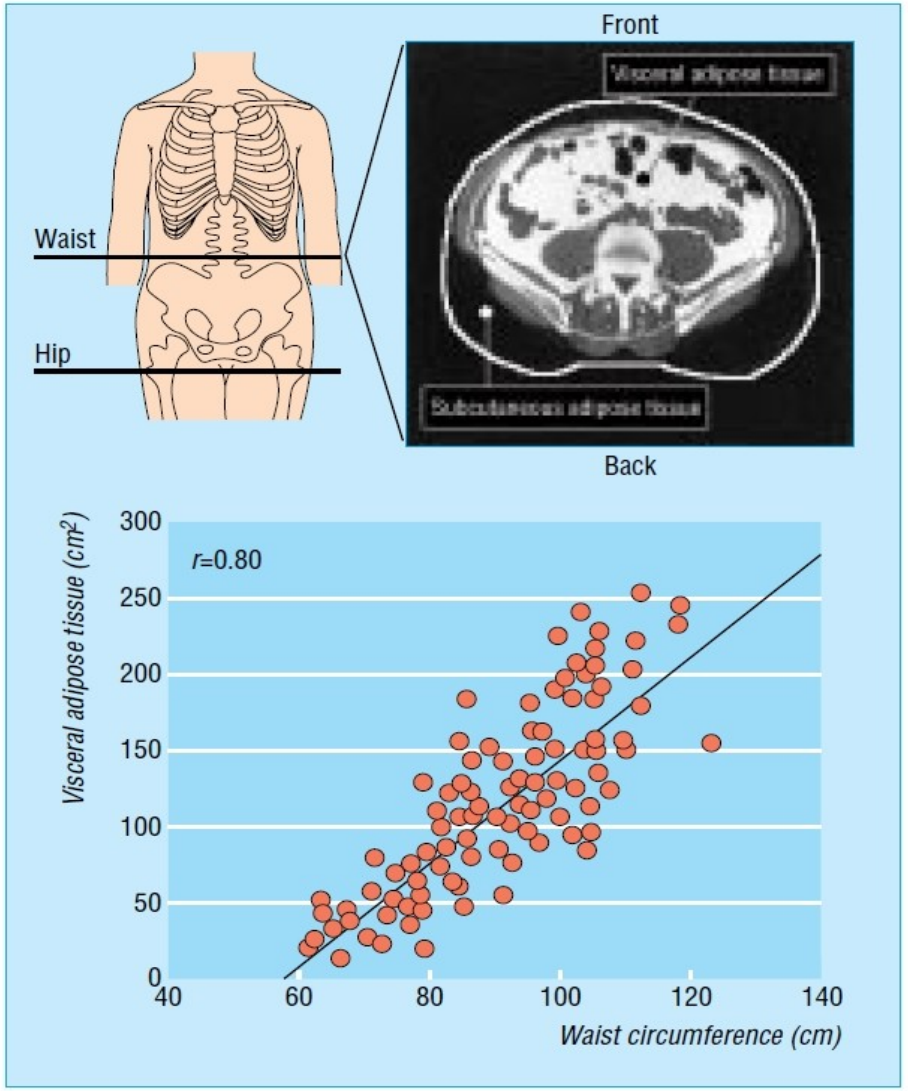
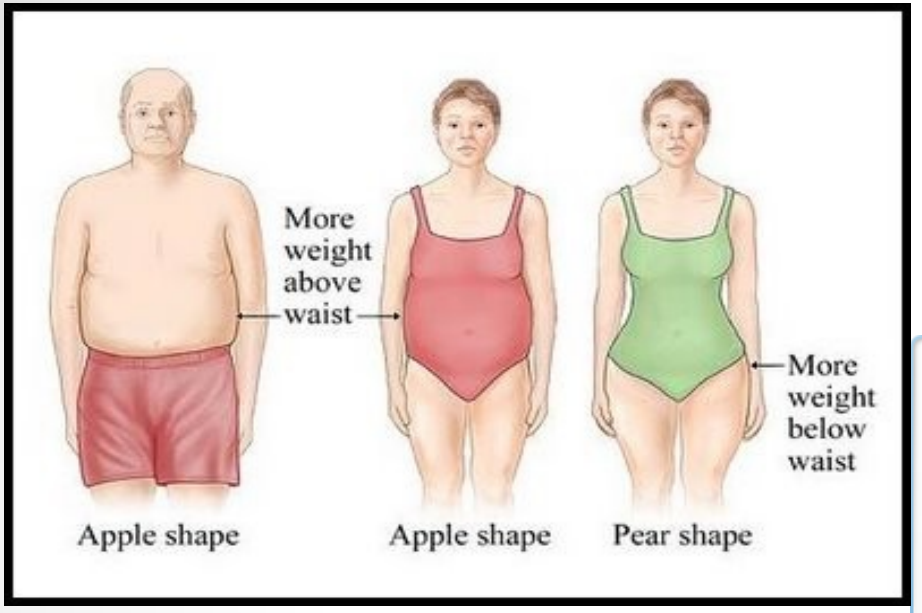


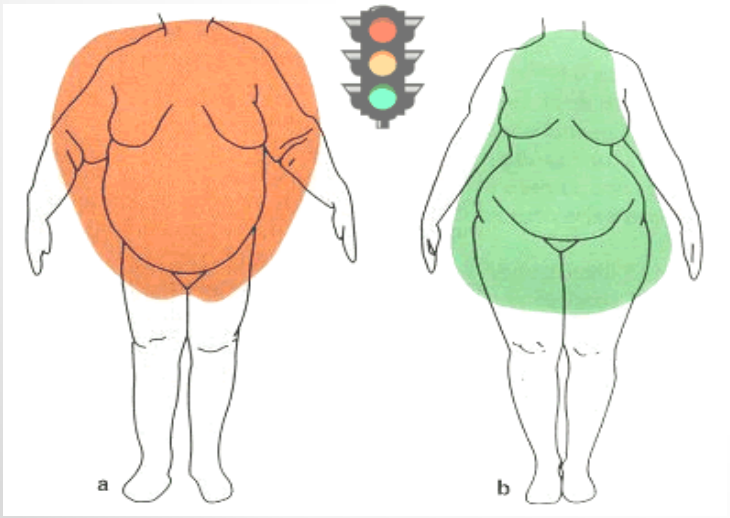

**Fig 1** Assessment of accumulation of abdominal fat by measurement of waist at mid-distance between bottom of rib cage and iliac crest. Amount of visceral adipose tissue that can be assessed by computed tomography can be estimated by waist measurement (adapted from Pouliot et al[9])

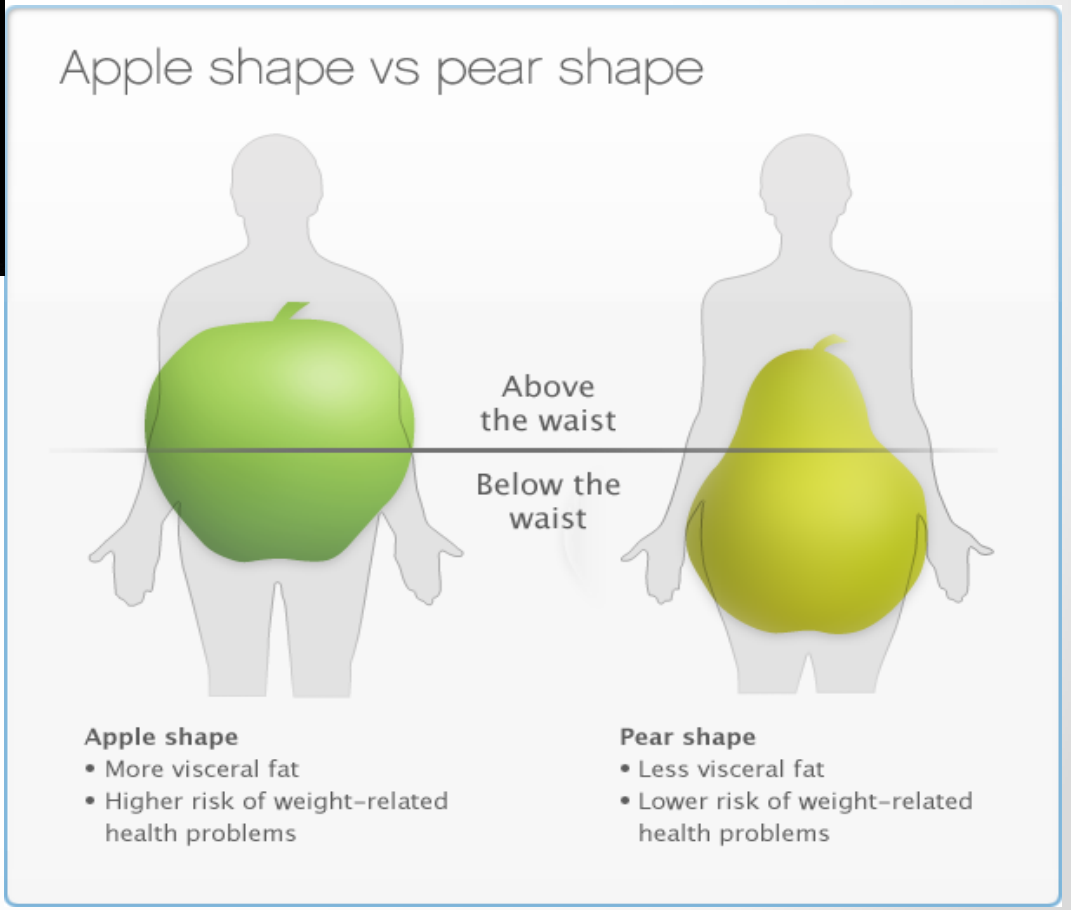


Després J P, Lemieux I, Prud'homme D: Treatment of obesity: need to focus on high risk abdominally obese patients. BMJ. 2001 Mar 24;322(7288):716-20

# WHR – Waist to Hip Ratio



# WHR – diagnostic criteria

| | Low risk | Moderate risk | High risk |
|---|---|---|---|
| **Men** | < 0.95 | 0.95 - 1.00 | > 1.00 |
| **Women** | < 0.80 | 0.81 - 0.85 | > 0.85 |

**Ideal value (health and fertility): Men 0.9, Women 0.7**

Definice abdominální obezity

| | WHO steps | NIDK | WHO – publ.894 | Lean | USDA (in Lear) | Sochor |
|---|---|---|---|---|---|---|
| Muži | > 0.90 | > 1.00 | > 1.00 | > 0.95 | > 0.95 | > 0.90 |
| Ženy | > 0.86 | > 0.80 | > 0.85 | > 0.80 | > 0.80 | > 0.85 |

# WHR interpretation pitfalls

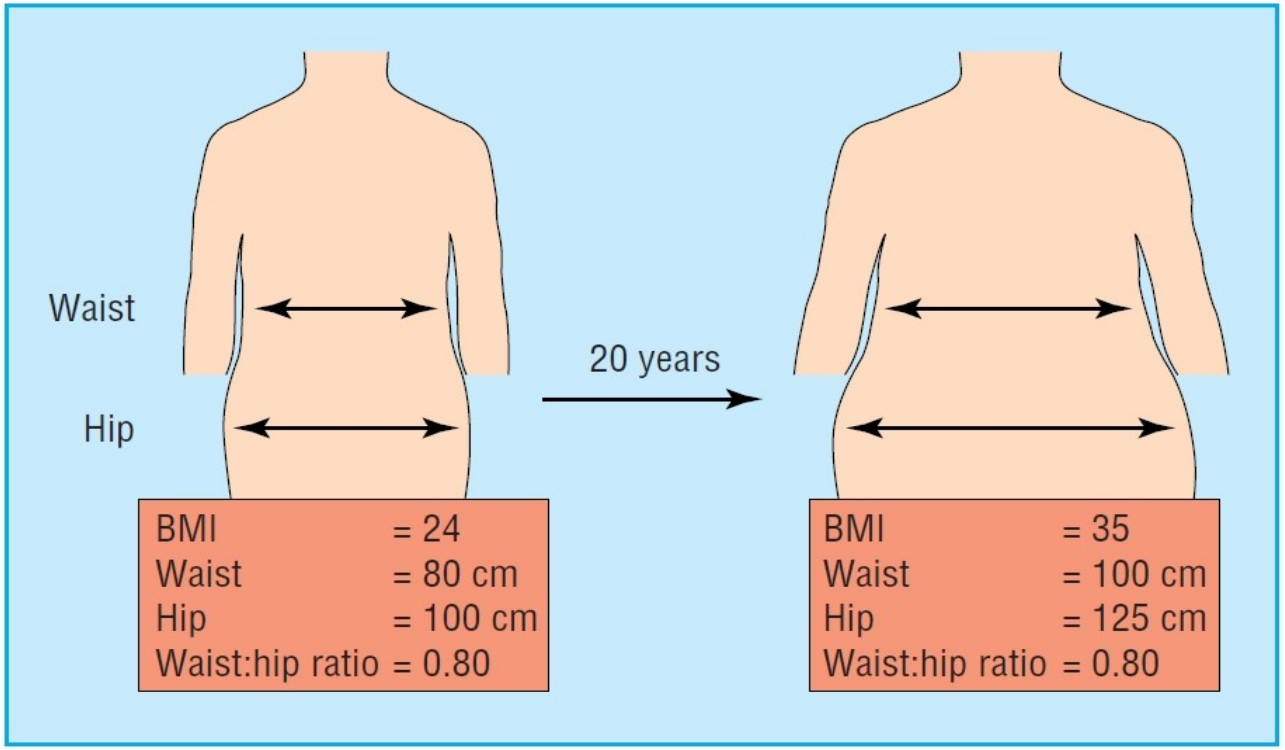
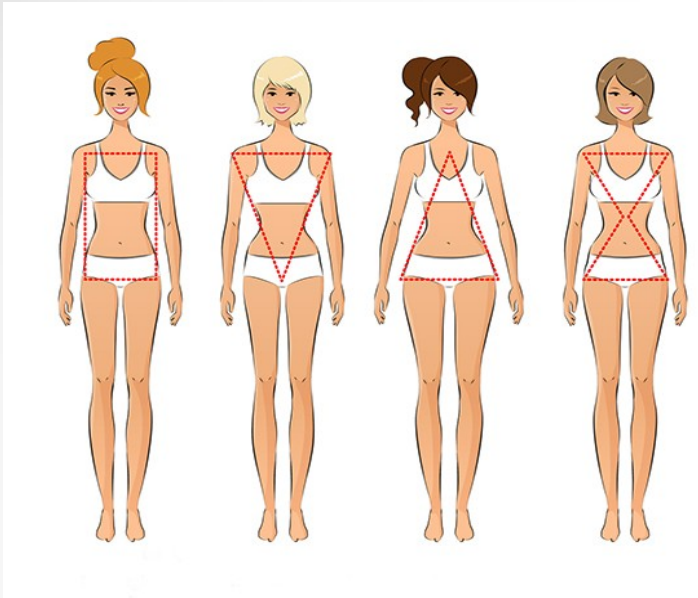
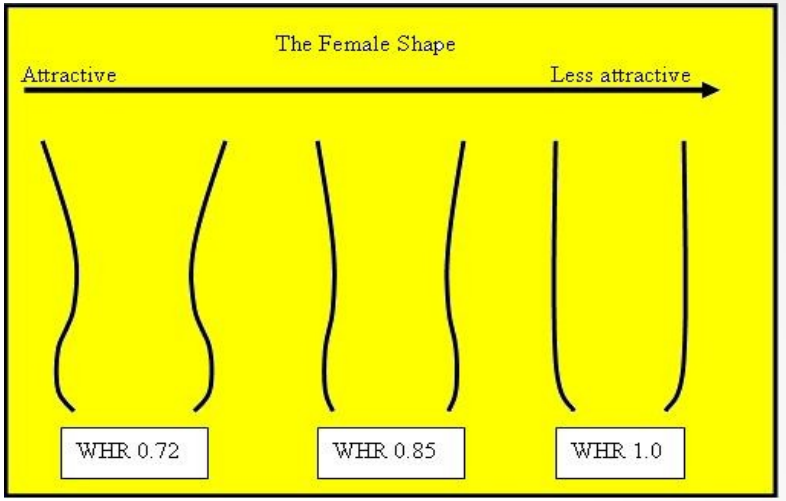



**Fig 2** Misleading information provided by follow up of changes in waist:hip ratio in woman followed over 20 years. Simultaneous increase in waist and hip measurements means ratio is stable over time despite considerable accumulation of visceral adipose tissue, which would have been predicted from 20 cm increase in waist observed over time. Thus, waist circumference provides crude index of absolute amount of abdominal adipose tissue whereas waist:hip ratio provides index of relative accumulation of abdominal fat

