

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)

■ 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 etc...)

■ Nutritional assessment – differentiate between:

- 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** (undernutrition vs. overnutrition).
- 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 - xerofthalmia
- ⇒ 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

Clinical malnutritions according to ESPEN

- **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**

Types of Protein-Energy Malnutrition (PEM)

- Underweight - adults low BMI, children low weight for age
- Starvation – pure caloric deficiency, conserves lean mass, increases 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

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

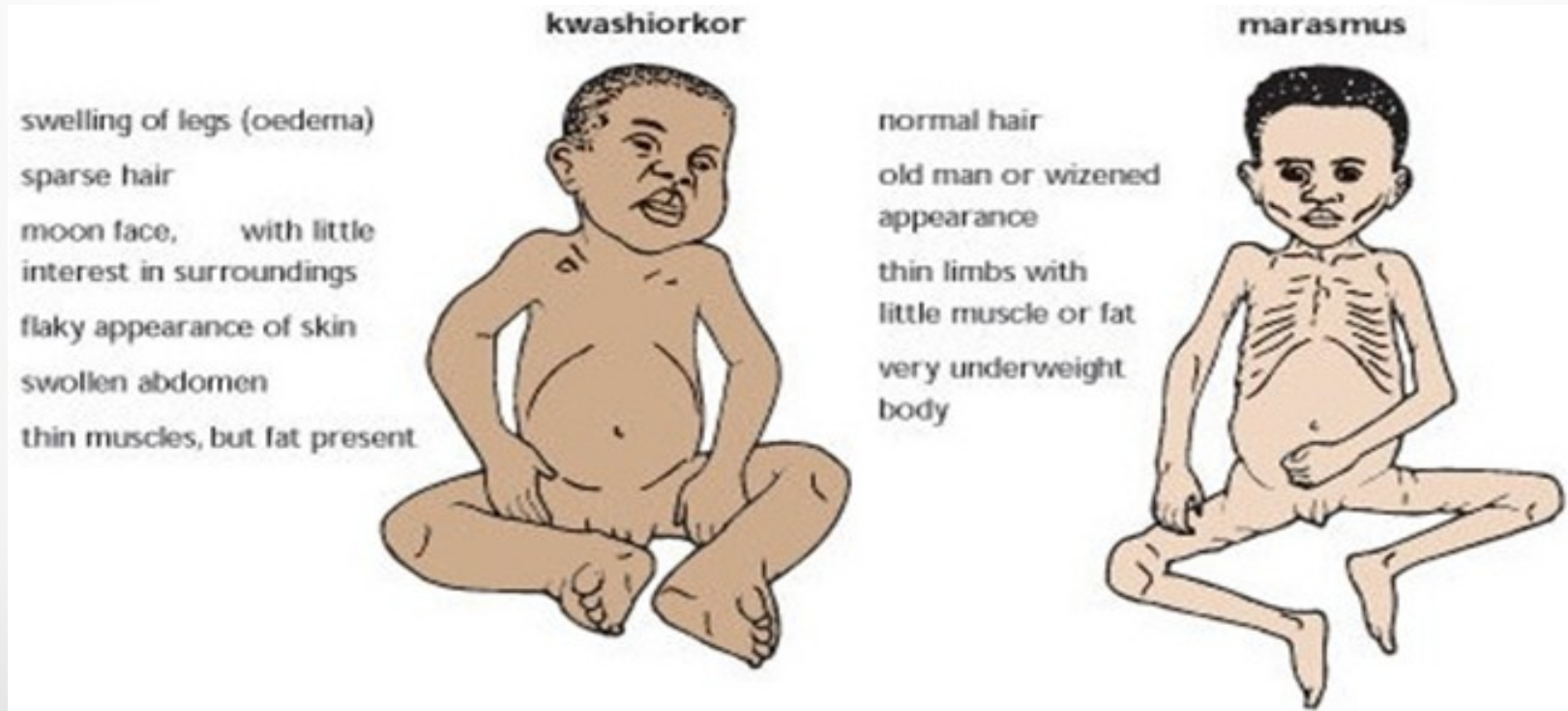
Marasmus vs Kwashiorkor

- 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.



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.

■ **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 µg/l = deficiency)

The spectrum of iodine deficiency disorders, IDD

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

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

Physical, (clinical) examination – general appearance

Symptoms and signs of undernutrition and micronutrient deficiency

Area/System	Symptom or Sign	Deficiency
Skin	<ul style="list-style-type: none"> • Pallor - especially palms • Bruising, ecchymosis, petechiae, hematomas • Hypo or hyperpigmentation, desquamation, ulceration • Hyperpigmentation exposed areas (Pellagra) • Perifollicular hyperkeratosis 	Anaemia from iron or folate Vitamin C, vitamin K Zinc or protein Niacin (vitamin PP, B3) Vitamin A
Eye	<ul style="list-style-type: none"> • Impaired night vision • Xerotic conjunctivae, xerotic cornea, Bitot's spot, keratomalacia (corneal drying and clouding), corneal scars 	Vitamin A
Hair	<ul style="list-style-type: none"> • Thinning or loss of hair, Depigmentation, pluckability, sparsity 	Protein - Kwashiorkor
Nails	<ul style="list-style-type: none"> • Koilonychia, spooning of nails 	Iron
Mouth	<ul style="list-style-type: none"> • Cheilosis, glossitis, loss of papillae, magenta tongue • Glossitis, scarlet tongue • Bleeding gums 	Riboflavin (B2) Niacin Vitamin C
Subcutaneous tissue	<ul style="list-style-type: none"> • Reduced subcutaneous tissue and fat • Oedema • Muscle wasting, weakness 	Energy Hypalbuminaemia, Na and K disturbances Undernutrition, protein
Bones	<ul style="list-style-type: none"> • Bone deformities - Craniotabes, prominent costochondral junctions, widening of metaphyses (wrists and ankle), frontal bossing, wide anterior fontanelle, rickety rosary, delayed dentition, bow legs. • Joint pain or swelling • Inadequate bone mass or osteoporosis 	Vitamin D Vitamin C Calcium
Abdomen	<ul style="list-style-type: none"> • Hepatomegaly 	Kwashiorkor
Central nervous system, neurologic	<ul style="list-style-type: none"> • Apathy • Peripheral neuropathy – paresthesias or numbness in stocking-glove distribution • Tetany • Cognitive and sensory deficits • Dementia 	Kwashiorkor, iron deficiency Thiamine (B1) – beri beri, or pyridoxine (B6) Calcium, magnesium Thiamine, niacin, pyridoxine, vitamin B12 Thiamine, niacin, B12
Cardiac	<ul style="list-style-type: none"> • Cardiac failure or enlargement 	Thiamine (B1)
Endocrine - Thyroid	<ul style="list-style-type: none"> • Goitre (thyromegaly) 	Iodine
Musculoskeletal	<ul style="list-style-type: none"> • Wasting of muscle 	Protein
GI	<ul style="list-style-type: none"> • Diarrhoea • Diarrhoea and dysgeusia • Dysphagia or odynophagia (Plummer-Vinson syndrome) 	Protein, niacin, folate, vitamin B12 Zinc Iron

Nails

- **Fe deficiency** - koilonychia, spooning of nails
- **Protein deficiency** – white transverse strips



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<https://img.medscapestatic.com/pi/meds/ckb/41/28841tn.jpg>

Eyes

■ Vit. A deficiency

- Xerotic cornea
- Bitot's spot
- Keratomolacia
- Corneal scars
- Impaired night vision



<https://upload.wikimedia.org/wikipedia/commons/thumb/3/34/Blepharitis.JPG/220px-Blepharitis.JPG>



https://webeye.ophth.uiowa.edu/eye_forum/atlas/photos-earlier/xerosis-conjunctivae.jpg



Corneal xerosis
with corneal ulcer



Corneal Scar

<https://image.slidesharecdn.com/problemsolvingexercise-vita-copy-160505054605/95/vitamin-a-and-its-deficiency-19-638.jpg?cb=1462427304>



https://openi.nlm.nih.gov/imgs/512/100/2873666/PMC2873666_jceh_23_72_004_f18.png?keywords=vitamin+a+deficiencies,bitot%27s+spots



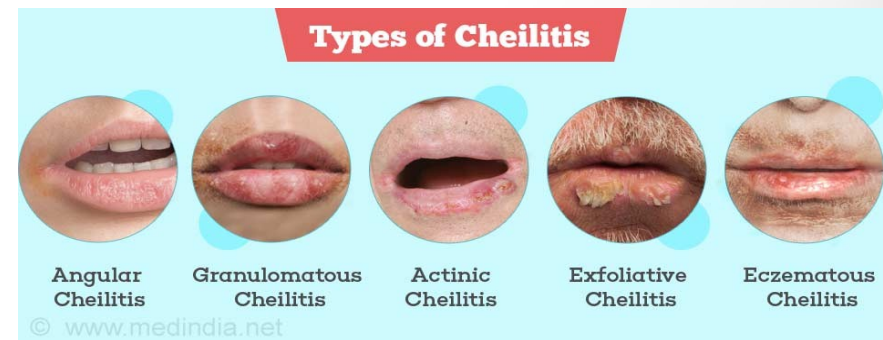
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Mouth, tongue, teeth, gums