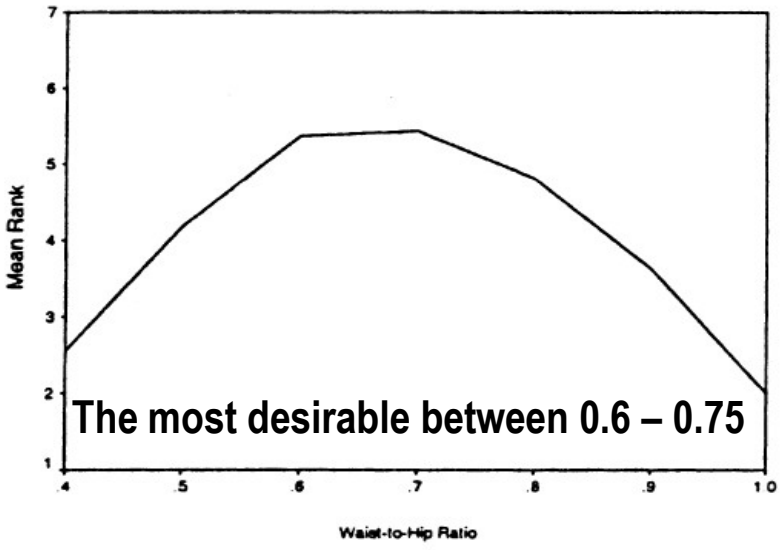
Després J P, Lemieux I, Prud'homme D: Treatment of obesity: need to focus on high risk abdominally obese patients. BMJ. 2001 Mar 24;322(7288):716-20

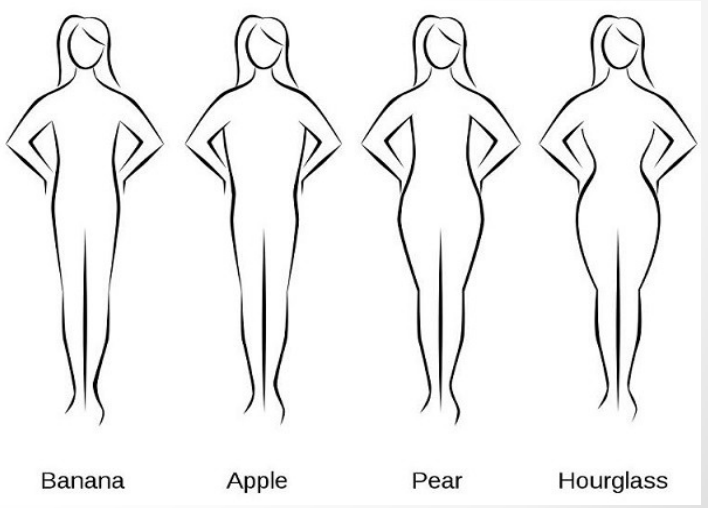
# WHR






c. desirability as a wife



*Sex identification via waist-to-hip ratio*

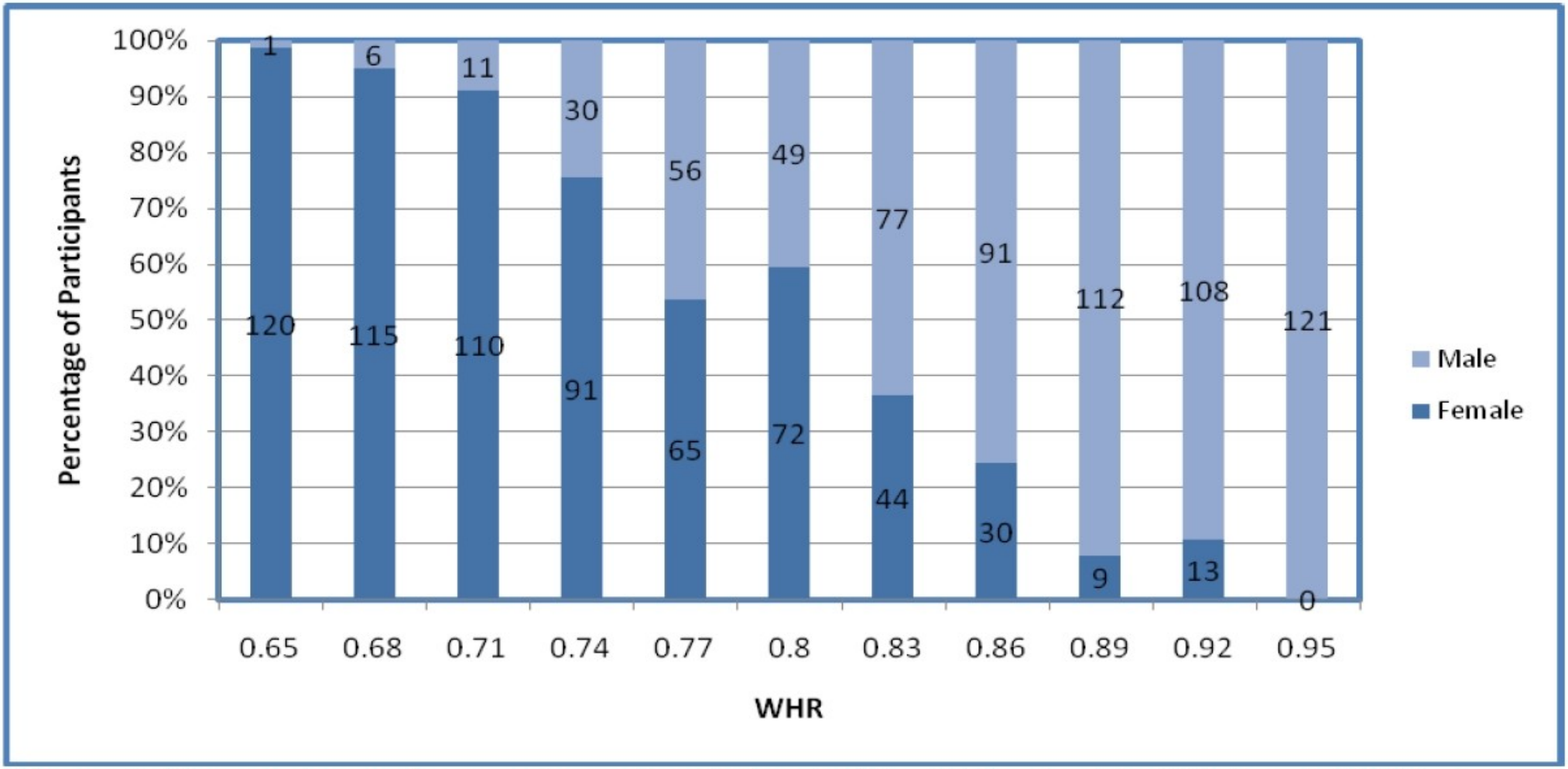
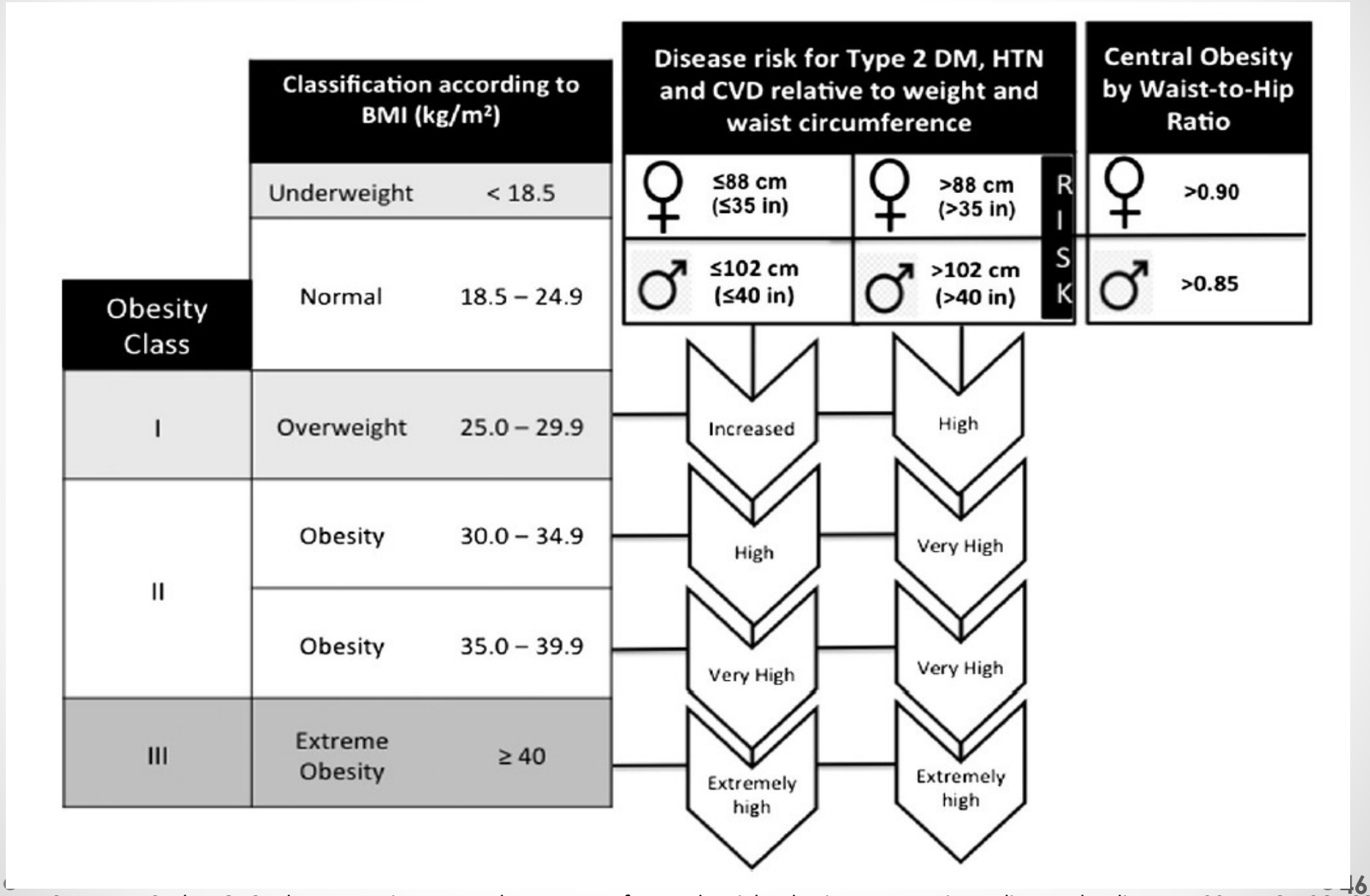



**Figure 2.** The number and percentage of participants ($N = 121$) who identified each WHR as indicating a male or female.

# Classification of obesity developed by the National Heart, Lung and Blood Institute task force, along with the associated disease risk with increasing BMI, waist circumference and waist to hip ratio.




Oliveros E, Somers V, Sochor O, Goel K, Lopez-Jimenez F: The concept of normal weight obesity. Progress in cardiovascular diseases, 2014, 56, 426-433

# METABOLIC SYNDROM

# Metabolic syndrome

- Metabolic syndrome, sometimes known by other names, is a clustering of at least three of the five following medical conditions: abdominal obesity, high blood pressure, high blood sugar, high serum triglycerides and low high-density lipoprotein (HDL) levels.
- Metabolic syndrome is associated with the risk of developing cardiovascular disease and type 2 diabetes.
- Insulin resistance, metabolic syndrome, and prediabetes are closely related to one another and have overlapping aspects.
- The syndrome is thought to be caused by an underlying disorder of energy utilization and storage.

## Table 1: The new International Diabetes Federation (IDF) definition

According to the new IDF definition, for a person to be defined as having the metabolic syndrome they must have:

**Central obesity** (defined as waist circumference* with ethnicity specific values)

**plus any two of the following four factors:**

| | |
|---|---|
| **Raised triglycerides** | ≥ 150 mg/dL (1.7 mmol/L)<br>**or specific treatment for this lipid abnormality** |
| **Reduced HDL cholesterol** | < 40 mg/dL (1.03 mmol/L) in males<br>< 50 mg/dL (1.29 mmol/L) in females<br>**or specific treatment for this lipid abnormality** |
| **Raised blood pressure** | systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg<br>**or treatment of previously diagnosed hypertension** |
| **Raised fasting plasma glucose** | (FPG) ≥ 100 mg/dL (5.6 mmol/L),<br>**or previously diagnosed type 2 diabetes**<br>If above 5.6 mmol/L or 100 mg/dL, OGTT is strongly recommended but is not necessary to define presence of the syndrome. |

** If BMI is >30kg/m², central obesity can be assumed and waist circumference does not need to be measured.*

## Table 2: Ethnic specific values for waist circumference

| Country/Ethnic group | | Waist circumference |
|---|---|---|
| **Europids*** In the USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes | Male | ≥ 94 cm |
| | Female | ≥ 80 cm |
| **South Asians** Based on a Chinese, Malay and Asian-Indian population | Male | ≥ 90 cm |
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** In future epidemiological studies of populations of Europid origin, prevalence should be given using both European and North American cut-points to allow better comparisons.*

*** Originally different values were proposed for Japanese people but new data support the use of the values shown above.*

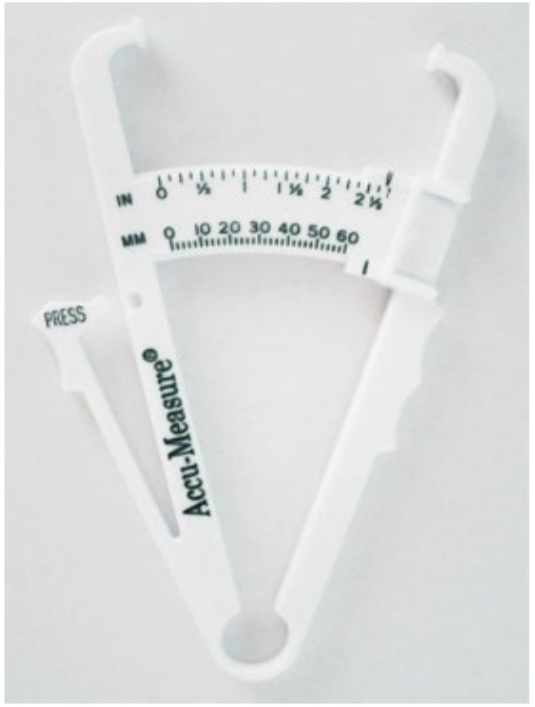
# BODY FAT AND BODY COMPOSITION MAEASUREMENT

# SKINFOLDS

# Skinfolds measurement

- Several types od calipers

Best:



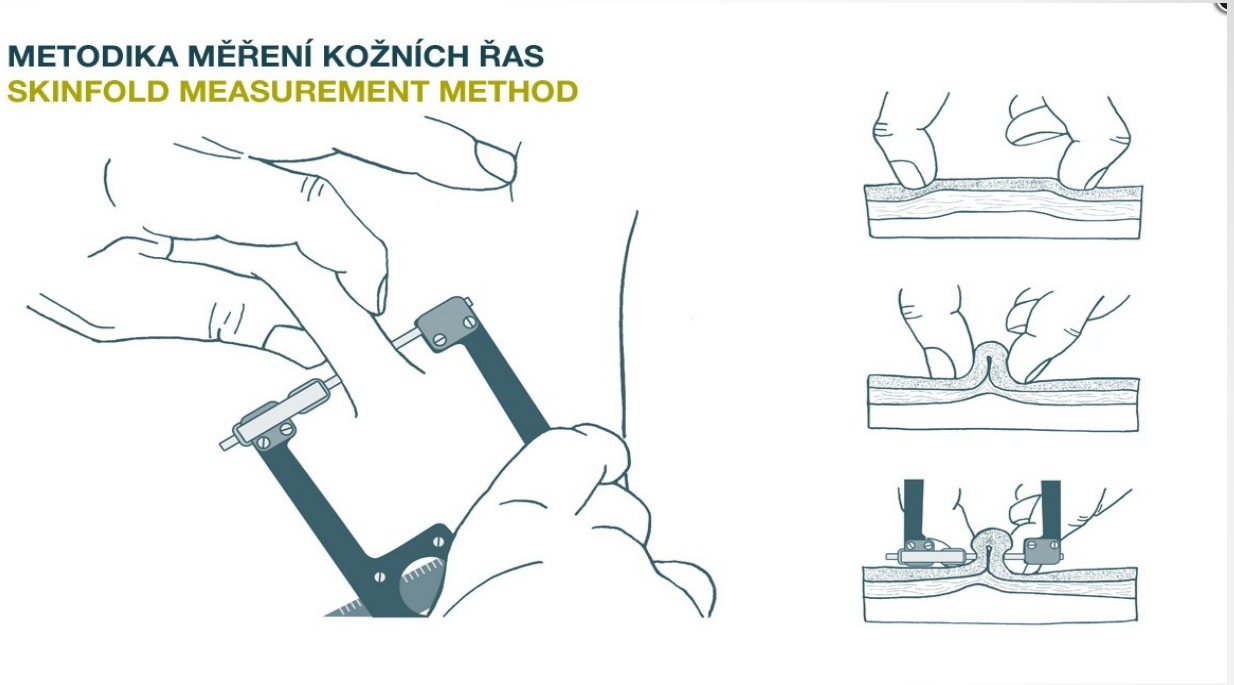

Plastic calipers. Courtesy of Wikipedia.

Harpenden:


Metal Harpenden calipers. Courtesy of Baty International Ltd.