- Gums
 - Bleeding gums – vit C
- Tongue
 - Glossitis, loss of papillae
- Teeth
 - Caries
 - Ca, F
 - Spotty enamel
 - Fluorine excess
- Rty
 - Angulární stomatitis – nedostatek riboflavinu, pyridoxinu, železa
 - Angulární jizvy – nedostatek riboflavinu, pyridoxinu
 - Cheilitis – nedostatek riboflavinu



<https://image/dental-probl>



https://upload.wikimedia.org/wikipedia/commons/thumb/4/4e/Dental_fluorosis_%28mild%29.png/300px-Dental_fluorosis_%28mild%29.png

Skin

- Pallor (anemia from iron, folate)
- Bruising, petechiae, hematomas (vit C, vit K)
- Hypo or hyperpigmentation (Zinc, niacin)
- Perifollicular hyperkeratosis (vit A)



http://www.uaz.edu.mx/histo/pathology/ed/ch_7/c7_rmsf_hand.jpg



<https://jamanetwork.com/data/Journals/DERM/4687/dsk50017f2.png>

<https://noskinproblems.com/wp-content/uploads/2015/06/seborrheic-dermatitis-face.jpg>



<http://slideplayer.com/1718407/7/images/10/Case+On+e%3A+Skin+Exam+Perifollicular+petechiae.jpg>

Skin

- Kůže

- Změny pigmentace

- Špinavě hnědé skvrny – chronická podvýživa
 - Depigmentace – kwashiorkor
 - Erytém, svědění, pálení – puchýřky – hrubnutí kůže – pelágr
 - Bledá kůže - chudokrevnost



<https://www.med.uottawa.ca/sim/data/Images/Kwashiorkor.jpg>



<https://niacinreviews.com/wp-content/uploads/2016/10/Pellagra-300x209.jpg>

Bones, skeleton

Vit. D deficiency

- Bone derformities:
- Craniotabes
- Prominet costovertebral junctions
- Widening of metaphyses (wrist and ankle)
- Frontal bossing
- Wide anteri



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

Thyroid

- Iodine deficiency
 - Goitre (thyromegaly)



<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)
- ⇒ Skinfolts

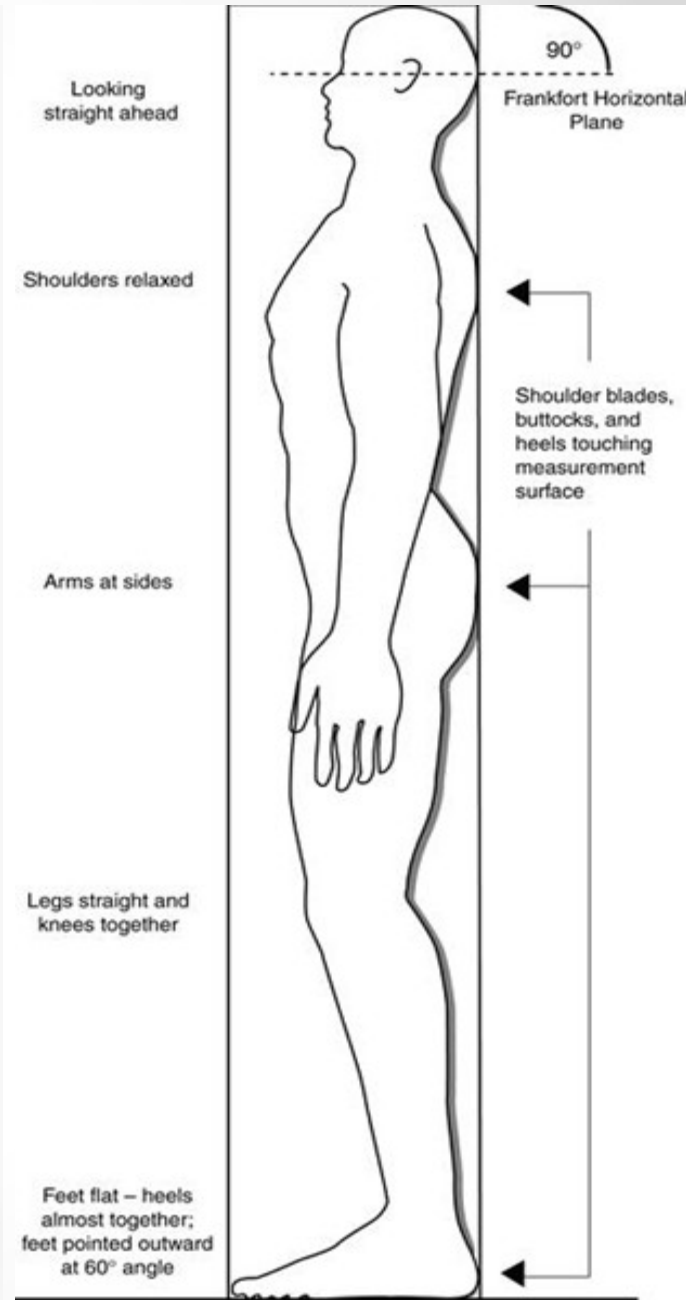
- Anthropometric indexes:

- ⇒ BMI
- ⇒ WHR

- Body composition analysis:

- ⇒ BIA
- ⇒ Hydrodensitometry (hydrostatic weighing)
- ⇒ DEXA
- ⇒ MRI
- ⇒ Plethysmography (BodPod) (whole body air displacement plethysmography)
- ⇒ 3D-scanning

Height



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) / height² (m²)

Body mass Index (BMI) =

weight (kg)
Height (m) x Height (m)

e.g.

Weight = 62kgs Height = 1.72m BMI = $62 / (1.72)^2 = 20.95\text{kgs/m}^2$

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/m ²	
	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 23.00 - 24.99
Overweight	≥25.00	≥25.00
Pre-Obese	25.00 - 29.99	25.00 - 27.49 27.50 - 29.99
Obese	≥30.00	≥30.00
Obese class I	30.00 - 34.99	30.00 - 32.49 32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49 37.50 - 39.99
Obese class III	≥40.00	≥40.0

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

Circumferences

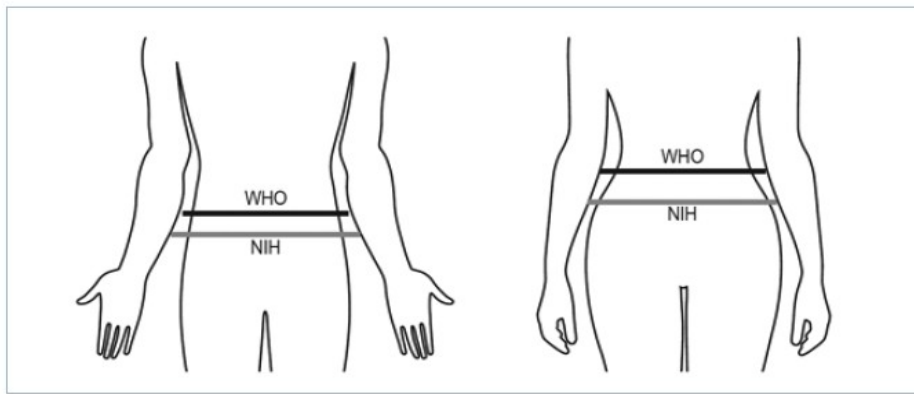
Possible circumferences in nutritional status assessment:

- Waist
- Hip
- Arm
- Calf

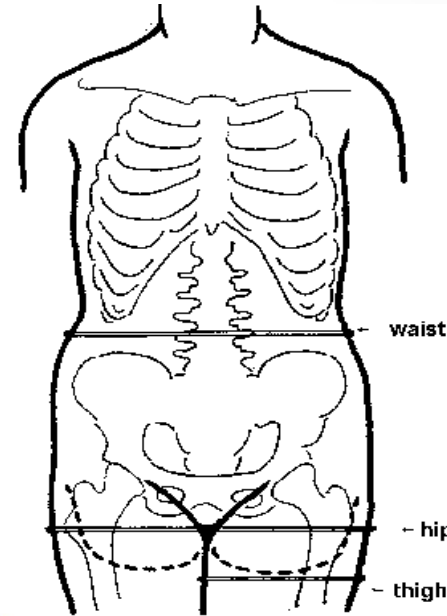


Circumferences – measuring sites:

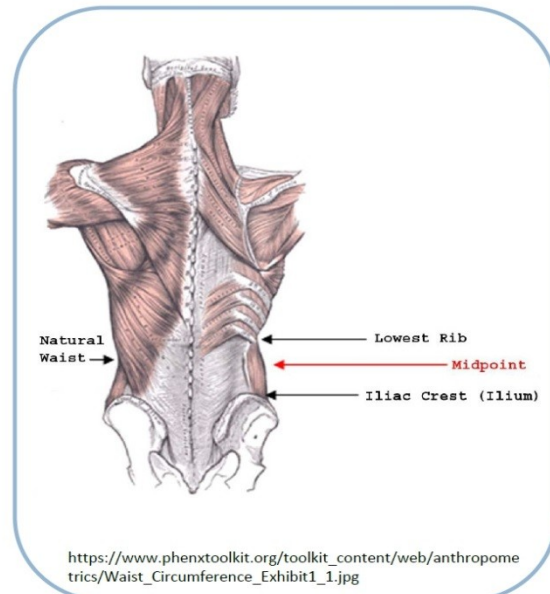
- Waist – taken in level of the umbilicus (navel)
- Hip - measurement is taken at the widest lateral extension of the hips
- Arm – mid upper arm, relaxed