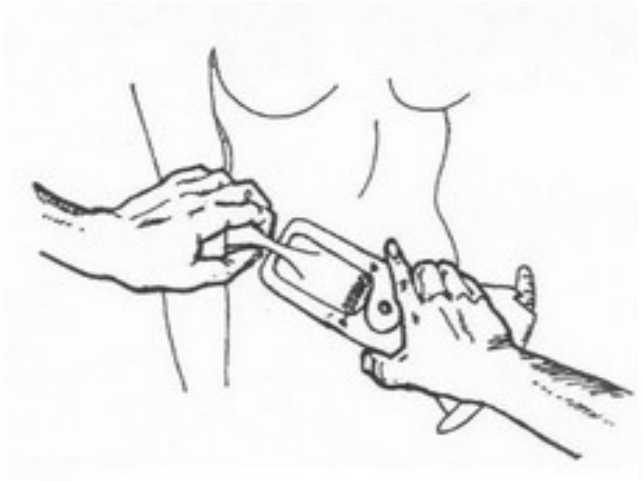
# Skinfolds measurement

- Measuring with Best caliper:

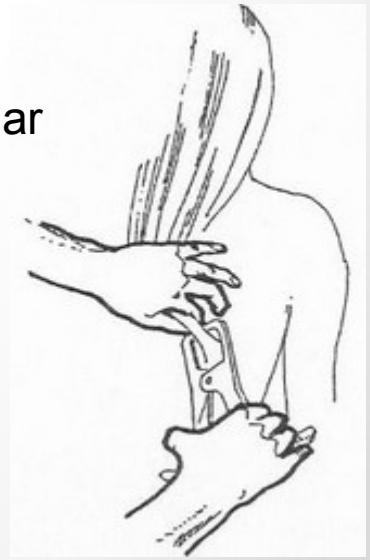



- Triceps

- Supraspinal



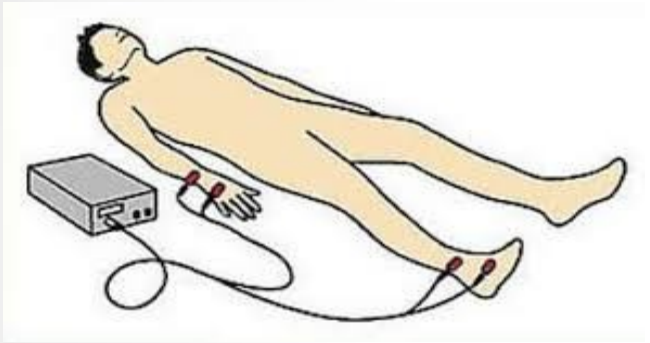
- Subscapular



# BIA - Bioelectrical impedance analysis

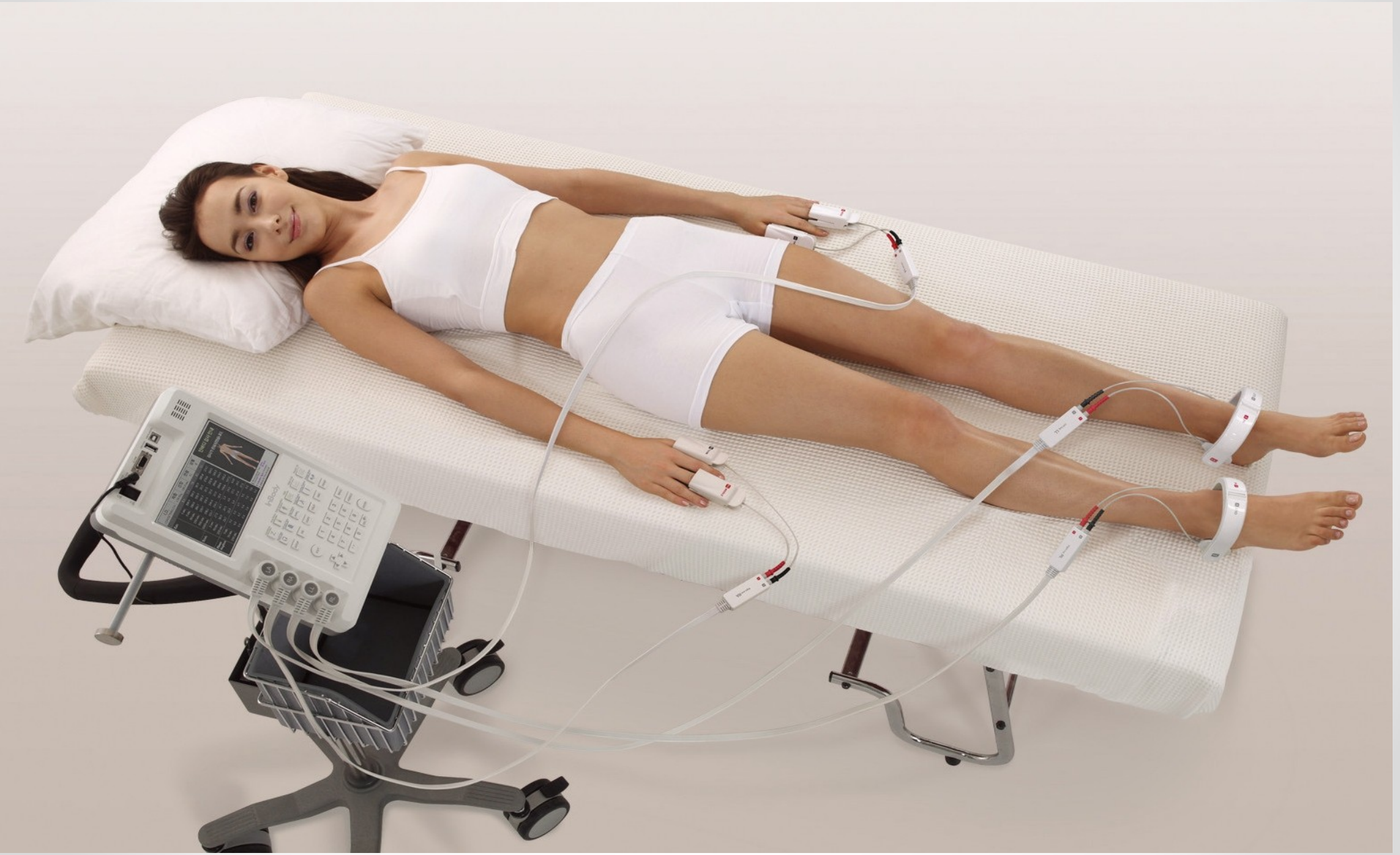
# BIA – Bioelectrical impedance analysis

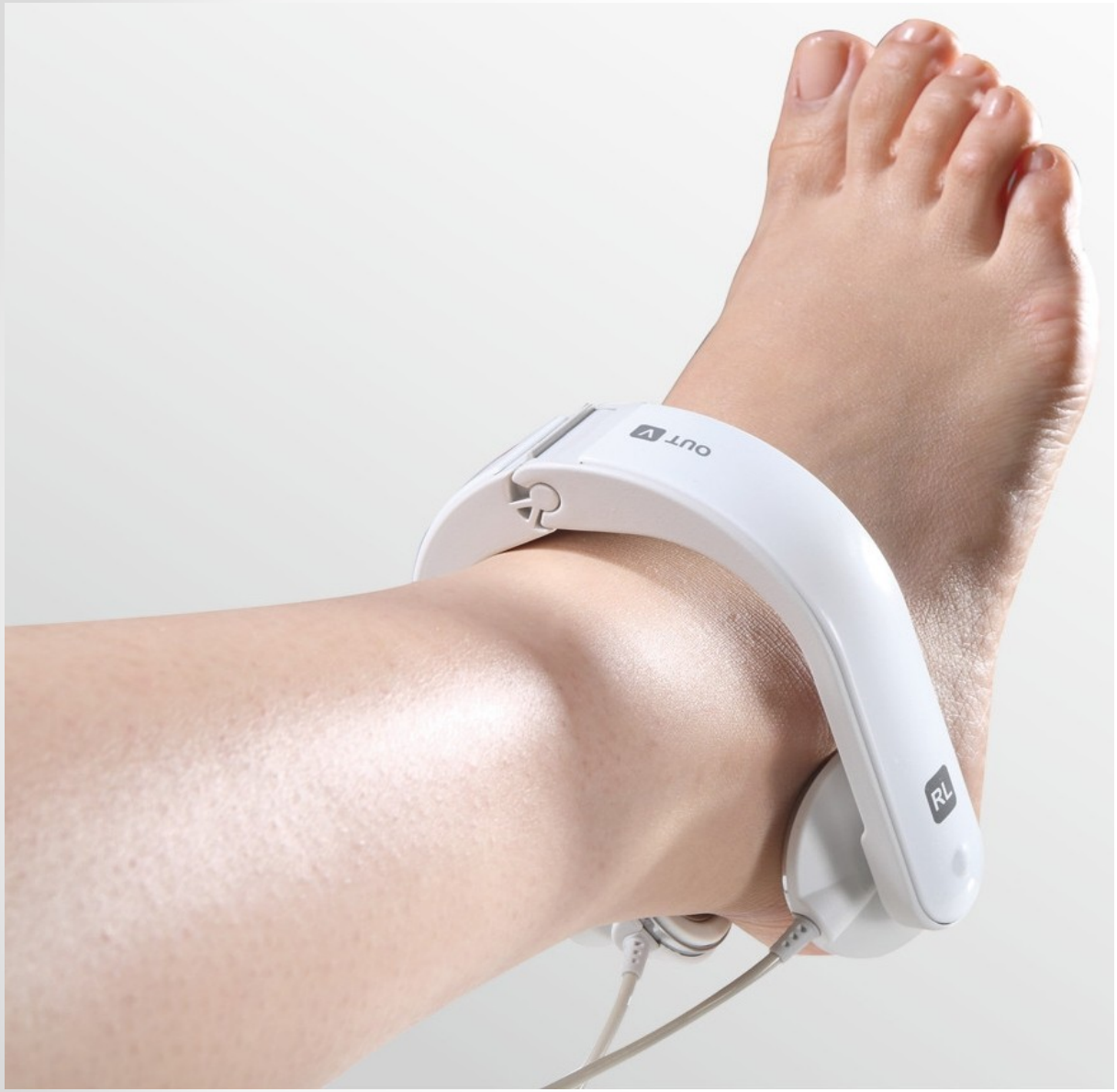
- BIA actually determines the electrical impedance, or opposition to the flow of an electric current through body tissues which can then be used to estimate total body water (TBW), which can be used to estimate fat-free body mass and, by difference with body weight, body fat.



# Inbody S10

# Inbody S10




OUT V
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LA MIDDLE
LA THUMB

- Body Composition Analysis
- Muscle-Fat Analysis
- Segmental Lean Analysis
- Research Items

InBody

I.D. BIO_208 | HEIGHT 164cm | DATE 2010. 01. 11
AGE 42 | GENDER Male | TIME 11 : 28 : 17

InBody
TEL:02-501-3939 FAX:02-501-3978

## Body Composition Analysis

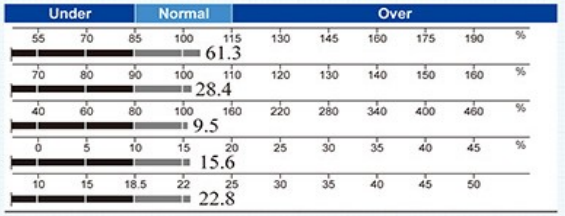
| Element | Unit | Measured | Normal Range |
|---|---|---|---|
| Intracellular Water | ℓ | 23.3 | 20.6 ~ 25.2 |
| Extracellular Water | ℓ | 15.1 | 12.6 ~ 15.4 |
| Protein Mass | kg | 10.1 | 8.9 ~ 10.9 |
| Mineral Mass | kg | 3.29 | 3.08 ~ 3.76 |
| Body Fat Mass | kg | 9.5 | 7.1 ~ 14.2 |

※Mineral Mass is estimated.

| Values | Total Body Water | Soft Lean Mass | Fat Free Mass | Weight |
|---|---|---|---|---|
| 23.3 | 38.4 | 49.1 | 51.8 | 61.3 |
| 15.1 | | | | |
| 10.1 | | | | |
| 3.29 | non-osseous / osseous : 2.67 | | | |
| 9.5 | | | | |

## Muscle-Fat Analysis

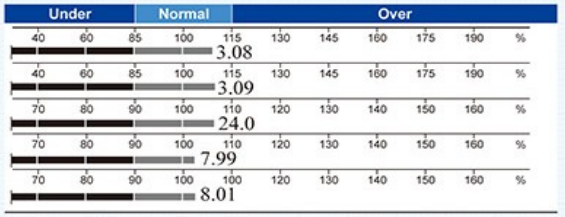
| Index | Unit | Measured | Normal Range |
|---|---|---|---|
| Weight | kg | 61.3 | 50.3 ~ 68.1 |
| Skeletal Muscle Mass | kg | 28.4 | 25.1 ~ 30.7 |
| Body Fat Mass | kg | 9.5 | 7.1 ~ 14.2 |
| Percent Body Fat | % | 15.6 | 10.0 ~ 20.0 |
| BMI | kg/m² | 22.8 | 18.5 ~ 25.0 |




## Segmental Lean Analysis

★ : Access Location
• : Location of Paralysis

| Segment | Unit | Measured | Normal Range |
|---|---|---|---|
| Right Arm | kg | 3.08 | 2.40 ~ 3.24 |
| Left Arm★ | kg | 3.09 | 2.40 ~ 3.24 |
| Trunk | kg | 24.0 | 20.3 ~ 24.8 |
| Right Leg• | kg | 7.99 | 7.05 ~ 8.61 |
| Left Leg | kg | 8.01 | 7.05 ~ 8.61 |




## Research Items

### Segmental Water Analysis

| | Measured | Normal Range |
|---|---|---|
| Right Arm | 2.40 ℓ | 1.99 ~ 2.43 |
| Left Arm | 2.42 ℓ | 1.99 ~ 2.43 |
| Trunk | 18.8 ℓ | 15.8 ~ 19.4 |
| Right Leg | 6.25 ℓ | 5.52 ~ 6.74 |
| Left Leg | 6.27 ℓ | 5.52 ~ 6.74 |

### ECW/TBW

| | Measured | Normal Range |
|---|---|---|
| Total | 0.392 | 0.36 ~ 0.39 |
| Right Arm | 0.381 | 0.36 ~ 0.39 |
| Left Arm | 0.388 | 0.36 ~ 0.39 |
| Trunk | 0.393 | 0.36 ~ 0.39 |
| Right Leg | 0.393 | 0.36 ~ 0.39 |
| Left Leg | 0.396 | 0.36 ~ 0.39 |

### Nutrition Index

| | Measured | Normal Range |
|---|---|---|
| BCM | 33.4 kg | 29.5 ~ 36.1 |
| BMC | 2.67 kg | 2.54 ~ 3.10 |
| AC | 29.6 cm | - |
| AMC | 26.7 cm | - |
| Waist Cir. | 75.1 cm | Under 94.0 |
| VFA | 63.9 cm² | Under 100.0 |
| BMR | 1488 kcal | - |
| TBW/FFM | 74.1 % | - |

### Body Water History

| No | DATE | TIME | WEIGHT | ICW | ECW | TBW | ECW/TBW | TBW/FFM |
|---|---|---|---|---|---|---|---|---|
| 1 | 09/12/11 | 11:28 | 61.3 | 23.3 | 15.1 | 38.4 | 0.392 | 74.1 |
| 2 | 09/10/11 | 16:23 | 62.8 | 23.2 | 13.7 | 36.9 | 0.372 | 73.7 |
| 3 | 09/09/10 | 11:45 | 65.1 | 24.6 | 15.4 | 40.0 | 0.385 | 74.2 |
| 4 | 09/08/09 | 15:34 | 61.9 | 22.1 | 12.9 | 35.0 | 0.369 | 73.4 |
| 5 | 09/07/09 | 10:47 | 64.8 | 23.0 | 14.6 | 37.6 | 0.389 | 74.3 |
| 6 | 09/06/12 | 16:25 | 61.3 | 24.3 | 13.8 | 38.1 | 0.363 | 73.4 |
| 7 | 09/06/12 | 11:12 | 64.1 | 24.1 | 14.8 | 38.8 | 0.380 | 73.8 |

### Blood Pressure

| | |
|---|---|
| Systolic | 120 mmHg |
| Diastolic | 79 mmHg |
| Heart Rate | 76 bpm |

### Impedance

[ Touch Type, Lying Posture, Before Dialysis ]

| | | RA | LA | TR | RL | LL |
|---|---|---|---|---|---|---|
| Z(Ω) | 1 kHz | 272.7 | 267.7 | 25.7 | 228.2 | 222.2 |
| | 5 kHz | 268.2 | 264.0 | 24.8 | 223.7 | 218.6 |
| | 50 kHz | 242.6 | 241.2 | 22.2 | 202.1 | 197.9 |
| | 250 kHz | 215.1 | 217.2 | 20.0 | 183.2 | 179.4 |
| | 500 kHz | 204.2 | 209.0 | 20.3 | 178.3 | 174.1 |
| | 1 MHz | 191.0 | 200.7 | 23.7 | 175.1 | 170.6 |
| Xc(Ω) | 5 kHz | 9.5 | 9.1 | 1.1 | 7.7 | 7.3 |
| | 50 kHz | 25.6 | 21.9 | 1.5 | 18.5 | 17.8 |
| | 250 kHz | 32.9 | 24.9 | 1.2 | 13.8 | 13.5 |
| Phase Angle(θ) | 5 kHz | 2.5 | 2.4 | 3.2 | 2.4 | 2.3 |
| | 50 kHz | 6.1 | 5.2 | 3.9 | 5.3 | 5.2 |
| | 250 kHz | 7.0 | 5.4 | 2.8 | 3.5 | 3.5 |