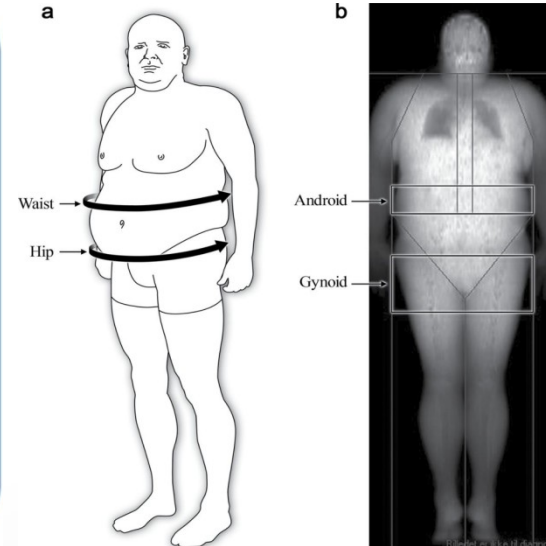
<http://www.statcan.gc.ca/pub/82-003-x/2012003/article/11707/c-g/fig1-eng.gif>



- 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
	Female	≥ 80 cm
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

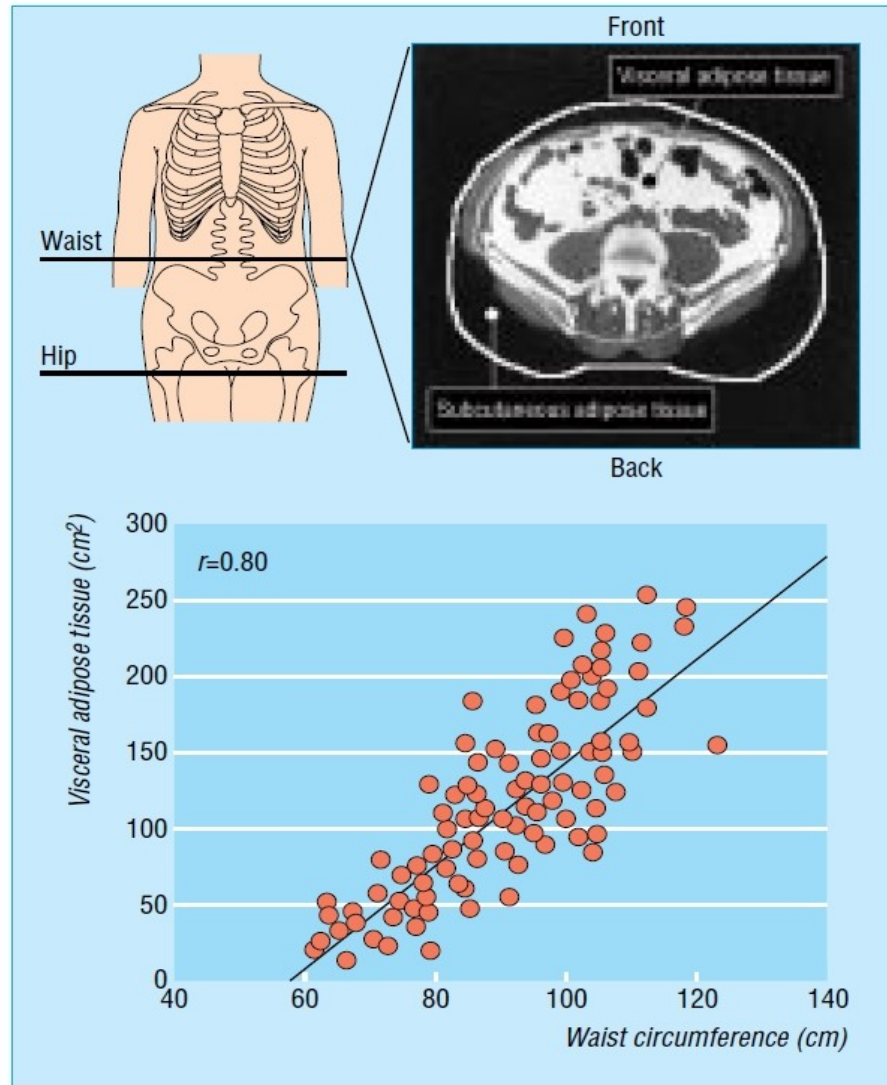


Fig 1 Assessment of accumulation of abdominal fat by measurement of waist at mid-distance between bottom of rib cage and iliac crest. Amount of visceral adipose tissue that can be assessed by computed tomography can be estimated by waist measurement (adapted from Pouliot et al⁹)

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.

Metabolic syndrome

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) or specific treatment for this lipid abnormality
Reduced HDL cholesterol	< 40 mg/dL (1.03 mmol/L) in males < 50 mg/dL (1.29 mmol/L) in females or specific treatment for this lipid abnormality
Raised blood pressure	systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg or treatment of previously diagnosed hypertension
Raised fasting plasma glucose	(FPG) ≥ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes 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 $>30\text{kg/m}^2$, central obesity can be assumed and waist circumference does not need to be measured.

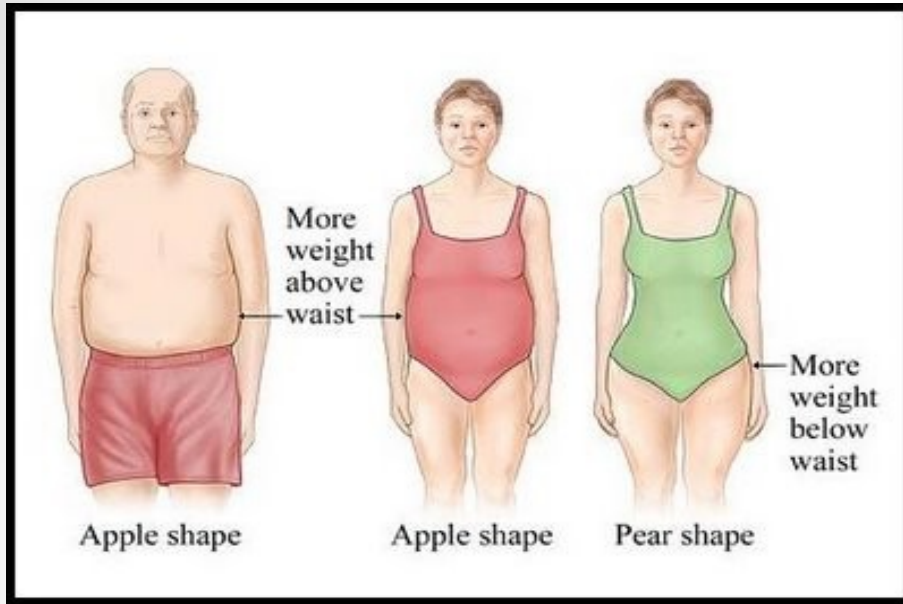
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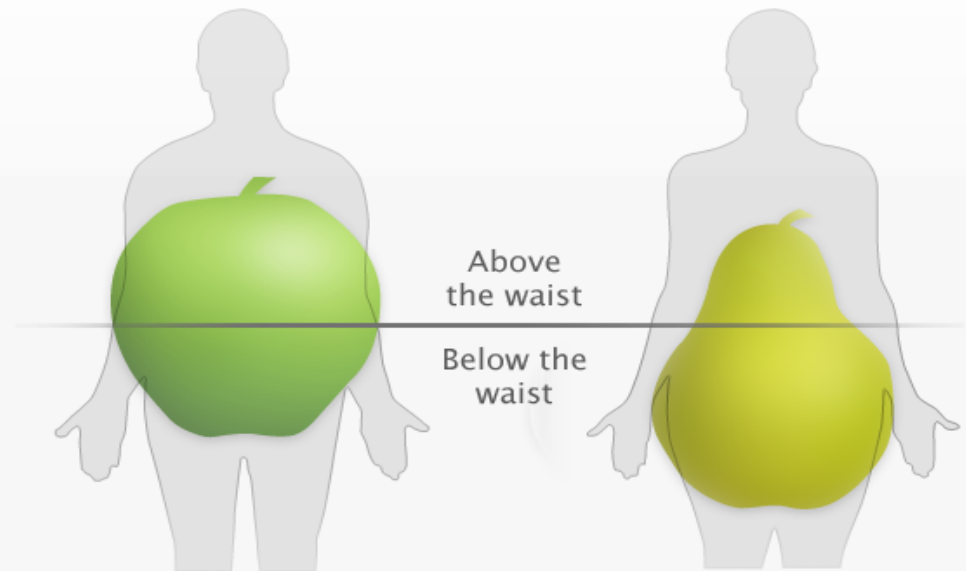
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WHR – Waist to Hip Ratio



Apple shape vs pear shape

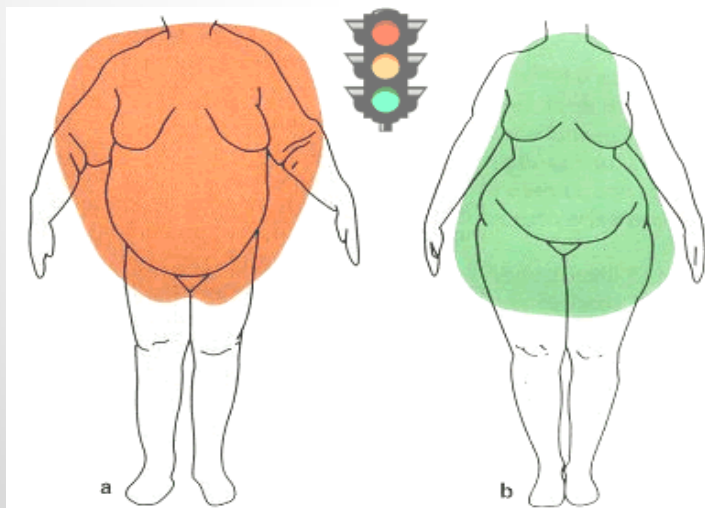


Apple shape

- More visceral fat
- Higher risk of weight-related health problems

Pear shape

- Less visceral fat
- Lower risk of weight-related health problems



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

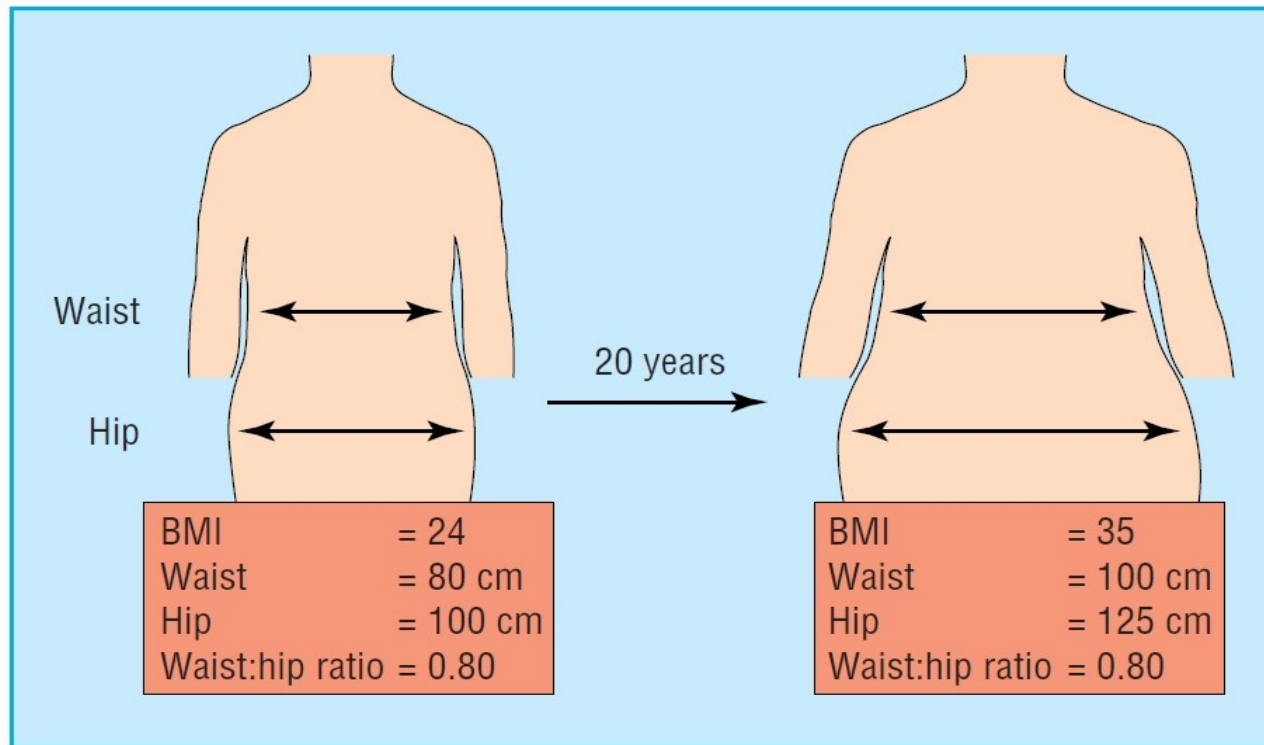
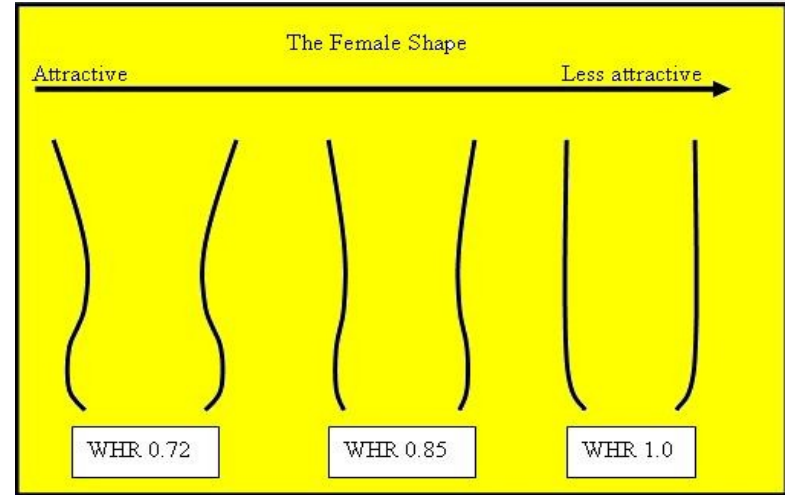
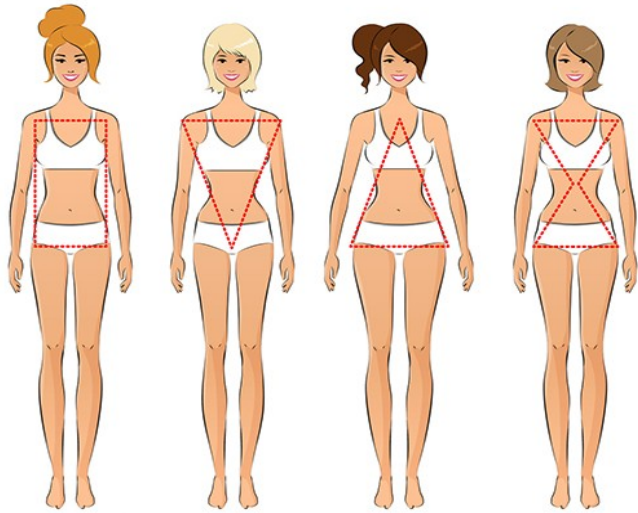
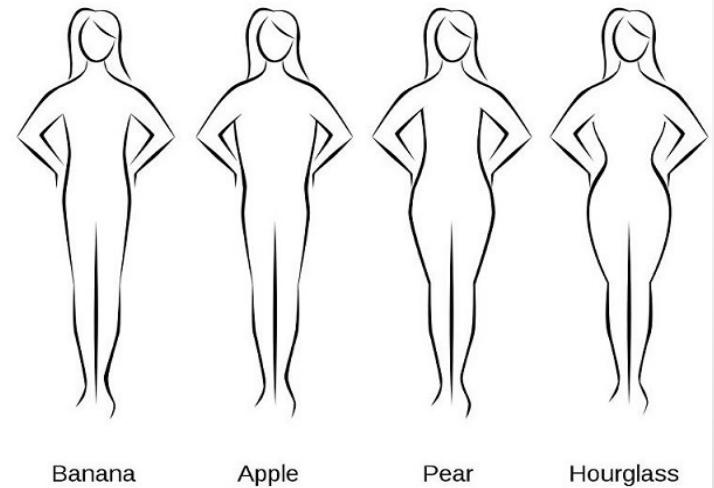
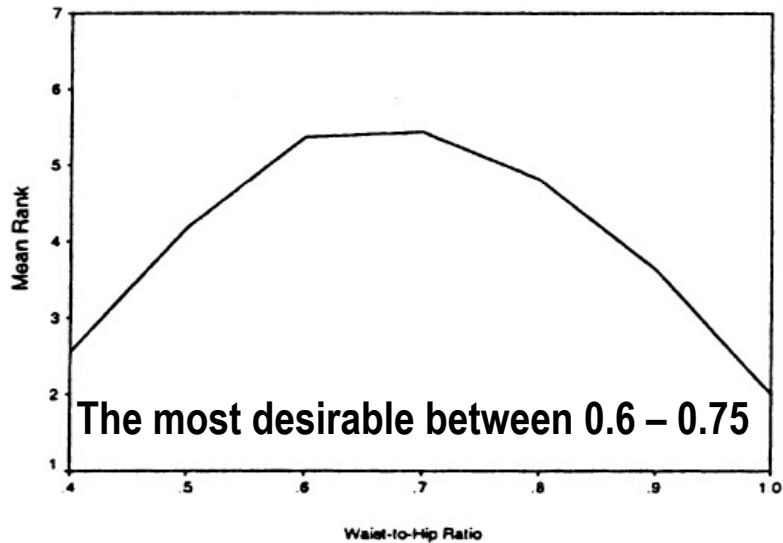