Inbody S10

## Body Composition Analysis

| Compartments | Unit | Measured | Normal Range |
|---|---|---|---|
| Intracellular Water | ℓ | 23.3 | 20.6 ~ 25.2 |
| Extracellular Water | ℓ | 15.1 | 12.6 ~ 15.4 |
| Protein Mass | kg | 10.1 | 8.9 ~ 10.9 |
| Mineral Mass | kg | 3.29 | 3.10 ~ 3.80 |
| Body Fat Mass | kg | 9.5 | 7.1 ~ 14.2 |

※Mineral Mass is estimated.

| Values | Total Body Water | Soft Lean Mass | Fat Free Mass | Weight |
|---|---|---|---|---|
| 23.3 | 38.4 | 49.1 | 51.8 | 61.3 |
| 15.1 | | | | |
| 10.1 | | | | |
| 3.29 | non-osseous | | | |
| | osseous : 2.67 | | | |
| 9.5 | | | | |

## Muscle-Fat Analysis

| Index | Unit | Measured | Normal Range |
|---|---|---|---|
| Weight | kg | 61.3 | 50.3 ~ 68.1 |
| Skeletal Muscle Mass | kg | 28.4 | 25.1 ~ 30.7 |
| Body Fat Mass | kg | 9.5 | 7.1 ~ 14.2 |
| Percent Body Fat | % | 15.6 | 10.0 ~ 20.0 |
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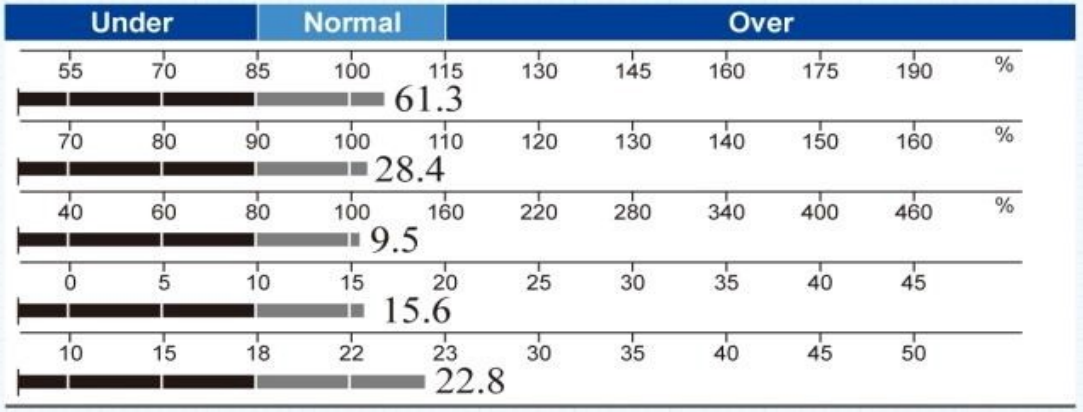


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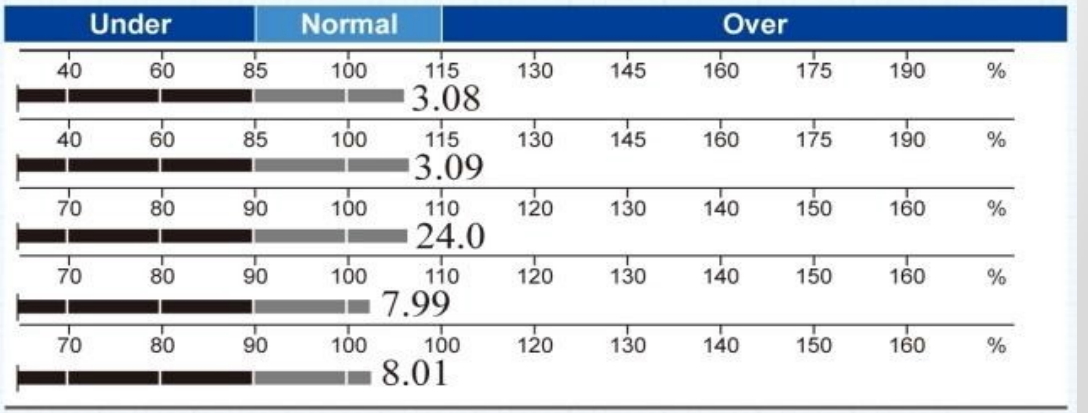
★ : Access Location
• : Location of Paralysis

| Segment | Unit | Measured | Normal Range |
|---|---|---|---|
| Right Arm | kg | 3.08 | 2.38 ~ 3.22 |
| Left Arm★ | kg | 3.09 | 2.38 ~ 3.22 |
| Trunk | kg | 24.0 | 20.3 ~ 24.8 |
| Right Leg• | kg | 7.99 | 7.02 ~ 8.58 |
| Left Leg | kg | 8.01 | 7.02 ~ 8.58 |



## *Research Items*

### Segmental Water Analysis

| | Measured | Normal Range |
|---|---|---|
| Right Arm | 2.40 ℄ | 1.99 ~ 2.43 |
| Left Arm | 2.42 ℄ | 1.99 ~ 2.43 |
| Trunk | 18.8 ℄ | 15.8 ~ 19.4 |
| Right Leg | 6.25 ℄ | 5.52 ~ 6.74 |
| Left Leg | 6.27 ℄ | 5.52 ~ 6.74 |

### ECW/TBW

| | Measured | Normal Range |
|---|---|---|
| Total | 0.392 | 0.36 ~ 0.39 |
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| Left Arm | 0.388 | 0.36 ~ 0.39 |
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| | Measured | Normal Range |
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### Body Water History

| No | DATE | TIME | WEIGHT | ICW | ECW | TBW | ECW/TBW | TBW/FFM |
|---|---|---|---|---|---|---|---|---|
| 1 | 09/12/11 | 11:28 | 61.3 | 23.3 | 15.1 | 38.4 | 0.392 | 74.1 |
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| 6 | 09/06/12 | 16:25 | 61.3 | 24.3 | 13.8 | 38.1 | 0.363 | 73.4 |
| 7 | 09/06/12 | 11:12 | 64.1 | 24.1 | 14.8 | 38.8 | 0.380 | 73.8 |

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| | |
|---|---|
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### Impedance

[ Touch Type, Lying Posture, Before Dialysis ]

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|---|---|---|---|---|---|---|
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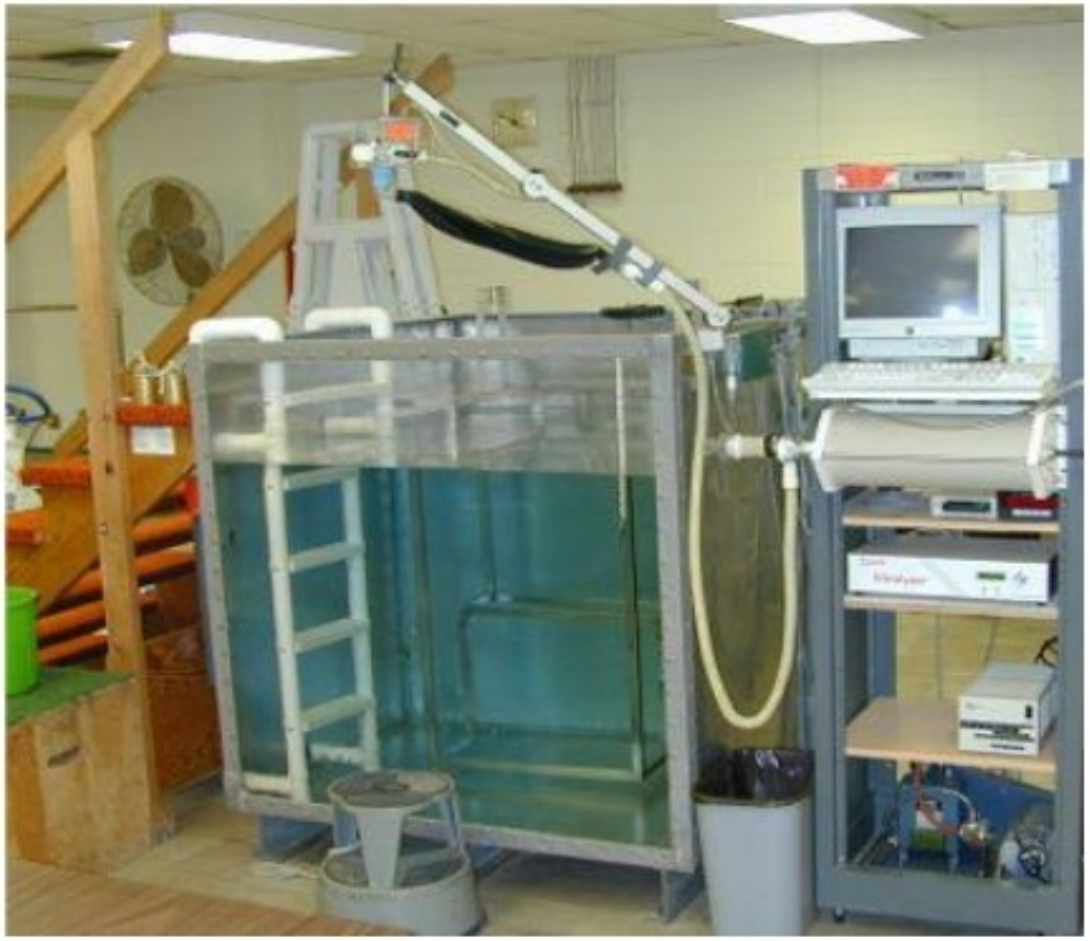
| | 250 kHz | 215.1 | 217.2 | 20.0 | 183.2 | 179.4 |
| | 500 kHz | 204.2 | 209.0 | 20.3 | 178.3 | 174.1 |
| | 1 MHz | 191.0 | 200.7 | 23.7 | 175.1 | 170.6 |
| $Xc_{(\Omega)}$ | 5 kHz | 9.5 | 9.1 | 1.1 | 7.7 | 7.3 |
| | 50 kHz | 25.6 | 21.9 | 1.5 | 18.5 | 17.8 |
| | 250 kHz | 32.9 | 24.9 | 1.2 | 13.8 | 13.5 |
| Phase Angle(°) | 5 kHz | 2.5 | 2.4 | 3.2 | 2.4 | 2.3 |
| | 50 kHz | 6.1 | 5.2 | 3.9 | 5.3 | 5.2 |
| | 250 kHz | 7.0 | 5.4 | 2.8 | 3.5 | 3.5 |

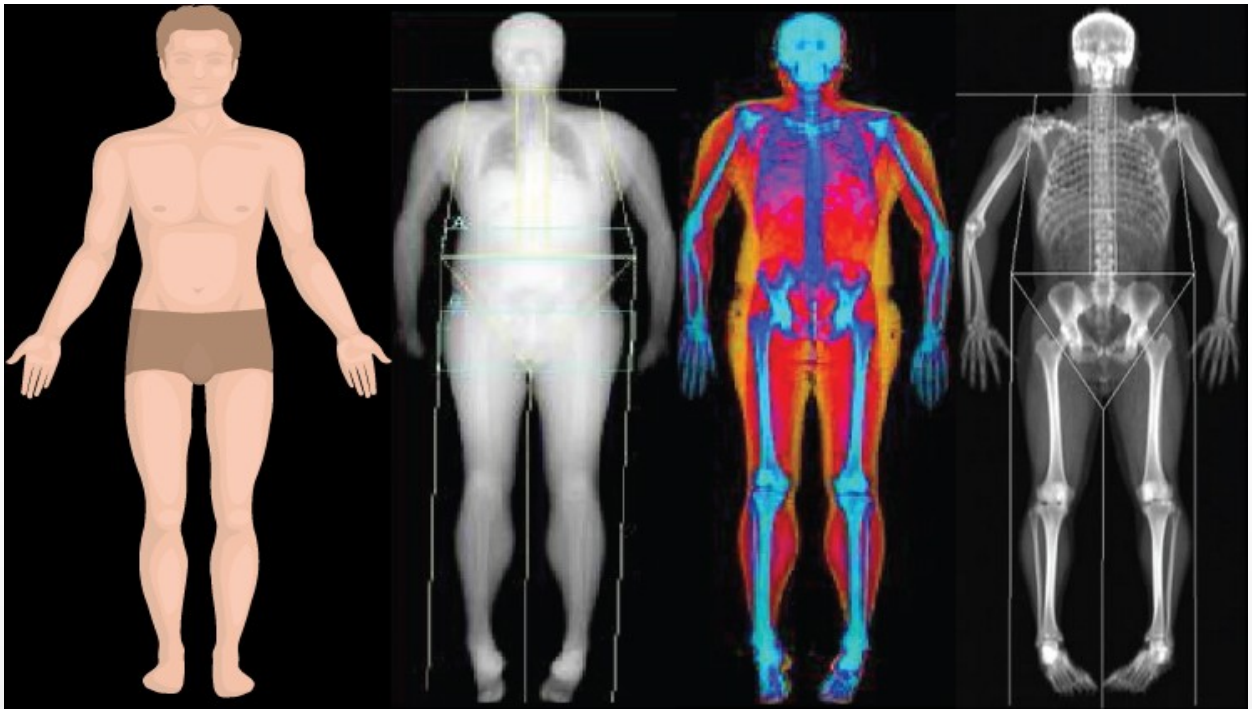
# OTHER TECHNIQUES

# Underwater weighing - hydrodensitometry

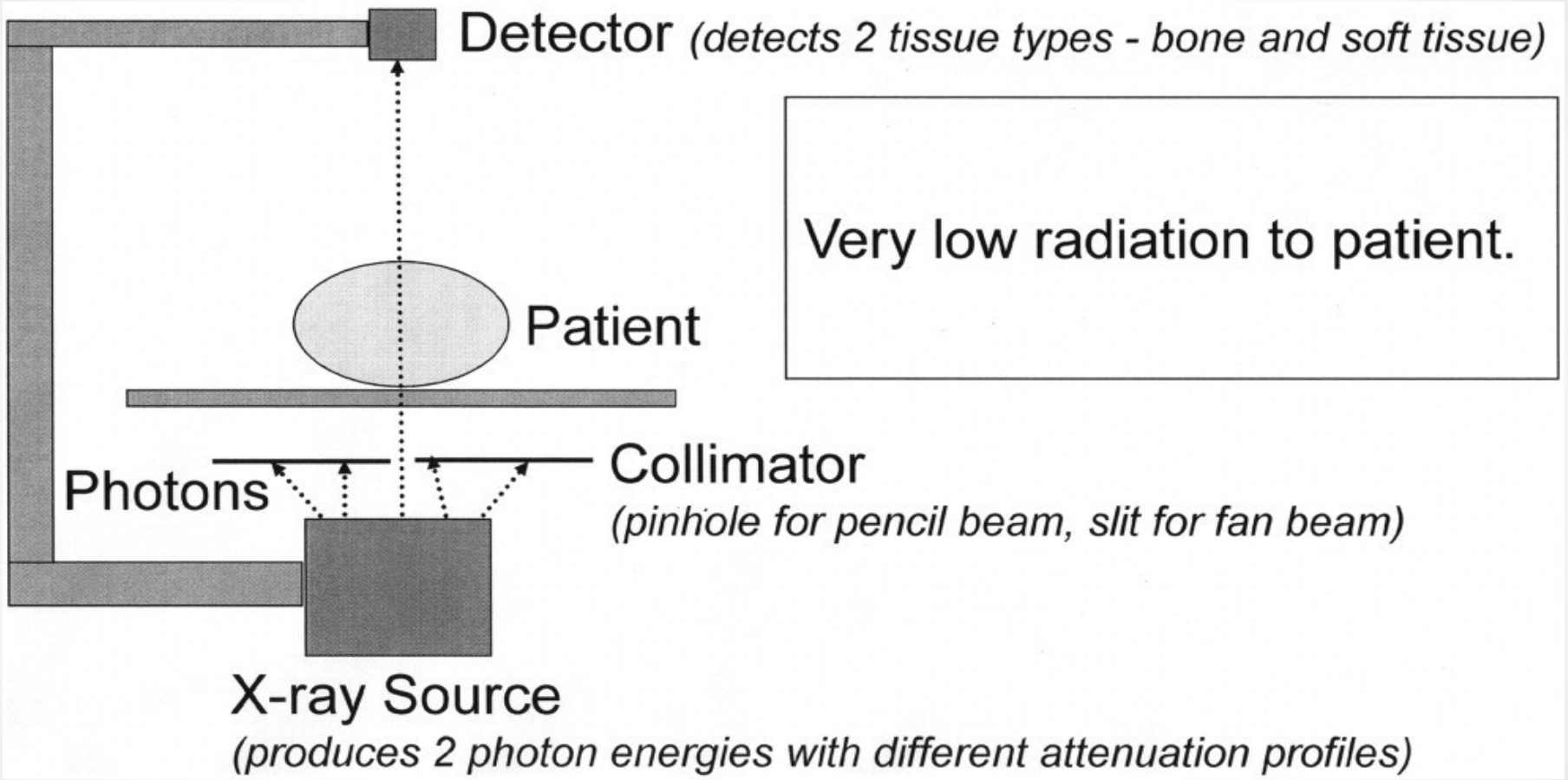


Hydrodensitometer. Courtesy of Human Performance Lab, University of Wisconsin-La Crosse.