Fig 2 Misleading information provided by follow up of changes in waist:hip ratio in woman followed over 20 years. Simultaneous increase in waist and hip measurements means ratio is stable over time despite considerable accumulation of visceral adipose tissue, which would have been predicted from 20 cm 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



c. desirability as a wife



Sex identification via waist-to-hip ratio

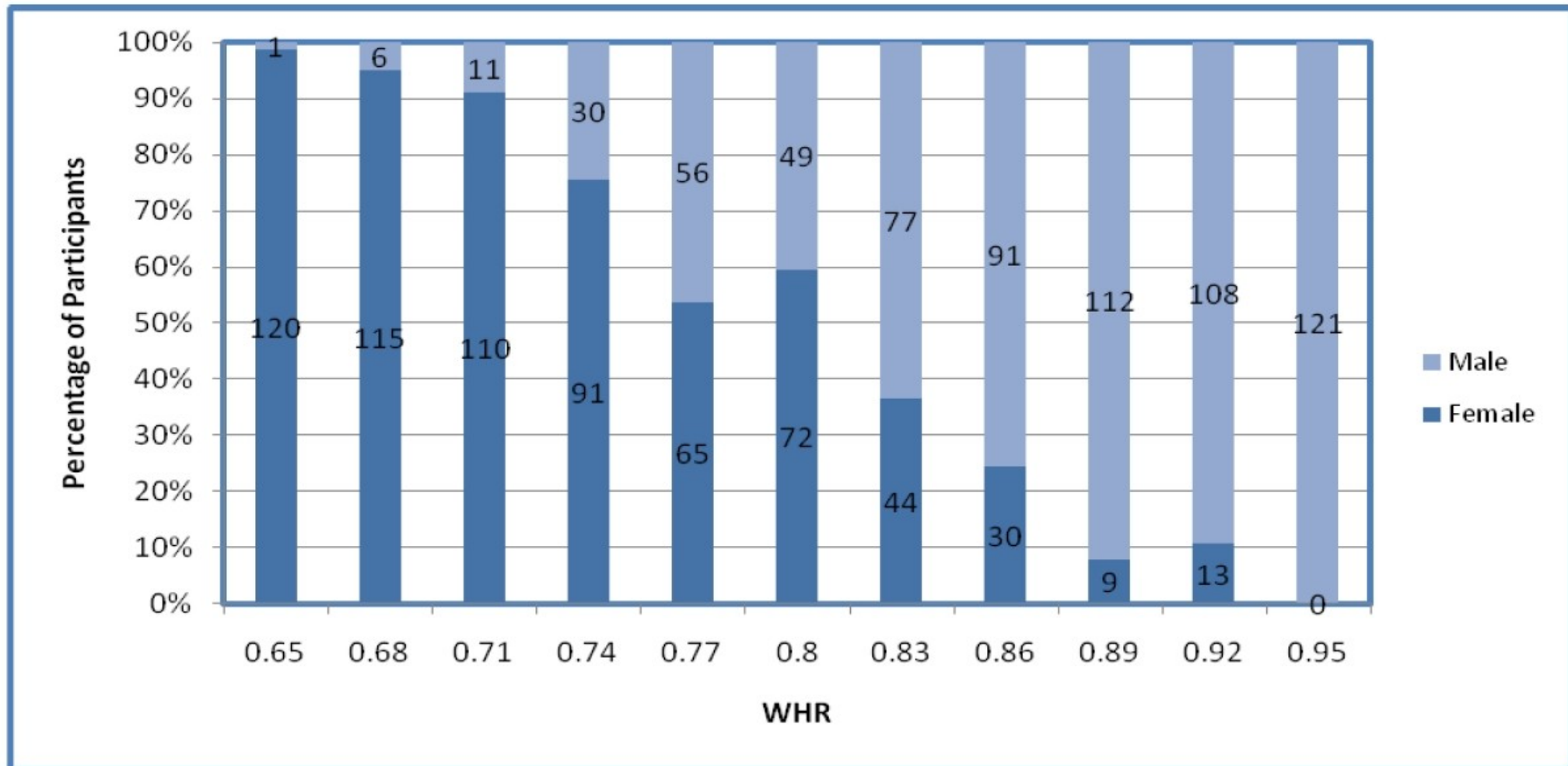


Figure 2. The number and percentage of participants ($N = 121$) who identified each WHR as indicating a male or female.

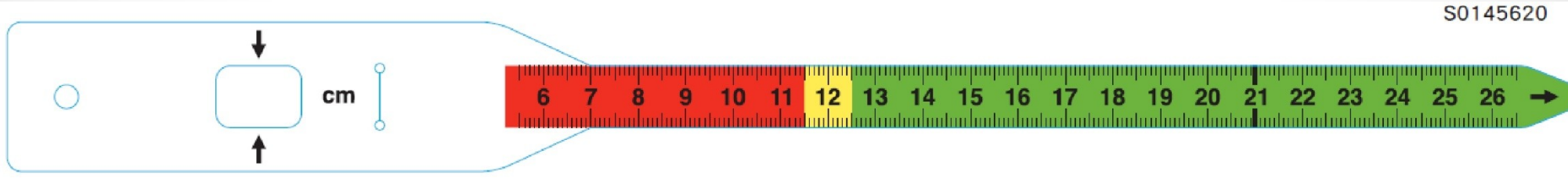
MUAC (Mid Upper Arm Circumference), MAC, AC

Adults: ■ ♂ >26 cm ■ ♀ >25 cm

UNICEF – Adults:

- Low MAC adult =< 24
- 21 – 23 = yellow zone
- < 21 cm – red

Children tape:



Calf (CC):

- < 31 cm – malnutrition
- > 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 disease. Int J Chron Obstruct Pulmon Dis. 2016; 11: 2075–2080.

BODY FAT AND BODY COMPOSITION MEASUREMENT

Skinfolds measurement

- Several types of calipers



Plastic calipers. Courtesy of Wikipedia.

Best:



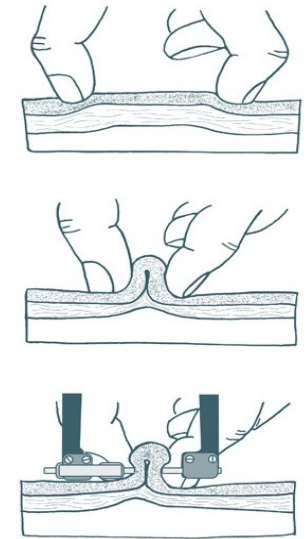
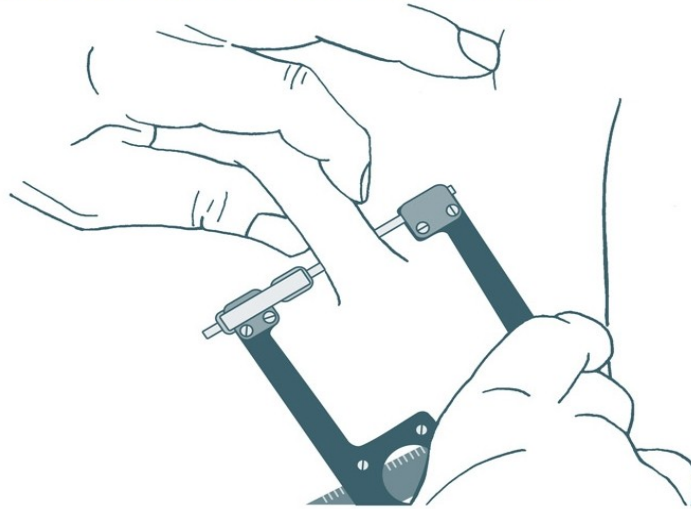
Harpenden:

Metal Harpenden calipers. Courtesy of Baty International Ltd.

Skinfolds measurement

- Measuring with Best caliper:

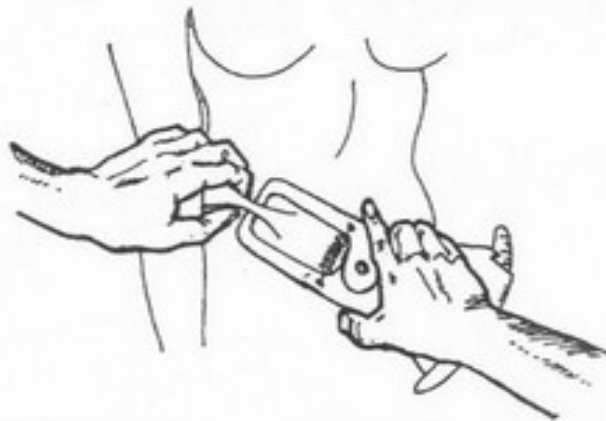
METODIKA MĚŘENÍ KOŽNÍCH ŘAS
SKINFOLD MEASUREMENT METHOD



- Triceps



- Supraspinal

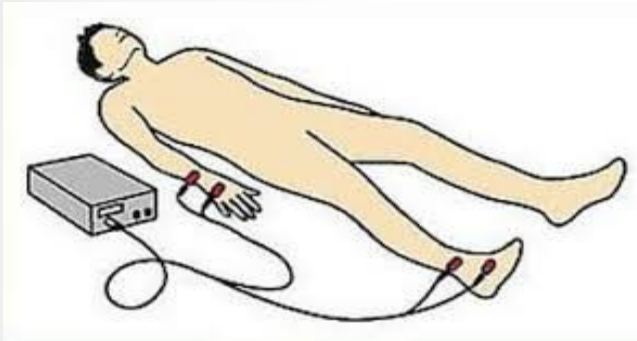


- Subscapular



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



※ Mineral Mass is estimated.

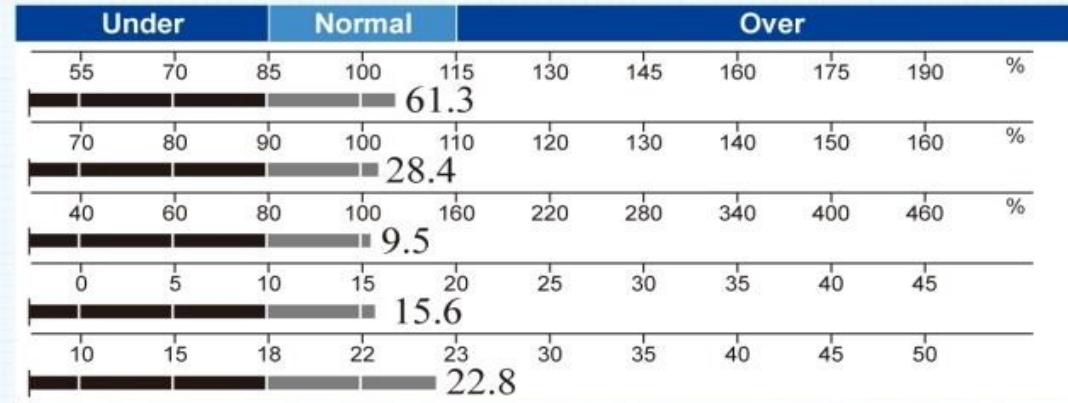
Body Composition Analysis

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

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

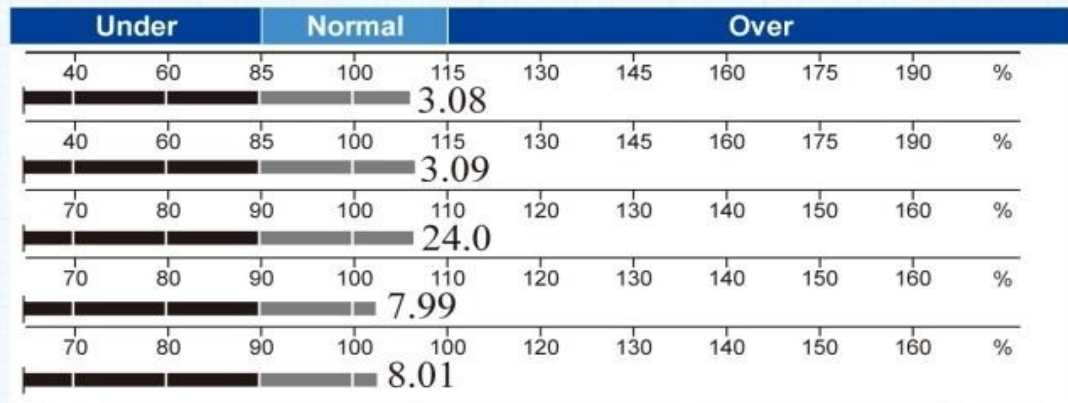
Index	Unit	Measured	Normal Range
Weight	kg	61.3	50.3 ~ 68.1
Skeletal Muscle Mass	kg	28.4	25.1 ~ 30.7
Body Fat Mass	kg	9.5	7.1 ~ 14.2
Percent Body Fat	%	15.6	10.0 ~ 20.0
BMI	kg/m ²	22.8	18.5 ~ 23.0



Segmental Lean Analysis

* : 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



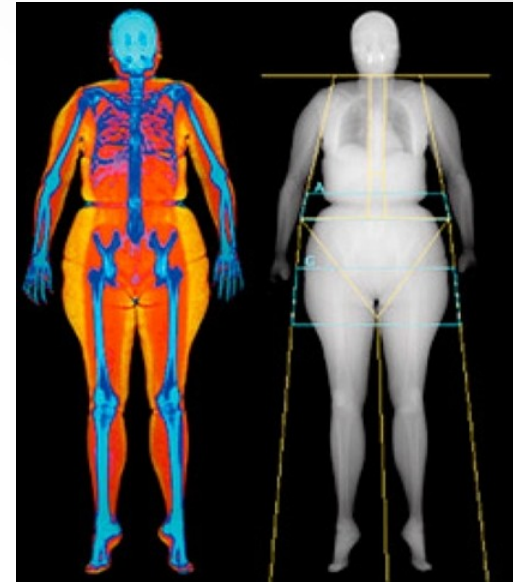
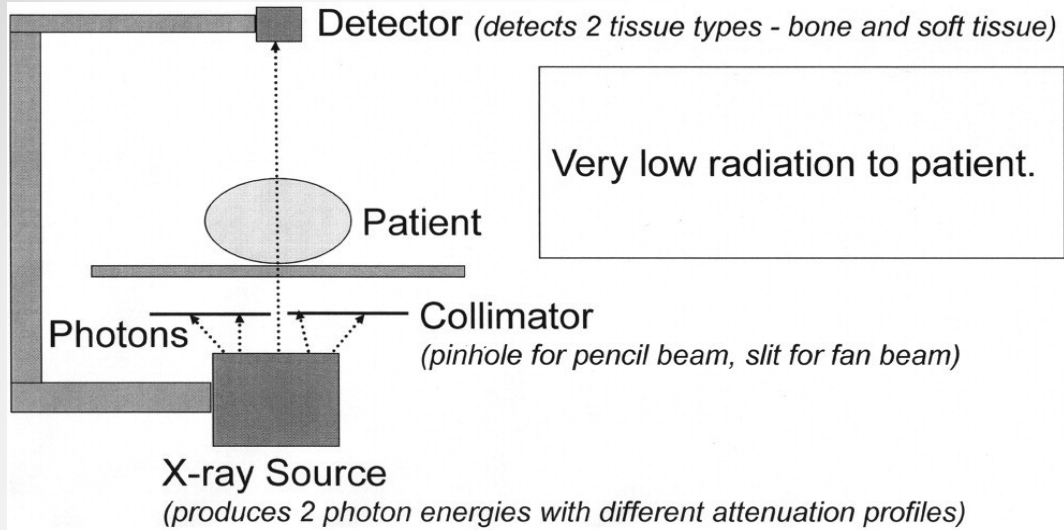
OTHER TECHNIQUES

Underwater weighing - hydrodensitometry



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

DEXA – Dual Energy X-ray Absorptiometry



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

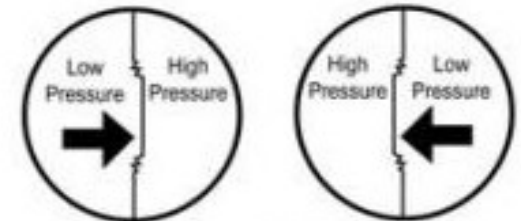
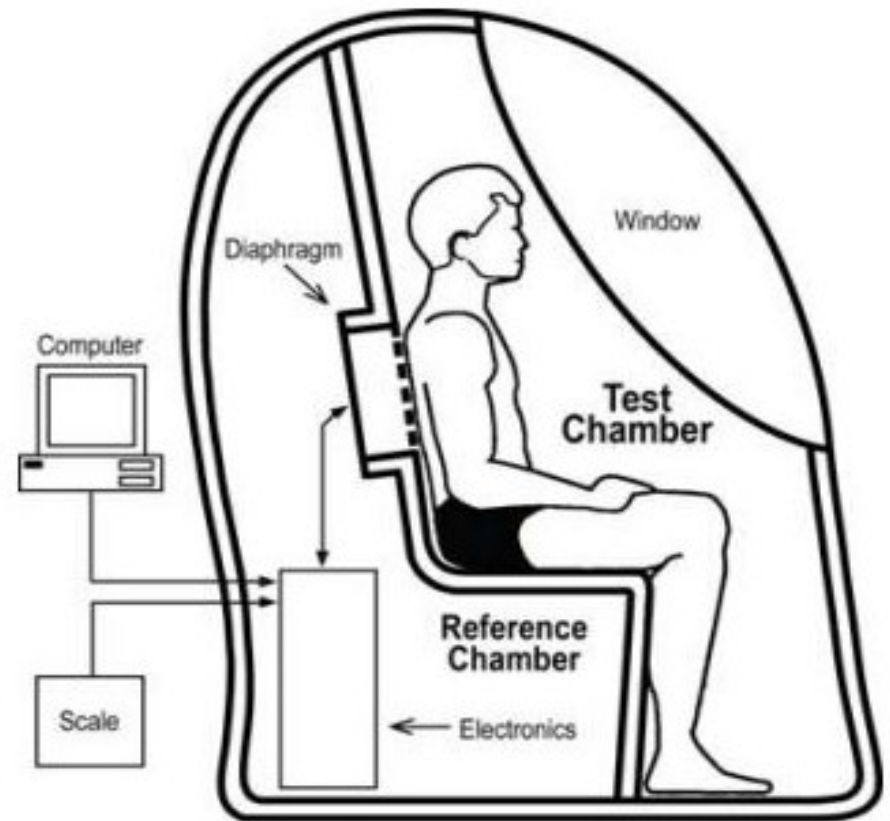
Delphi A

SN: 45775

Version 11.2 :3

01/29/2003 09:33

BodPod –Air displacement plethysmography



Moving diaphragm produces complementary pressure changes in the chambers.

Air displacement plethysmograph. Courtesy of Wikipedia.