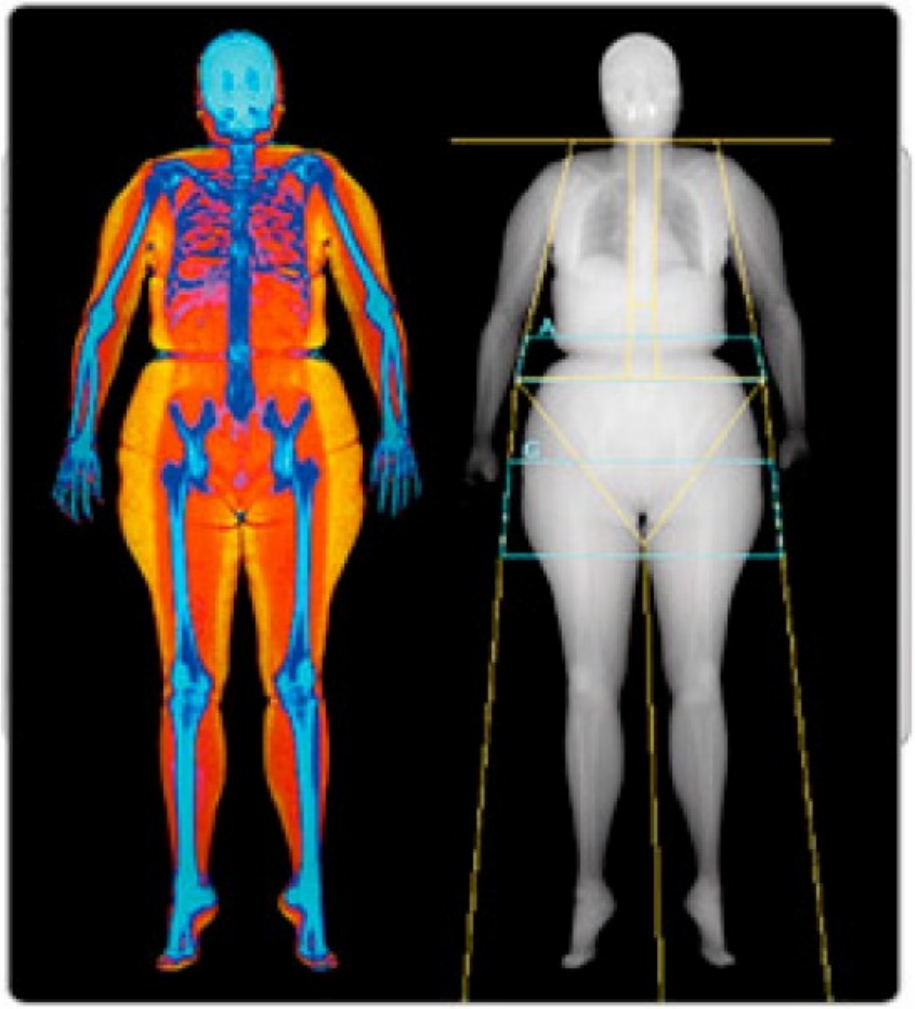
# DEXA – Dual Energy X-ray Absorptiometry



# DEXA – Dual Energy X-ray Absorptiometry - principle



# DEXA – Dual Energy X-ray Absorptiometry



http://www.itnonline.com/sites/default/files/imagecache/node_image/photo_article/BodyMan250x503.jpg

Whole Body Fan Beam Analysis

Image not for diagnostic use

TBAR2620

F.S. 68.00% -10.00%

Head assumes 17.0% brain fat

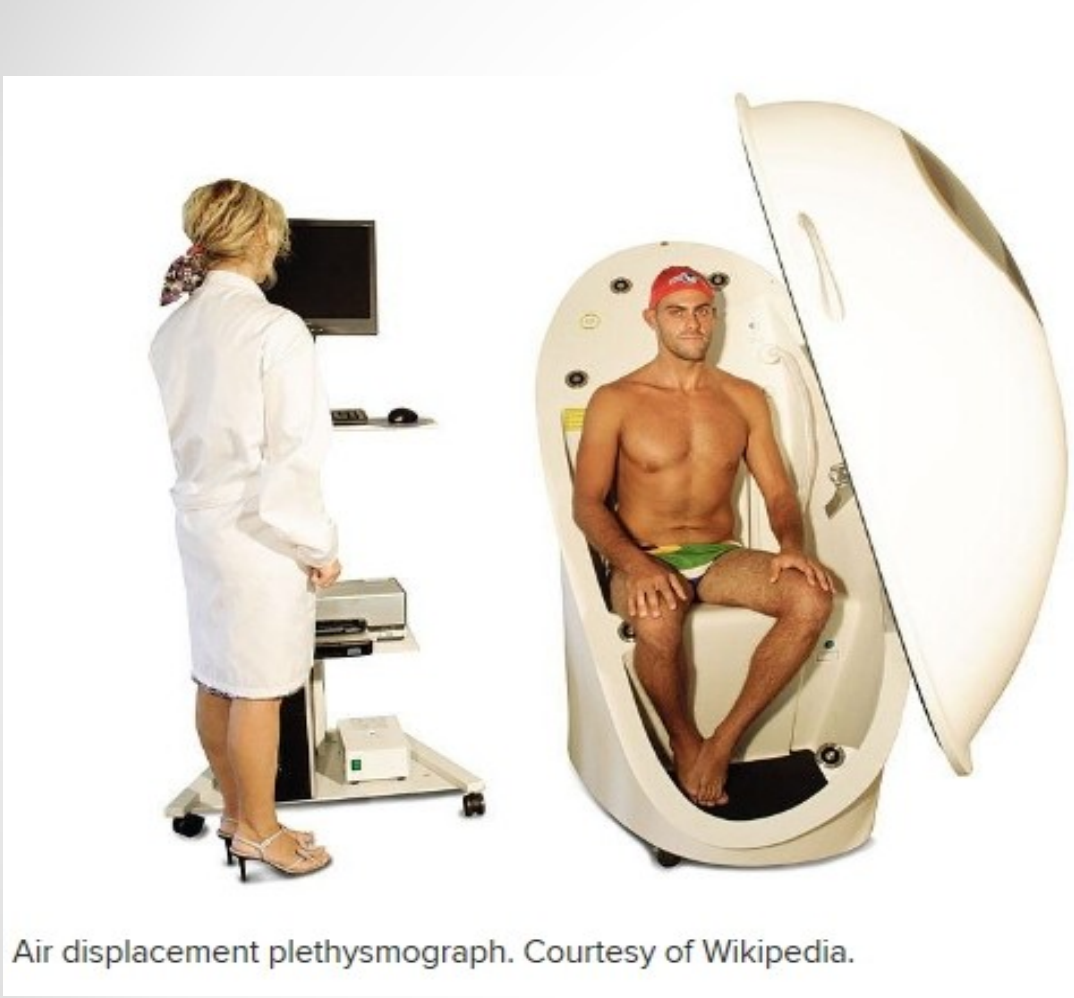
LBM 73.2% water

| Region | Fat (g) | Lean+BMC (g) | Total (g) | %Fat (%) |
|---|---|---|---|---|
| L Arm | 1205.0 | 3685.3 | 4890.3 | 24.6 |
| R Arm | 1203.9 | 3902.3 | 5106.2 | 23.6 |
| Trunk | 8246.8 | 31777.5 | 40024.2 | 20.6 |
| L Leg | 3683.0 | 11385.1 | 15068.1 | 24.4 |
| R Leg | 3794.4 | 11755.3 | 15549.8 | 24.4 |
| Sub Tot | 18133.0 | 62505.5 | 80638.6 | 22.5 |
| Head | 1087.4 | 4189.0 | 5276.4 | 20.6 |
| TOTAL | 19220.4 | 66694.5 | 85915.0 | 22.4 |

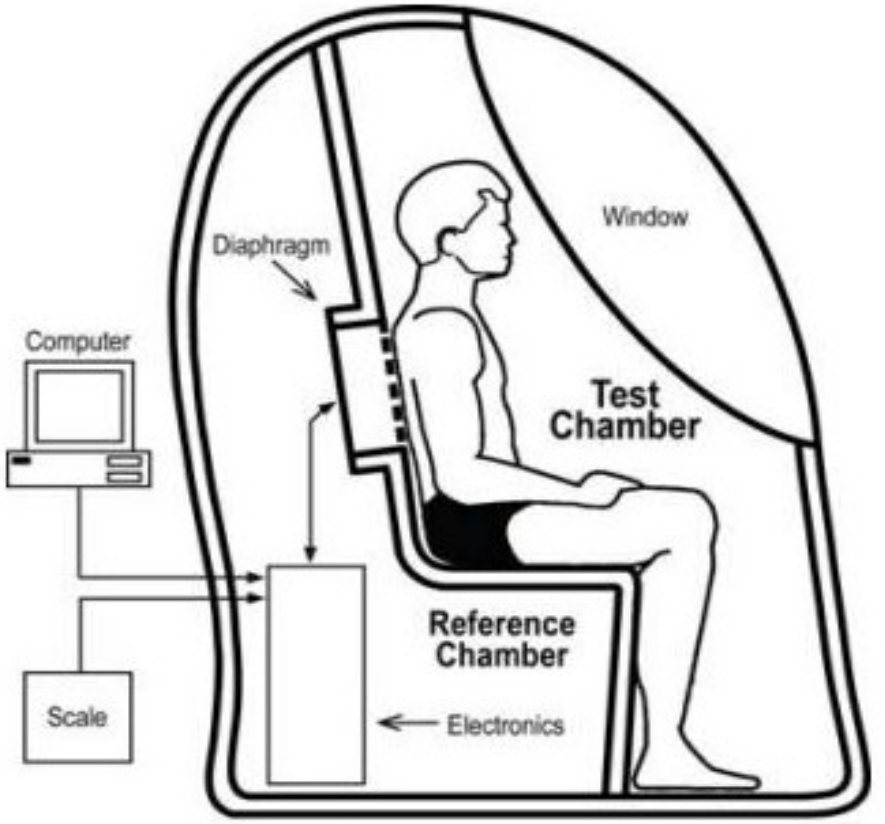
Delphi A SN: 45775

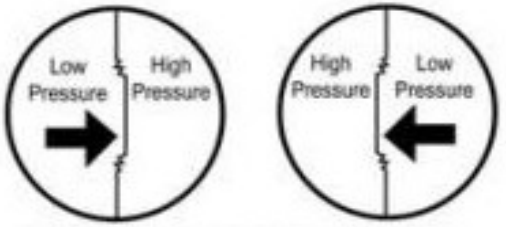
Version 11.2 :3 01/29/2003 09:33

# BodPod –Air displacement plethysmography



Air displacement plethysmograph. Courtesy of Wikipedia.




Moving diaphragm produces complementary pressure changes in the chambers.

# Body fat - diagnostic criteria

| | Men | Women |
|---|---|---|
| Normal | < 20 | < 30 |
| Overfat | 20 - 25 | 30 - 35 |
| Obesity | > 25 | > 35 |

Oliveros E, Somers V, Sochor O, Goel K, Lopez-Jimenez F: The concept of normal weight obesity. Progress in cardiovascular diseases, 2014, 56, 426-433

*Biospace*: **Standard body fat percent is 15 % (range 10 - 20) for men and 23 % (range 18 - 28) for women**

**Measured PBF corresponding to BMI cut-offs:** (Galagher et al.)

| Category | OK | Overweight | Obesity |
|---|---|---|---|
| BMI | < 25 | 25 – 30 | > 30 |
| PBF males | < 20 % | 20 – 25 % | > 25 % |
| PBF females | < 32 % | 32 – 38 % | > 38 % |

**Human Kinetics:** http://www.humankinetics.com/excerpts/excerpts/normal-ranges-of-body-weight-and-body-fat

This is an excerpt from Sport Nutrition, Second Edition, by Asker Jeukendrup, PhD, and Michael Gleeson, PhD

Table 13.1 Body fat percentages for males and females and their classification

| Males | Females | Rating |
|---|---|---|
| 5-10 | 8-15 | Athletic |
| 11-14 | 16-23 | Good |
| 15-20 | 24-30 | Acceptable |
| 21-24 | 31-36 | Overweight |
| >24 | >37 | Obese |

Table 13.2A Body fat percentage for the average population

| Age | Up to 30 | 30-50 | 50+ |
|---|---|---|---|
| Females | 14-21% | 15-23% | 16-25% |
| Males | 9-15% | 11-17% | 12-19% |

**ACE -(American Council on Exercise** - ACE (2009) What are the guidelines for percentage of body fat loss? American Council on Exercise (ACE). Ask the Expert Blog. December 2, 2009.

| | Men | Women |
|---|---|---|
| Essential fat | 2–5% | 10–13% |
| Athletes | 6–13% | 14–20% |
| Fitness | 14–17% | 21–24% |
| Average | 18–24% | 25–31% |
| Obese | 25%+ | 32%+ |

# The health impact of obesity, NWO

- Condition „**fit fat**“ is better (healthier) than „**unfit unfat**“
- The most important is the ratio between fat and muscle tissue
- NWO  (Normal Weight Obesity) – increased fat in normal BMI, it poses metabolic and health risk. Diagnosis is often missed!

# LABORATORY

# Hxx

- Albumin → Half life = 20 days
  Low in malnutrition, also in infection, burns, fluid overload, hepatic failure, cancer, nephrotic syndrome.
- Transferrin → Half-life = 10 days
  Low in protein energy malnutrition, but also affected by iron status
- Prealbumin → Half-life = 2-3 days
  Low in malnutrition, also in infections, liver failure and increased in renal failure
- CRP — Positive acute phase reactant. Helps determine whether above proteins are reduced because of inflammatory process or due to inadequate substrate, as in malnutrition.

# Biochemical examinations – serum proteins

| | Normal [g/l] | Heavy deficiency [g/l] | Halftime |
|---|---|---|---|
| **Albumin** | > 32 | < 21 | 20 days |
| **Transferin** | > 2 | < 1 | 8-10 days |
| **Prealbumin** | > 0.2 | < 0.1 | 2 days |

Usefulness of Selected Laboratory Tests for the Assessment of Nutritional Status

| Nutrient | Test | Usefulness | Availability* | Comments |
|---|---|---|---|---|
| **Protein** | Serum protein and albumin | Poor | Available | Reduced in liver and renal disease |
| | Transferrin and transthyretin | Good | Limited | Reduced in infections |
| | Nitrogen balance | Good | Research tool | |
| **Vitamin A** | Serum retinol | Poor | Limited | Reduced with acute phase response |
| | Retinol binding protein | Poor | Limited | |
| **Vitamin D** | Plasma calcium and phosphate | Good | Available | May be first sign of deficiency |
| | 25 OH Vitamin D | Good | Limited | |
| | 1,25 Di OH Vitamin D | Good | Limited | |
| **Folate** | Serum folate | Good | Available | Reflects recent uptake |
| | Red cell folate | Good | Available | Reflects whole body status |
| **Iron** | Serum ferritin | Good | Available | Reduced with acute phase response |
| | Bone marrow iron | Good | Limited | |
| | Serum iron and total iron binding capacity | Poor | Available | Reduced with acute phase response |
| **Zinc** | Plasma zinc | Good | Available | Increased with acute infections |
| | Plasma alkaline phosphatase | Poor | Available | |
| **Copper** | Plasma copper | Good | Limited | |
| **Iodine** | Thyroid function tests | Good | Limited | |

Adapted from refs. *26* and *27*.

*Most of these tests are not available in primary care situations and will generally be available in regional hospitals. However, in many developing countries they may only be available in specialist centres.

# Pros and cons of serum nutritional markers

Pros and cons of serum nutritional markers

| Nutritional marker | Pros | Cons |
|---|---|---|
| Albumin | • Ease of measurement<br>• Low cost<br>• Reproducibility<br>• Excellent predictor of surgical outcomes<br>• Consistent response to interventions | • Long half-life<br>• Decreased levels in<br>• infection, burns, fluid overload, hepatic failure, cancer and nephrotic syndrome |
| Transferrin | • Shorter half-life (8–10 days) • Responds more rapidly to changes in protein status | • Influenced by several factors including liver disease, fluid status, stress and illness<br>• Unreliable in the assessment of mild malnutrition and its response to nutritional intervention<br>• Expensive |
| Prealbumin | • Half-life of prealbumin (2–3 days) is much shorter than that of albumin,<br>• Easily available<br>• Expected to change more rapidly with changes in nutrient intake<br>• Unaffected by hydration status | • Levels may be increased in the setting of renal dysfunction, corticosteroid therapy<br>• Physiological stress, infection and liver dysfunction can decrease prealbumin levels |

*The value of albumin as an indicator of chronic nutritional status*

In short, it has none. Even the patholgists agree. Albumin is what one might call a "negative acute phase protein", and one's production of albumin is among the first frivolities sacrificed by the fascist austerity measures of the hypercatabolic stress response. In critical illness, the serum albumin is not a reliable measure of nutritional status, because (almost by definition) everybody in ICU is sufficiently unwell to have a vigorous stress response, and markedly diminished albumin production. It is probably more related to the severity of the illness (by magnitude of its decrease, rather like a magnitude of increase in the CRP). However, it has seemed attractive in the past, because its production is also sacrificed in chronic malnutrition, and it has a long halflife.