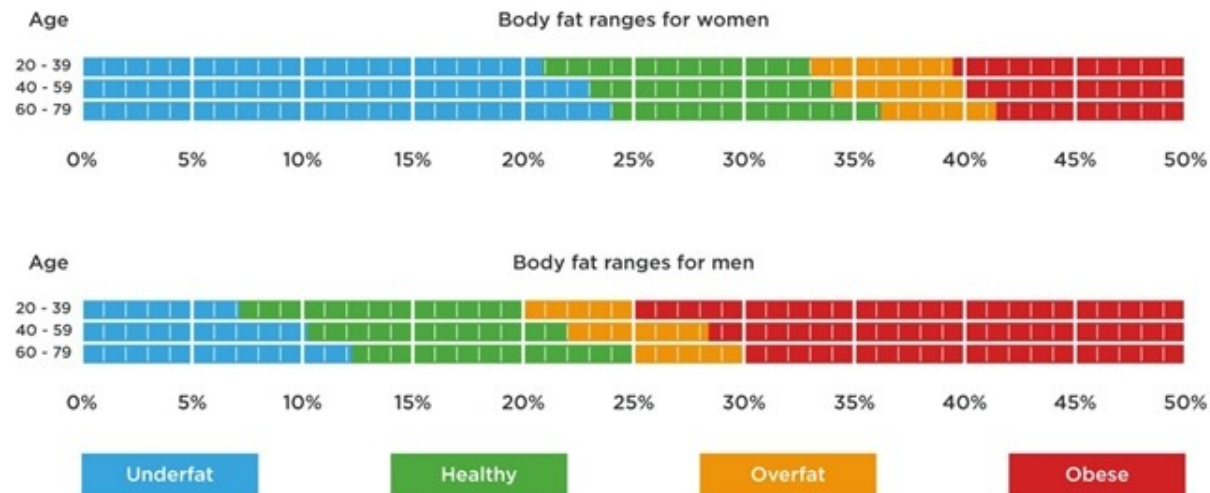
Body fat - diagnostic criteria

Cut-offs for „too high BFP“ according to different sources:

	Men	Women
PBF Corresponding to BMI	< 20	< 32
Oliveros	< 20	< 30
Tanita	< 20–25	< 33–36
Biospace	< 20	< 28
Bodystat	< 18	< 26

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 %



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

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%+

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%


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

Biochemical parameters in nutritional status

- 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.

	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
Vitamin A	Nitrogen balance	Good	Research tool	
	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 DiOH 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.

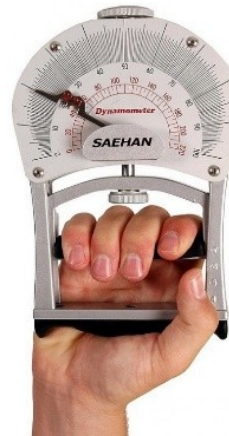
*Most of these tests are not available in primary care situations and will generally be available in regional hospitals. However, in many developing countries they may only be available in specialist centres.

Dynamometry - hand grip (muscle strength)

■ ♂ >30 kp

■ ♀ >20 kp

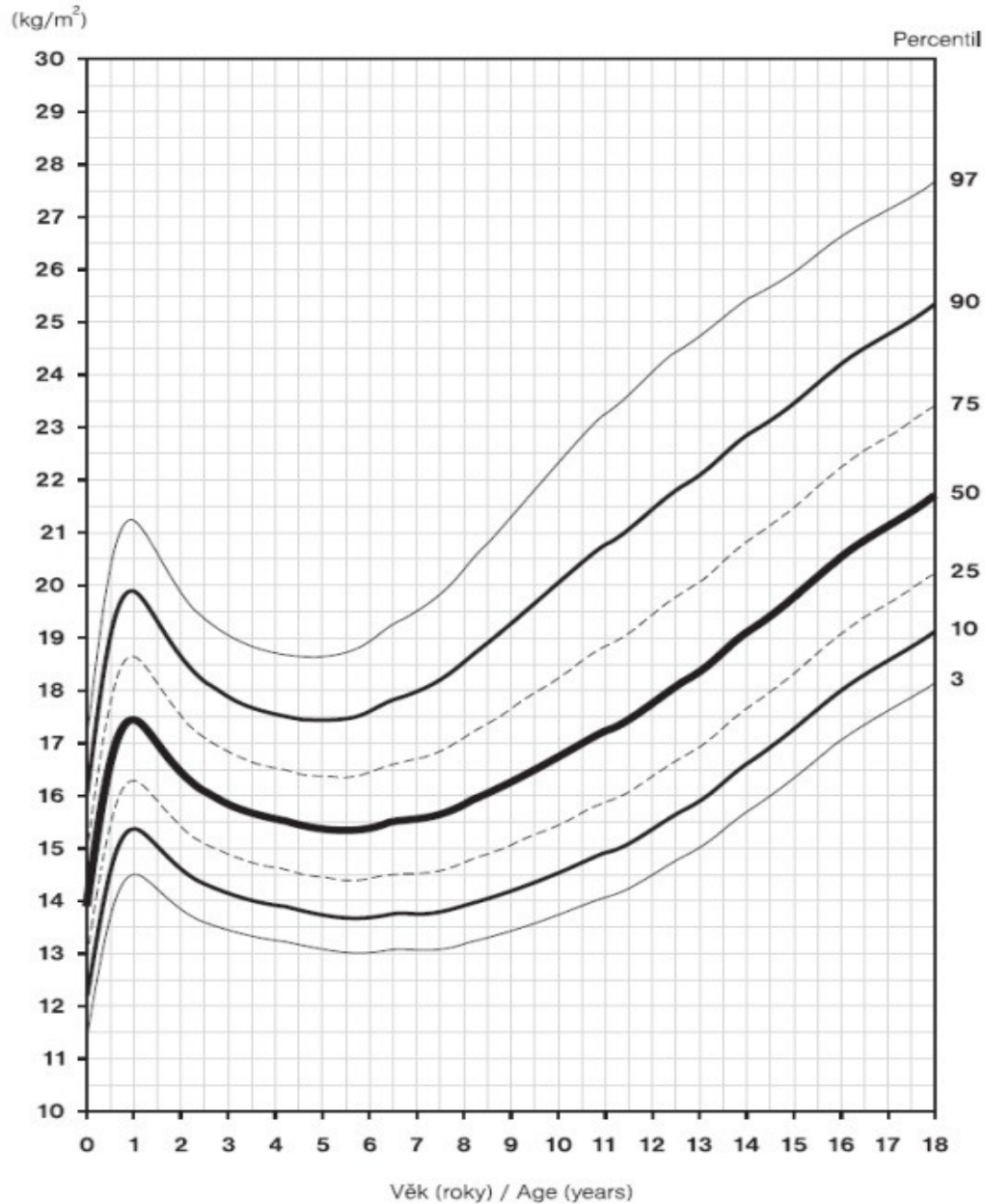
The values above refers to age category 65-70, where they correspond to 85% of the table norm according to age.



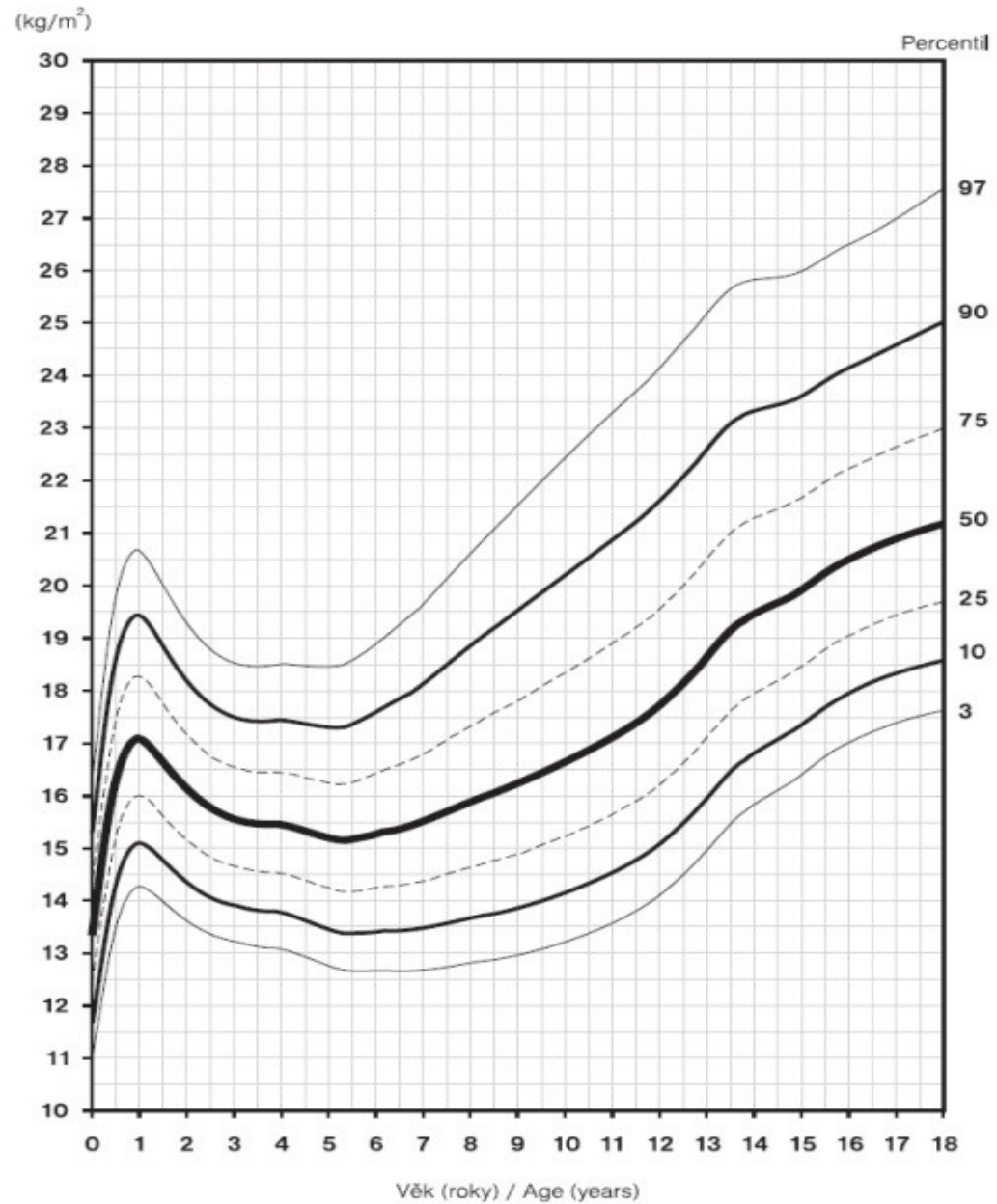
CHILDREN

Nutritional status assessment in children – BMI percentiles

Body Mass Index (BMI) (0 - 18 roků)
Body Mass Index (BMI) (0 -18 years)
Chlapci / Boys



Body Mass Index (BMI) (0 - 18 roků)
Body Mass Index (BMI) (0 - 18 years)
Dívky / Girls



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 Centile channel	Hodnocení 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.