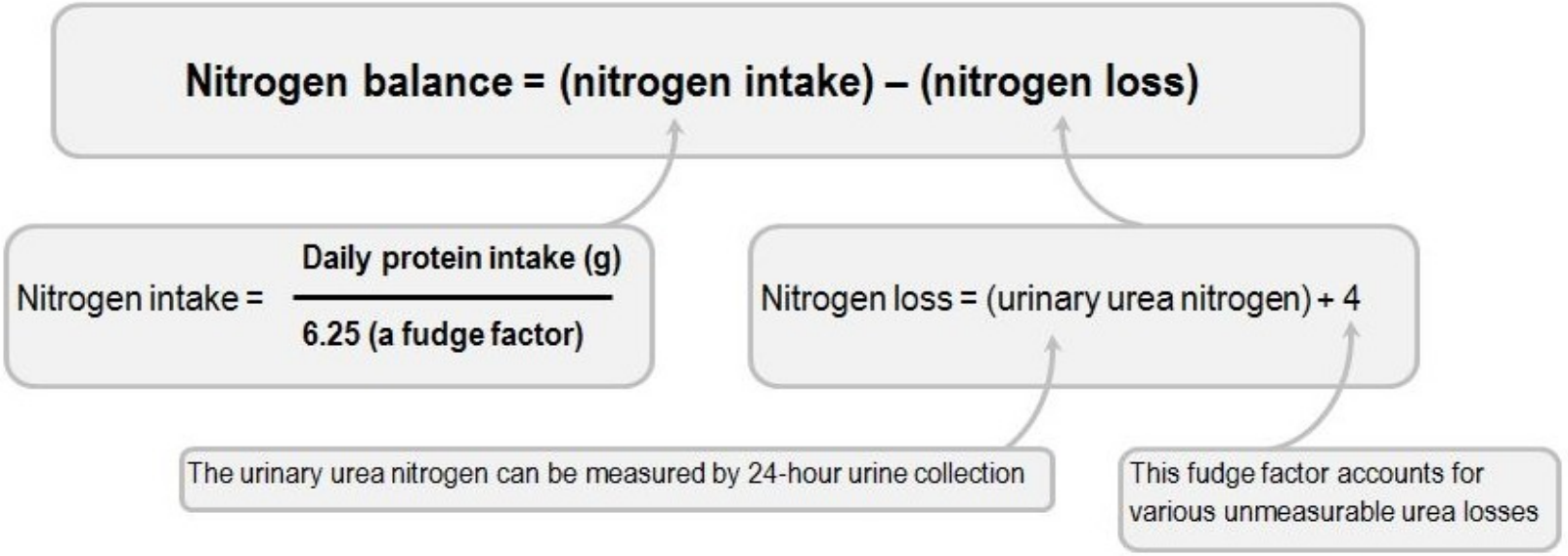
*The value of prealbumin as an indicator of recent nutritional status*

Prealbumin is perhaps slighly more useful than albumin as a means of assessing recent nutrition. Its halflife is only 2 days, which means that its levels will fall rapidly if your stressed-out body has recently prioritised the synthesis of CRP and fibrinogen. In fact, it seems prealbumin levels are inversely proportional to CRP. So in ICU a single prealbumin level is probably meaningless. However, sequential measurements can be used to assess the adequacy of nutritional support. There has been at least one study which has demonstrated that for an ICU patient, an increase in prealbumin indicates that at least 65% of protein-energy needs have been met.

# Nitrogen balance/

*Calculation of nitrogen balance*

The equation for calculating nitrogen balance is as follows:




Obviously, the inconvenience of 24-hour urine collection and the wild inaccuracy of this tecnique have limited its clinical use. The errors tend to overestimate intake and underestimate output, thereby leading to falsely positive balances. Intake, after all, is dependent on a working gut (and who in the ICU can confidently report one of those?). Urinary output can be measured, but what of sweat and faecal losses? And what if the patient produces no urine? Don't get me started on nitrogen balance in dialysis.

# CHILDREN

# Children types of malnutrition

- Stunting – low height for age
- Wasting – low weight for height
- Marasmus – severe deficiency in almost all nutrients
- Kwashiorkor – low proteins intake, adequate calories $\Rightarrow$ oedemas
- Overweight

**Normal Height for age (WHO Growth Standards)**

**Normal**
Normal weight and height

**Wasted**
Thinner than normal

**Stunted**
Shorter than normal

**Wasted & Stunted**
Thinner and shorter than normal

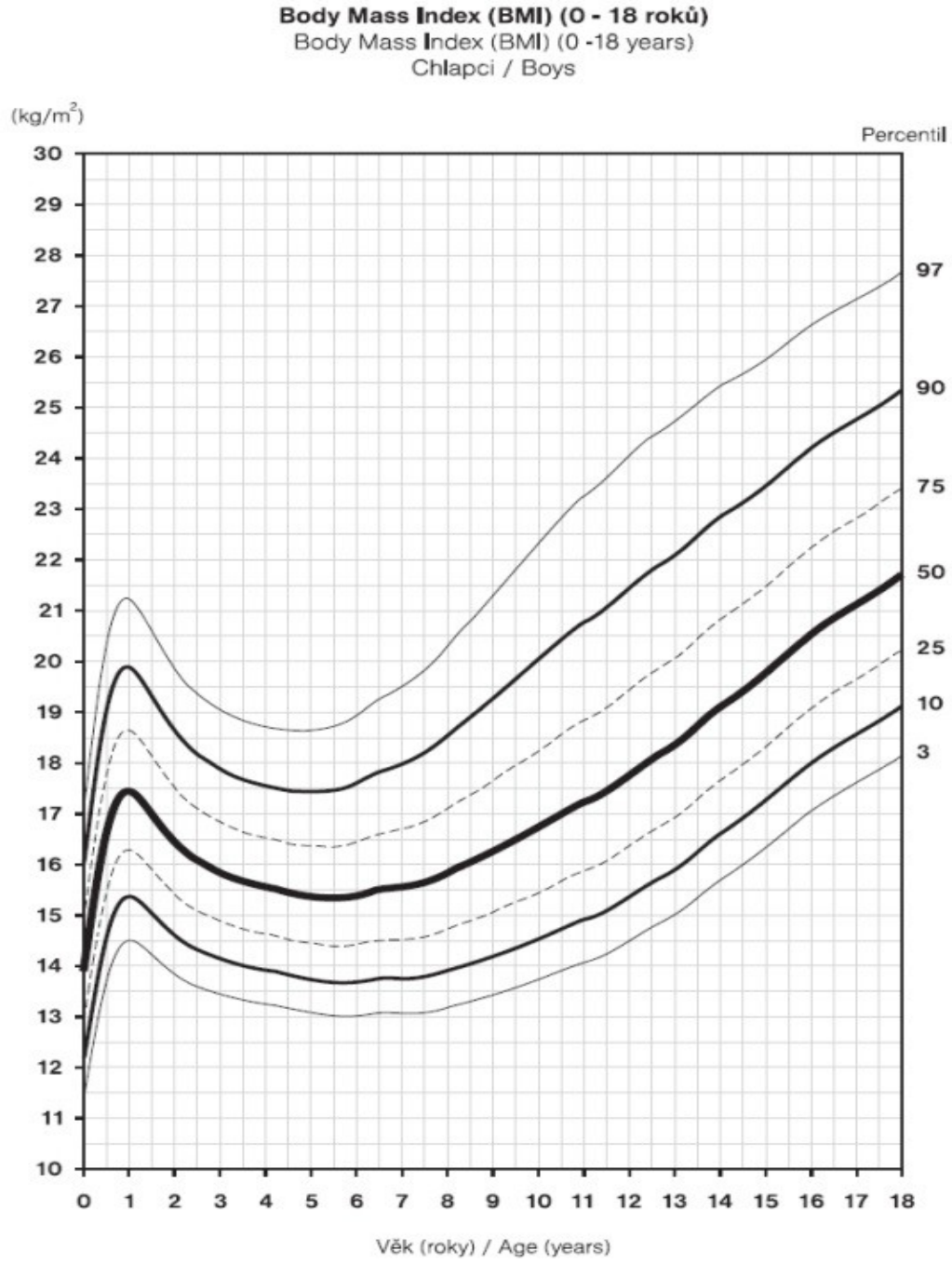
# Definitions

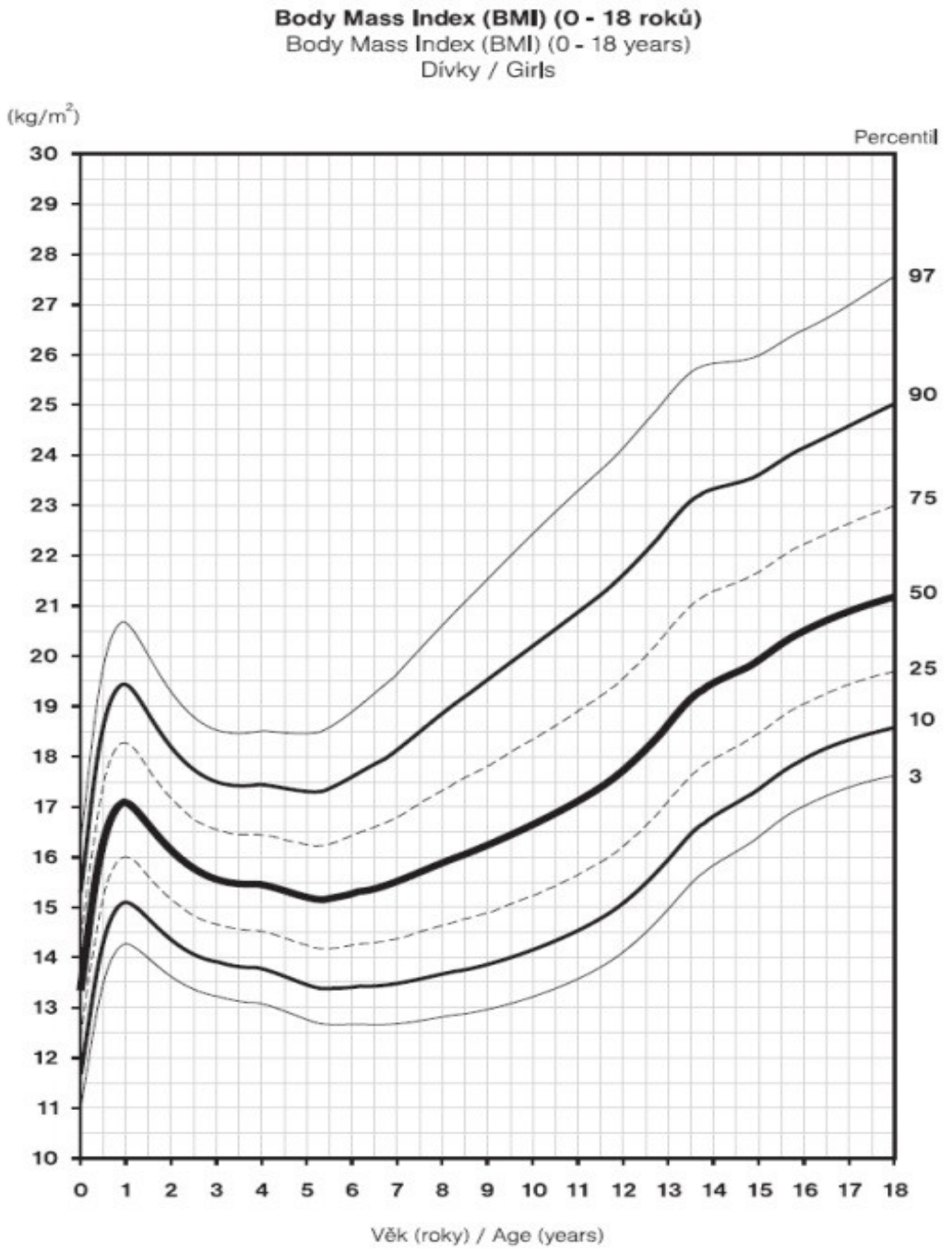
unicef

## Nutrition

| Definitions of the indicators |
| --- |
| **Low birthweight** - Less than 2,500 grams. |
| **Underweight** - Moderate and severe - below minus two standard deviations from median weight for age of reference population; severe - below minus three standard deviations from median weight for age of reference population. |
| **Wasting** - Moderate and severe - below minus two standard deviations from median weight for height of reference population. |
| **Stunting** - Moderate and severe - below minus two standard deviations from median height for age of reference population. |

# Nutritional status assessment in children – BMI percentiles



# Hodnocení výživového stav dětí

**Hodnocení BMI a hmotnosti k tělesné výšce podle percentilových grafů**

Classification of the child's growth by weight-for-height or BMI centile charts

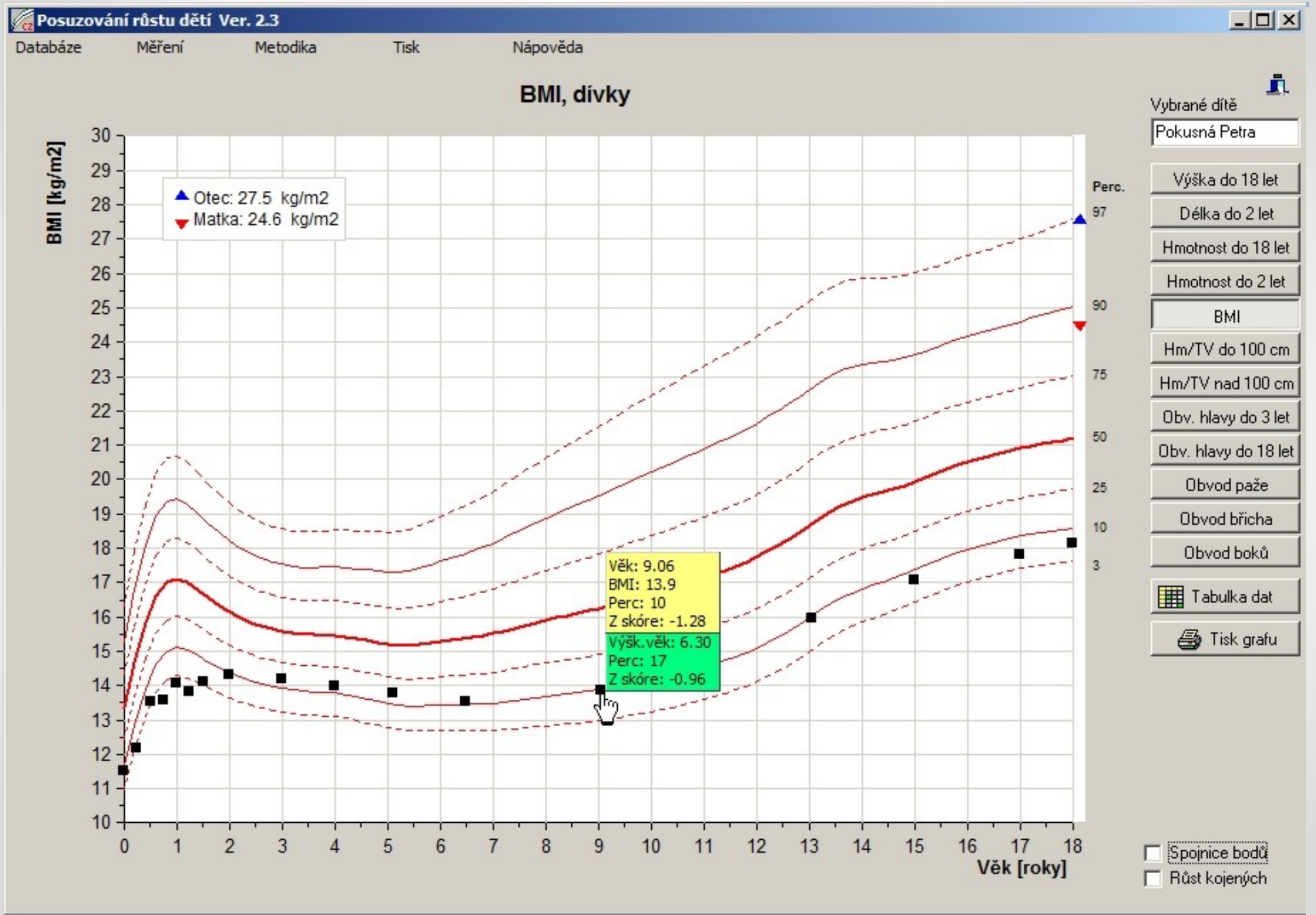
| **Percentilové pásmo**<br>Centile channel | **Hodnocení**<br>Classification |
|---|---|
| 97 < | obézní / obese |
| 90 – 97 | nadměrná hmotnost / overweight |
| 75 – 90 | robustní / plump |
| 25 – 75 | proporcionální / proportionate |
| 10 – 25 | štíhlé / thin |
| < 10 | hubené / underweight |

*Poznámka: Hodnocení podle hmotnosti k tělesné výšce nemusí nutně korespondovat s hodnocením podle BMI.*

*Note: Assessments by weight-for-height and that by BMI may not correspond.*

# Application Rust.cz

# Hodnocení výživového stav dětí



# Z - score

- The difference between the measured value and the 50. percentile, expressed in units of SD.

# Z - score (WHO)

- There are three different systems by which a child or a group of children can be compared to the reference population: Z-scores (standard deviation scores), percentiles, and percent of median. For population-based assessment—including surveys and nutritional surveillance—the Z-score is widely recognized as the best system for analysis and presentation of anthropometric data because of its advantages compared to the other methods (5). At the individual level, however, although there is substantial recognition that Z-score is the most appropriate descriptor of malnutrition, health and nutrition centers (e.g. supplementary feeding programmes in refugee camps) have been in practice reluctant to adopt its use for individual assessment. A detailed description of the three systems, including a discussion of their strengths and weaknesses, can be found elsewhere (5, 14).

- In this database, weight-for-height, height-for-age and weight-for-age are interpreted by using the Z-score classification system. The Z-score system expresses the anthropometric value as a number of standard deviations or Z-scores below or above the reference mean or median value. A fixed Z-score interval implies a fixed height or weight difference for children of a given age. For population-based uses, a major advantage is that a group of Z-scores can be subjected to summary statistics such as the mean and standard deviation. The formula for calculating the Z-score is (5):

- Z-score (or SD-score) = (observed value - median value of the reference population) / standard deviation value of reference population

- Interpreting the results in terms of Z-scores has several advantages:
- The Z-score scale is linear and therefore a fixed interval of Z-scores has a fixed height difference in cm, or weight difference in kg, for all children of the same age. For example, on the height-for-age distribution for a 36-month-old boy, the distance from a Z-score of -2 to a Z-score of -1 is 3.8 cm. The same difference is found between a Z-score of 0 and a Z-score of +1 on the same distribution. In other words, Z-scores have the same statistical relation to the distribution of the reference around the mean at all ages, which makes results comparable across ages groups and indicators.
- Z-scores are also sex-independent, thus permitting the evaluation of children's growth status by combining sex and age groups.
- These characteristics of Z-scores allow further computation of summary statistics such as means, standard deviations, and standard error to classify a population's growth status.

# MID-UPPER ARM CIRCUMFERENCE (MUAC) MEASURING TAPES

An accurate way to measure fat-free mass is to measure the Mid Upper Arm Circumference (MUAC). The MUAC is the circumference of the upper arm at the midway between the shoulder tip and the elbow tip on the left arm. A low reading indicates a loss of muscle mass.
MUAC is a good screening tool in determining the risk of mortality among children, and people living with HIV/AIDS. MUAC is the only anthropometric measure for assessing nutritional status among pregnant women. It is also very simple for use in screening a large number of people, especially during community level screening for community-based nutrition interventions or during emergency situations.
MUAC is therefore used as a screening tool for community based nutrition programmes. MUAC is also used for screening target children and pregnant women for severe acute malnutrition (SAM) and moderate acute malnutrition (MAM).

# MID-UPPER ARM CIRCUMFERENCE (MUAC) MEASURING TAPES

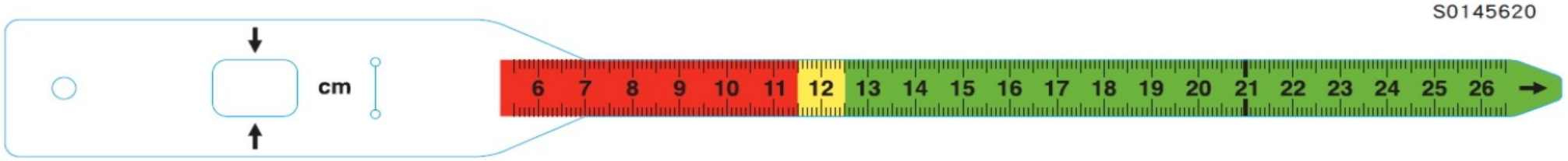
In May 2009, the Word Health Organization (WHO) and UNICEF issued a joint statement on WHO child growth standards and the identification of severe acute malnutrition in infants and children. To reflect this, a new standard MUAC tape (S0145620 MUAC, Child 11.5 Red/PAC-50) was made available.

**S0145620 MUAC, Child 11.5 Red/PAC-50**

This is a new item. It was created in order to support implementation of the new standards (see above).

**Cut-off points of S0145620:**

| | |
|---|---|
| Red: | 0 – **11.5 cm** |
| Yellow: | **11.5 cm** - 12.5 cm |
| Green: | from 12.5 cm |



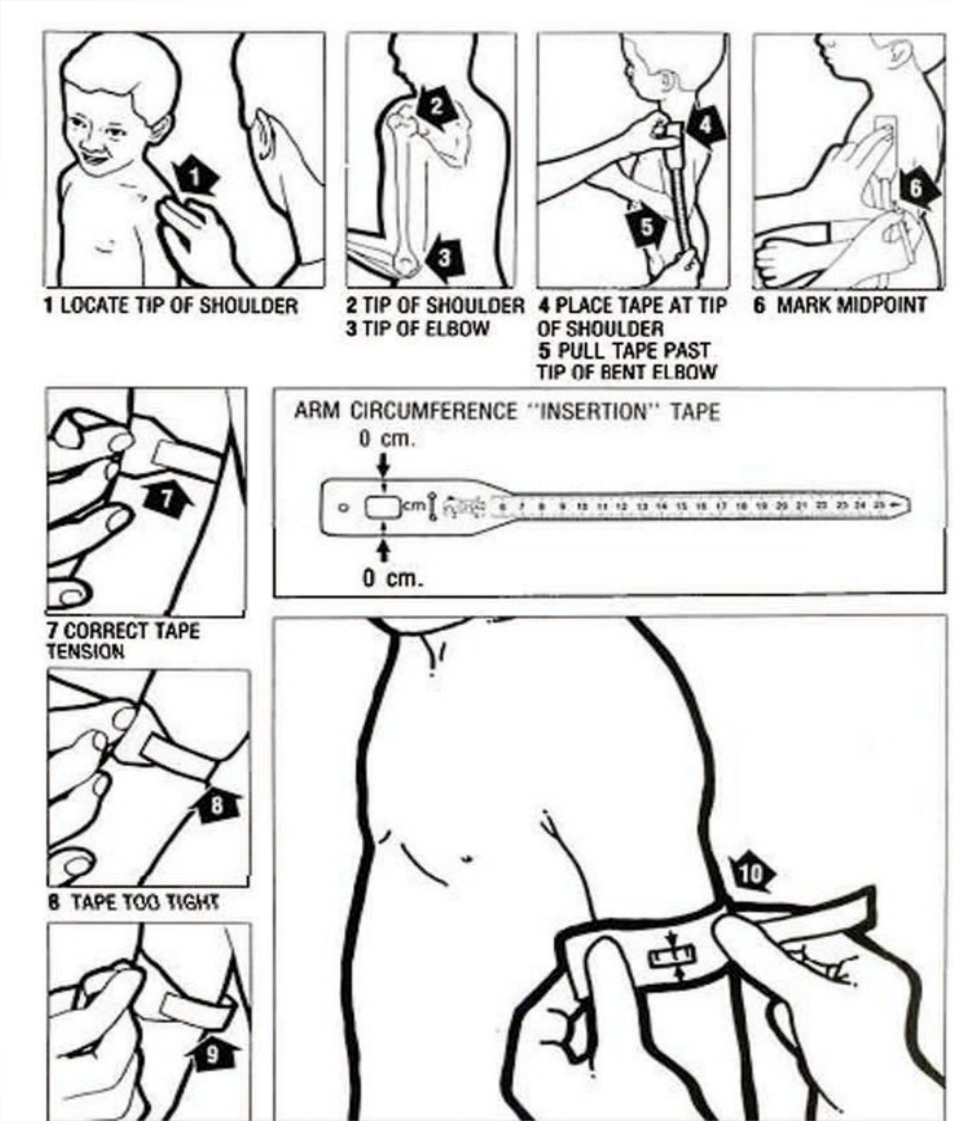



Figure 5.8 Measuring MUAC. (Source: UNICEF, 1986, *How to weigh and measure children: assessing the nutrition status of young children*)

# Arm and Calf circumferences cut-offs

## *Arm (AC, MAC, MUAC):*

- Children:
  - <11.5 cm – severe malnutrition (severe wasting)
  - 11.5 – 12.5 – yelow range
- Adults:
  - LOW MAC = < 24

UNICEF:

- < 21 cm – red
- 21 – 23 – yelow

## *Calf (CC):*

- < 31 cm – manutrition
- > 31 - OK

Mid-arm and calf circumferences (MAC and CC) are better than body mass index (BMI) in predicting health status and mortality risk in institutionalized elderly Taiwanese.
Arch Gerontol Geriatr. 2012 May-Jun;54(3):443-7.

Mid-arm and calf circumferences are stronger mortality predictors than body mass index for patients with chronic obstructive pulmonary diseaseInt J Chron Obstruct Pulmon Dis. 2016; 11: 2075–2080.

# Screening tests

# Validated screening test

- MNA – Mini Nutritional Assessment
- MNA-SF (Short Form)
- SGA – Subjective Global Assessment
- PG-SGA (Patient Generated)
- NRS – Nutritional Risk Screening
- MUST – Malnutrition Universal Screening Tool
- Nottingham questionnaire

# Validated screening test

## Recommended Patient Screening Tools

Various screening tools have been designed to detect protein and energy under-nutrition in patients. Common screening tools are effective at predicting whether under-nutrition is likely to develop and/or worsen. Based on guidelines of the European Society for Clinical Nutrition and Metabolism (ESPEN),[2] and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.),[3] the following tools have been recommended to avoid unnecessary nutrient depletion:

- Nutritional Risk Screening 2002 (NRS 2002)[2]
- Subjective Global Assessment (SGA)[3]
- Malnutrition Universal Screening Tool (MUST)[2]
- Mini-Nutritional Assessment (MNA)[2]

# MNA – Mini Nutritional assessment

- Sensitivity: 98.9 %
- Specifity: 94.3 %
- Diagnostic accuracy: 97.2 %

## Screening

**A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?**

0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake ☐

**B Weight loss during the last 3 months**

0 = weight loss greater than 3kg (6.6lbs)
1 = does not know
2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

**C Mobility**

0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

**D Has suffered psychological stress or acute disease in the past 3 months?**

0 = yes 2 = no ☐

**E Neuropsychological problems**

0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

**F Body Mass Index (BMI) = weight in kg / (height in m)$^2$** ☐

0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater ☐

**Screening score (subtotal max. 14 points)** ☐☐

12-14 points: ☐ Normal nutritional status
8-11 points: ☐ At risk of malnutrition
0-7 points: ☐ Malnourished

For a more in-depth assessment, continue with questions G-R

## Assessment

**G Lives independently (not in nursing home or hospital)**
1 = yes 0 = no ☐

**H Takes more than 3 prescription drugs per day**
0 = yes 1 = no ☐

**I Pressure sores or skin ulcers**
0 = yes 1 = no ☐

**J How many full meals does the patient eat daily?**
0 = 1 meal
1 = 2 meals
2 = 3 meals ☐

**K Selected consumption markers for protein intake**
- At least one serving of dairy products (milk, cheese, yoghurt) per day — yes ☐ no ☐
- Two or more servings of legumes or eggs per week — yes ☐ no ☐
- Meat, fish or poultry every day — yes ☐ no ☐

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes ☐.☐

**L Consumes two or more servings of fruit or vegetables per day?**
0 = no 1 = yes ☐

**M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?**
0.0 = less than 3 cups
0.5 = 3 to 5 cups
1.0 = more than 5 cups ☐.☐

**N Mode of feeding**
0 = unable to eat without assistance
1 = self-fed with some difficulty
2 = self-fed without any problem ☐

**O Self view of nutritional status**
0 = views self as being malnourished
1 = is uncertain of nutritional state
2 = views self as having no nutritional problem ☐

**P In comparison with other people of the same age, how do the patient consider his / her health status?**
0.0 = not as good
0.5 = does not know
1.0 = as good
2.0 = better ☐.☐

**Q Mid-arm circumference (MAC) in cm**
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC greater than 22 ☐.☐

**R Calf circumference (CC) in cm**
0 = CC less than 31
1 = CC 31 or greater ☐

**Assessment (max. 16 points)** ☐☐.☐
**Screening score** ☐☐.☐
**Total Assessment (max. 30 points)** ☐☐.☐

**Malnutrition Indicator Score**

| | | |
|---|---|---|
| 24 to 30 points | ☐ | Normal nutritional status |
| 17 to 23.5 points | ☐ | At risk of malnutrition |
| Less than 17 points | ☐ | Malnourished |

Complete the screen by filling in the boxes with the appropriate numbers.
Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition Indicator Score.

## Screening

**A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?**
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake

**B Weight loss during the last 3 months**
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3 = no weight loss

**C Mobility**
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out

**D Has suffered psychological stress or acute disease in the past 3 months?**
0 = yes 2 = no

**E Neuropsychological problems**
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems

**F Body Mass Index (BMI) = weight in kg / (height in m)$^2$**
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater

**Screening score (subtotal max. 14 points)**
12-14 points: Normal nutritional status
8-11 points: At risk of malnutrition
0-7 points: Malnourished

For a more in-depth assessment, continue with questions G-R

## Assessment

**G Lives independently (not in nursing home or hospital)**
1 = yes 0 = no

**H Takes more than 3 prescription drugs per day**
0 = yes 1 = no

**I Pressure sores or skin ulcers**
0 = yes 1 = no

**J How many full meals does the patient eat daily?**
0 = 1 meal
1 = 2 meals
2 = 3 meals

**K Selected consumption markers for protein intake**
- At least one serving of dairy products (milk, cheese, yoghurt) per day — yes no
- Two or more servings of legumes or eggs per week — yes no
- Meat, fish or poultry every day — yes no

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes

**L Consumes two or more servings of fruit or vegetables per day?**
0 = no 1 = yes

**M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?**
0.0 = less than 3 cups
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**P In comparison with other people of the same age, how does the patient consider his / her health status?**
0.0 = not as good
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2.0 = better

**Q Mid-arm circumference (MAC) in cm**
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC greater than 22

**R Calf circumference (CC) in cm**
0 = CC less than 31
1 = CC 31 or greater

**Assessment (max. 16 points)**
**Screening score**
**Total Assessment (max. 30 points)**

**Malnutrition Indicator Score**

| | |
|---|---|
| 24 to 30 points | Normal nutritional status |
| 17 to 23.5 points | At risk of malnutrition |
| Less than 17 points | Malnourished |


References
1. Vellas B, Villars H, Abellan G, *et al*. Overview of the MNA® - Its History and Challenges. *J Nutr Health Aging*. 2006; **10**:456-465.
2. Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: Developing the Short-Form Mini Nutritional Assessment (MNA-SF). *J. Geront*. 2001; **56A**: M366-377
3. Guigoz Y. The Mini-Nutritional Assessment (MNA®) Review of the Literature - What does it tell us? *J Nutr Health Aging*. 2006; **10**:466-487.

## Screening:

- Food intake decline over the past 3 months due to loss of appetite, digestive problems
- Weight loss during the last 3 months
- Mobility
- Psychological stress or acute disease in the past 3 months
- Neuropsychological problems (dementia or depression)
- BMI (<19, 19-20.9, 21-22.9, ≥23)

*Screening score:*

0-7: Malnourished
8-11: At risk of malnutrition
12-14: Normal nutritional status

---

## Assessment:

*Generally:*

- Self-sufficiency – lives independently?
- Drugs – more than 3 prescription drugs per day
- Skin defects – pressure sores or skin ulcers

*Diet:*

- How many full meals daily
- Markers for protein intake
- Fruits or vegetable – two or more servings per day?
- How much fluid per day?
- Mode of feeding – self-sufficiency?)

*Self view:*

- Self view of nutritional status
- Self view of his/her nutritional status in comparison with other people

*Anthropometry – 2 circumference:*

- Arm circumferences (<21, 21-21.9, ≥22)
- Calf circumference (<31, ≥31)

*Total assessment – Malnutrition Indicator Score (Screening score + Assessment score):*

<17: Malnourished
17-23.5: At risk of malnutrition
24-30: Normal nutritional status

# MNA - SF

## Mini Nutritional Assessment – Short Form (MNA®-SF)

The MNA®-SF provides a simple and quick method of identifying elderly persons who are at risk for malnutrition, or who are already malnourished. It identifies the risk of malnutrition before severe changes in weight or serum protein levels occur.

The MNA®-SF was developed by Nestlé and leading international geriatricians and remains one of the few validated screening tools for the elderly. It has been well validated in international studies in a variety of settings[5-7] and correlates with morbidity and mortality.

In 2009 the MNA®-SF was validated as a stand alone screening tool, based on the full MNA®.[8] The MNA®-SF may be completed at regular intervals in the community and in the hospital or long-term care setting. It is recommended to be done annually in the community, and every 3 months in the hospital or long-term care or whenever a change in clinical condition occurs.

# MNA - SF

Last name: First name:

Sex: Age: Weight, kg: Height, cm: Date:

Complete the screen by filling in the boxes with the appropriate numbers. Total the numbers for the final screening score.

## Screening

**A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?**
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake

**B Weight loss during the last 3 months**
0 = weight loss greater than 3 kg (6.6 lbs)
1 = does not know
2 = weight loss between 1 and 3 kg (2.2 and 6.6 lbs)
3 = no weight loss

**C Mobility**
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out

**D Has suffered psychological stress or acute disease in the past 3 months?**
0 = yes 2 = no

**E Neuropsychological problems**
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems

**F1 Body Mass Index (BMI) (weight in kg) / (height in m)$^2$**
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater

IF BMI IS NOT AVAILABLE, REPLACE QUESTION F1 WITH QUESTION F2.
DO NOT ANSWER QUESTION F2 IF QUESTION F1 IS ALREADY COMPLETED.

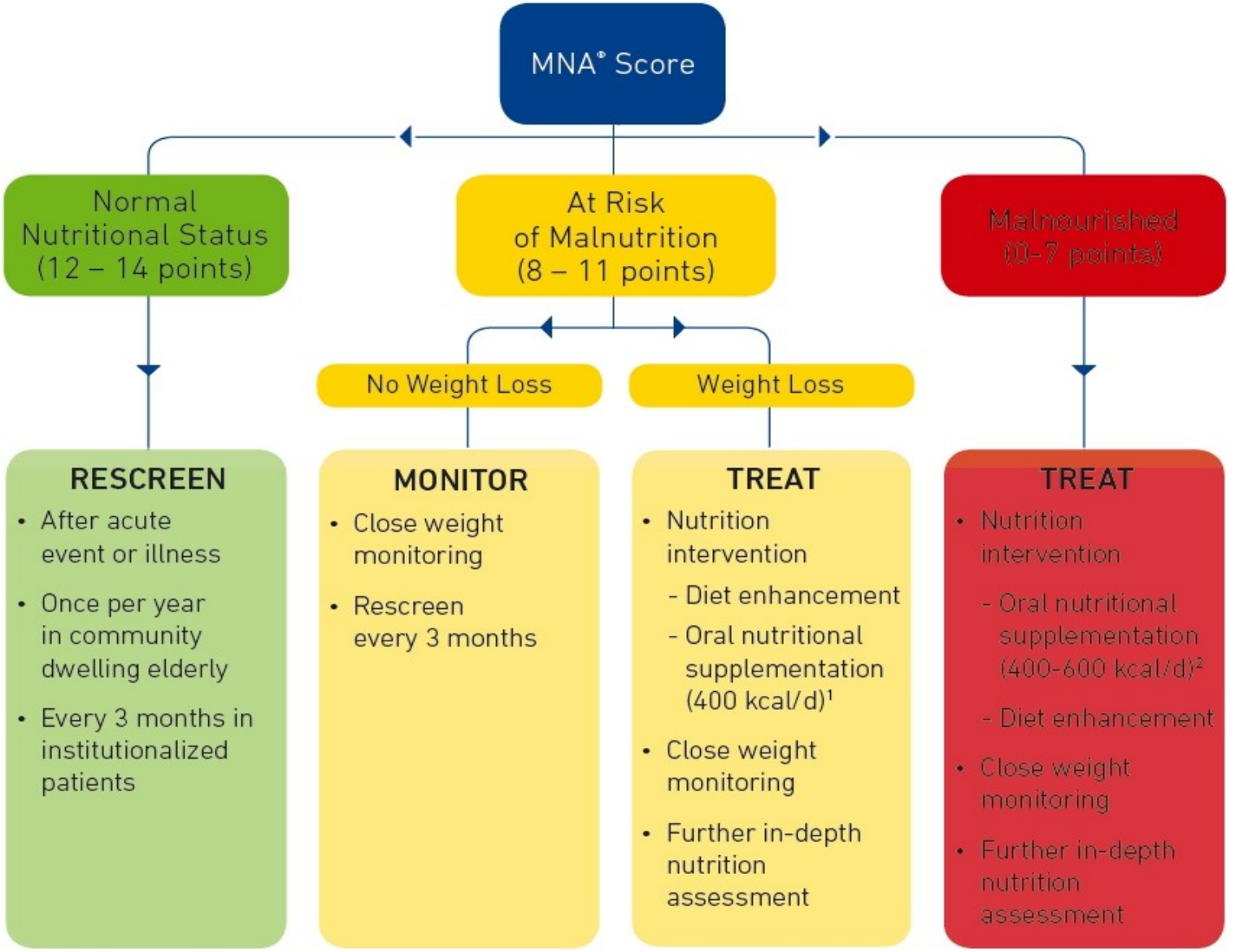
**F2 Calf circumference (CC) in cm**
0 = CC less than 31
3 = CC 31 or greater

**Screening score**
(max. 14 points)

**12-14 points:** Normal nutritional status
**8-11 points:** At risk of malnutrition
**0-7 points:** Malnourished

Save
Print
Reset

# Recommendations for Intervention




1. Milne AC, *et al. Cochrane Database Syst Rev.* 2009:**2**:CD003288
2. Gariballa S, *et al. Am J Med.* 2006;**119**:693-699

# SGA – Subjective Global Assessment

*It covers 3 areas:*

- Medical History
  - Weight change
  - Dietary intake change
  - Gastrointestinal symptoms
  - Functional capacity
- Physical examination
  - Loss of subcutaneous fat
  - Loss of muscle mass
  - Presence of oedema, ascites
- Subjective global assessment
  - A – Well nourished
  - B - Mildly/Moderately Malnourished
  - C - Severely Malnourished

The individual items are not point scored as the assessment is subjective. The results of the medical history and physical examination are summarized in the „Subjective Global Assessment“

# Subjective Global Assessment Form

## MEDICAL HISTORY

## NUTRIENT INTAKE

1. ☐ No change; adequate
2. Inadequate; duration of inadequate intake _____
   ☐ Suboptimal solid diet ☐ Full fluids or only oral nutrition supplements ☐ Minimal intake, clear fluids or starvation
3. **Nutrient Intake in past 2 weeks***
   ☐ Adequate _____ ☐ Improved but not adequate _____ ☐ No improvement or inadequate _____

## WEIGHT

**Usual weight** _____ **Current weight** _____

1. **Non fluid weight change past 6 months** Weight loss (kg) _____
   ☐ <5% loss or weight stability ☐ 5-10% loss without stabilization or increase ☐ >10% loss and ongoing
   If above not known, has there been a subjective loss of weight during the past six months?
   ☐ None or mild ☐ Moderate ☐ Severe
2. **Weight change past 2 weeks*** Amount (if known) _____
   ☐ Increased ☐ No change ☐ Decreased

## SYMPTOMS (Experiencing symptoms affecting oral intake)

1. ☐ Pain on eating ☐ Anorexia ☐ Vomiting ☐ Nausea ☐ Dysphagia ☐ Diarrhea
   ☐ Dental problems ☐ Feels full quickly ☐ Constipation
2. ☐ None ☐ Intermittent/mild/few ☐ Constant/severe/multiple
3. **Symptoms in the past 2 weeks***
   ☐ Resolution of symptoms ☐ Improving ☐ No change or worsened

## FUNCTIONAL CAPACITY (Fatigue and progressive loss of function)

1. No dysfunction
2. Reduced capacity; duration of change _____
   ☐ Difficulty with ambulation/normal activities ☐ Bed/chair-ridden
3. **Functional Capacity in the past 2 weeks***
   ☐ Improved ☐ No change ☐ Decrease

## Subcutaneous fat

| Physical examination | Normal | Mild/Moderate | Severe |
|---|---|---|---|
| **Under the eyes** | Slightly bulging area | Somewhat hollow look, Slightly dark circles, | Hollowed look, depression, dark circles |
| **Triceps** | Large space between fingers | Some depth to fat tissue, but not ample. Loose fitting skin. | Very little space between fingers, or fingers touch |
| **Ribs, lower back, sides of trunk** | Chest is full; ribs do not show. Slight to no protrusion of the iliac crest | Ribs obvious, but indentations are not marked. Iliac Crest somewhat prominent | Indentation between ribs very obvious. Iliac crest very prominent |

## Muscle wasting

| Physical examination | Normal | Mild/Moderate | Severe |
|---|---|---|---|
| **Temple** | Well-defined muscle | Slight depression | Hollowing, depression |
| **Clavicle** | Not visible in males; may be visible but not prominent in females | Some protrusion; may not be all the way along | Protruding/prominent bone |
| **Shoulder** | Rounded | No square look; acromion process may protrude slightly | Square look; bones prominent |
| **Scapula/ribs** | Bones not prominent; no significant depressions | Mild depressions or bone may show slightly; not all areas | Bones prominent; significant depressions |
| **Quadriceps** | Well defined | Depression/atrophy medially | Prominent knee, Severe depression medially |
| **Interosseous muscle between thumb and forefinger (back of hand)** | Muscle protrudes; could be flat in females | Slightly depressed | Flat or depressed area |

# SGA – Subjective Global Assessment

## Fluid retention

| Physical examination | Normal | Mild/Moderate | Severe |
|---|---|---|---|
| Oedema | None | Pitting oedema of extremities /pitting to knees, possible sacral oedema if bedridden | Pitting beyond knees, sacral oedema if bedridden, may also have generalized oedema |
| Ascites | Absent | Present (may only be present on imaging) | |

## Subjective Global Assessment

| A - Well-nourished | B - Mildly/moderately malnourished | C- Severely malnourished |
|---|---|---|
| ■ No decrease in food/nutrient intake;<br>■ < 5% weight loss;<br>■ No/minimal symptoms affecting food intake;<br>■ No deficit in function;<br>■ No deficit in fat or muscle mass | ■ Definite decrease in food/nutrient intake;<br>■ 5% - 10% weight loss without stabilization or gain;<br>■ Mild/some symptoms affecting food intake;<br>■ Moderate functional deficit or recent deterioration;<br>■ Mild/moderate loss of fat and/or muscle mass | ■ Severe deficit in food/nutrient intake;<br>■ > 10% weight loss which is ongoing;<br>■ Significant symptoms affecting food/ nutrient intake;<br>■ Severe functional deficit<br>■ OR *recent significant deterioration obvious signs of fat and/or muscle loss |

# NRS 2002 - Nutritional Risk Screening

**Table 1** Initial screening

| | | Yes | No |
|---|---|---|---|
| 1 | Is BMI <20.5? | | |
| 2 | Has the patient lost weight within the last 3 months? | | |
| 3 | Has the patient had a reduced dietary intake in the last week? | | |
| 4 | Is the patient severely ill ? (e.g. in intensive therapy) | | |

**Yes**: If the answer is 'Yes' to any question, the screening in Table 2 is performed.
**No**: If the answer is 'No' to all questions, the patient is re-screened at weekly intervals. If the patient e.g. is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.

**Table 2** Final screening

| **Impaired nutritional status** | | **Severity of disease (≈ increase in requirements)** | |
|---|---|---|---|
| Absent **Score 0** | Normal nutritional status | Absent **Score 0** | Normal nutritional requirements |
| Mild **Score 1** | Wt loss >5% in 3 mths or Food intake below 50–75% of normal requirement in preceding week | Mild **Score 1** | Hip fracture* Chronic patients, in particular with acute complications: cirrhosis*, COPD*. *Chronic hemodialysis, diabetes, oncology* |
| Moderate **Score 2** | Wt loss >5% in 2 mths or BMI 18.5 – 20.5 + impaired general condition or Food intake 25–60% of normal requirement in preceding week | Moderate **Score 2** | Major abdominal surgery* Stroke* *Severe pneumonia, hematologic malignancy* |
| Severe **Score 3** | Wt loss >5% in 1 mth (>15% in 3 mths) or BMI <18.5 + impaired general condition or Food intake 0-25% of normal requirement in preceding week in preceding week. | Severe **Score 3** | Head injury* Bone marrow transplantation* *Intensive care patients (APACHE>10).* |
| **Score:** | + | **Score:** | **=Total score** |
| **Age** | if ≥70 years: add 1 to total score above | **=age-adjusted total score** | |

**Score ≥3**: the patient is nutritionally at-risk and a nutritional care plan is initiated
**Score <3**: weekly rescreening of the patient. If the patient e.g. is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.

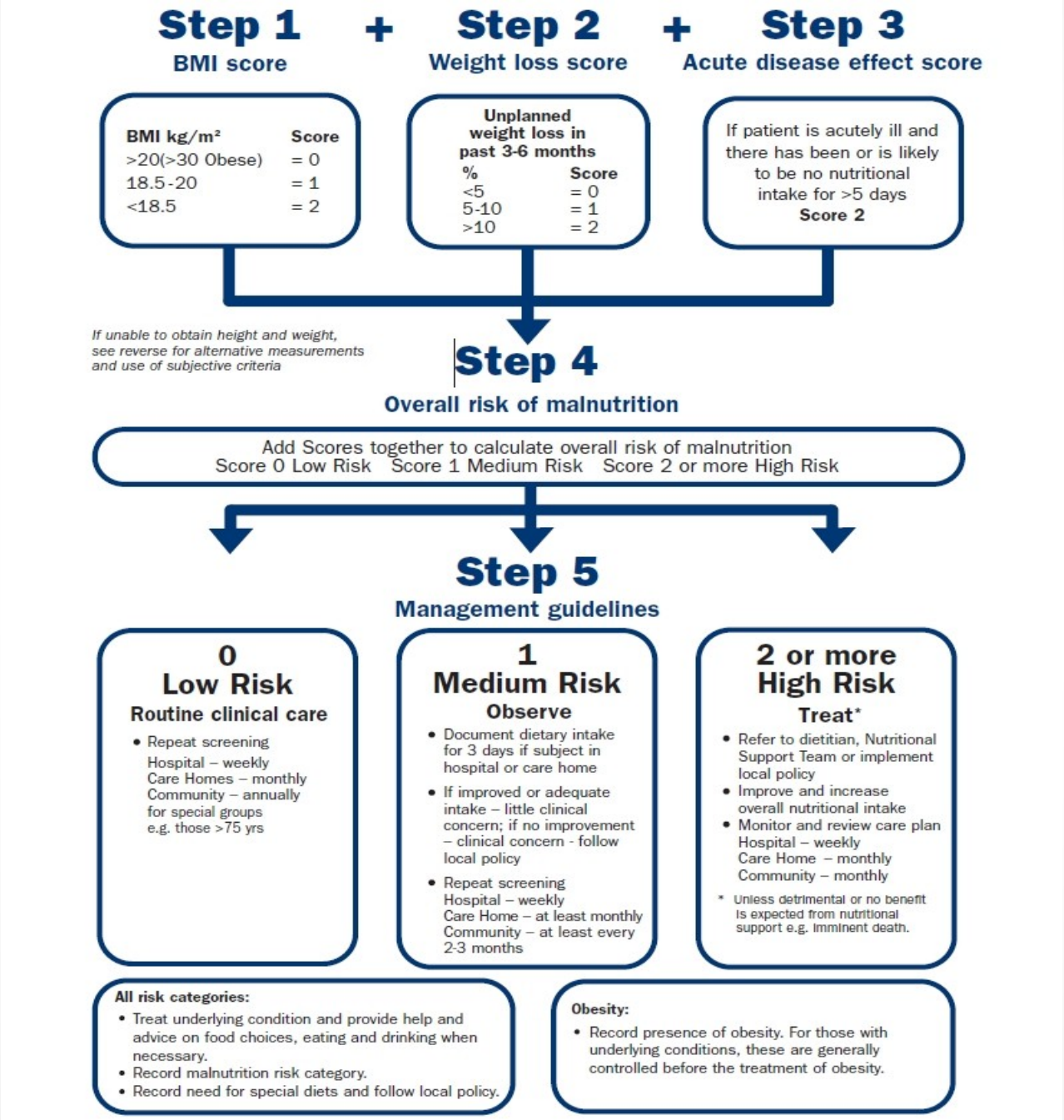
Prototypes for severity of disease

Score=1: a patient with chronic disease, admitted to hospital due to complications. The patient is weak but out of bed regularly. Protein requirement is increased, but can be covered by oral diet or supplements in most cases.

Score=2: a patient confined to bed due to illness, e.g. following major abdominal surgery. Protein requirement is substantially increased, but can be covered, although artificial feeding is required in many cases.

Score=3: a patient in intensive care with assisted ventilation etc. Protein requirement is increased and cannot be covered even by artificial feeding. Protein breakdown and nitrogen loss can be significantly attenuated.

# MUST – Malnutrition Universal Screening Tool



# MUST
# Malnutrition Universal Screening Tool

| Step 1<br>BMI kg/m$^2$ | | Score |
|---|---|---|
| > 20<br>> 30 (obese)<br>18.5 – 20<br>< 18.5 | **0**<br>**0**<br>**1**<br>**2** | _____ |
| **Step 2**<br>**Unplanned weight loss in past 3-6 months %** | | |
| < 5%<br>5-10%<br>>10% | **0**<br>**1**<br>**2** | _____ |
| **Step 3**<br>**Acute disease effect score** | | |
| If patient is acutely ill and there has been or is unlikely to be no nutritional intake for > 5 days | **2** | _____ |
| **Step 4** | | |
| Add steps 1, 2 + 3 | | _____ |

| Score 0<br>Low Risk | Score 1<br>Medium Risk | Score 2 or more<br>High Risk |
|---|---|---|
| Routine clinical care | Observe | Develop treatment pathway |