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.

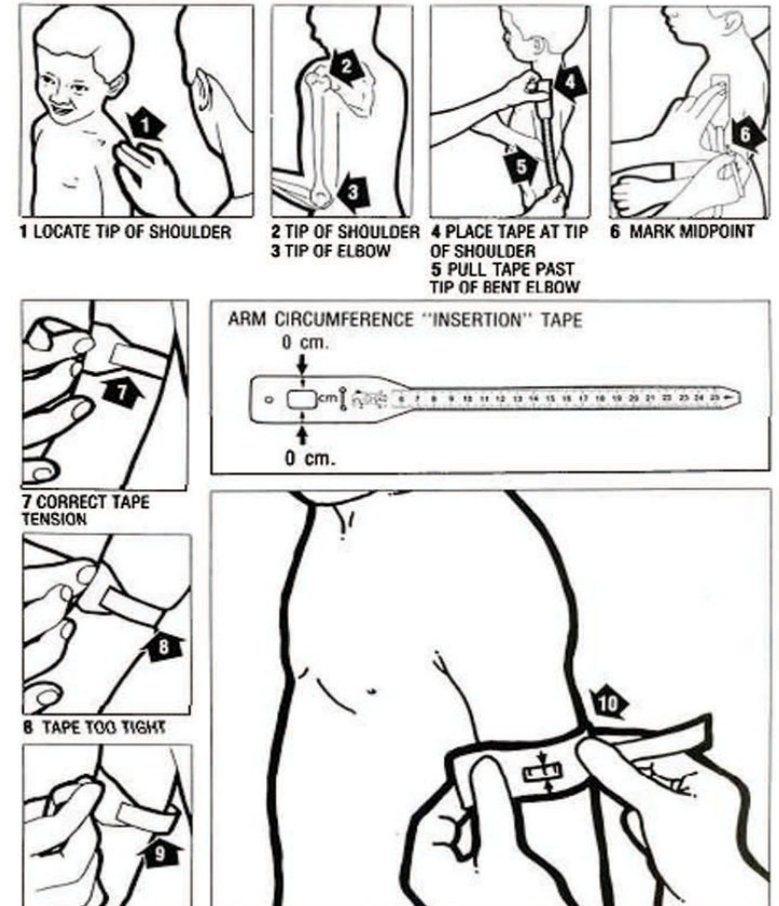
Wasting - Moderate and severe - below minus two standard deviations from median weight for height of reference population.

Stunting - Moderate and severe - below minus two standard deviations from median height for age of reference population.

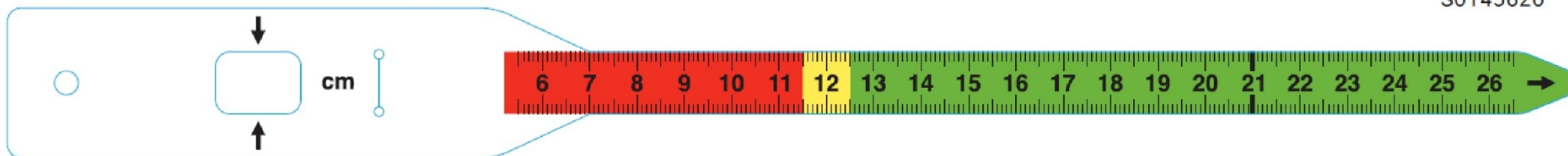
Z - score

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

MUAC (Mid Upper Arm Circumference), MAC, AC



Children tape:



Screening tests

Validated screening test

- MNA – Mini Nutritional Assessment (+ MNA-SF – short form)
- SGA – Subjective Global Assessment
- NRS (or NRS 2002) – Nutritional Risk Screening
- MUST – Malnutrition Universal Screening Tool

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 (SF)

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

MNA - continuing

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 does 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) .

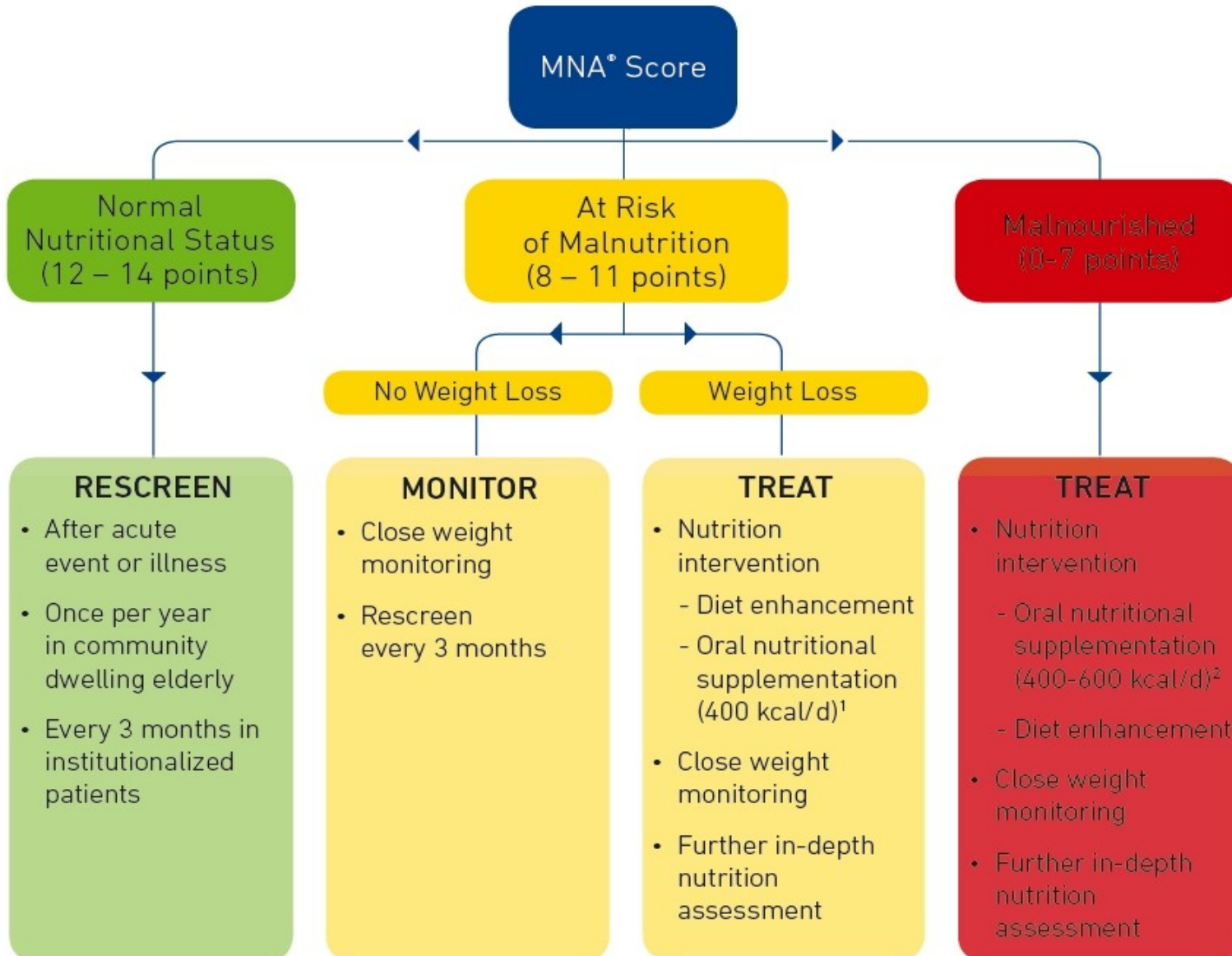
Screening score .

Total Assessment (max. 30 points) .

Malnutrition Indicator Score

24 to 30 points	<input type="checkbox"/>	Normal nutritional status
17 to 23.5 points	<input type="checkbox"/>	At risk of malnutrition
Less than 17 points	<input type="checkbox"/>	Malnourished

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

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

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

WEIGHT

Usual weight _____ Current weight _____

- Non fluid weight change past 6 months**
 <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
- Weight change past 2 weeks*** Amount (if known) _____
 Increased No change Decreased

SYMPTOMS (Experiencing symptoms affecting oral intake)

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

FUNCTIONAL CAPACITY (Fatigue and progressive loss of function)

- No dysfunction
- Reduced capacity; duration of change _____
 Difficulty with ambulation/normal activities Bed/chair-ridden
- 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

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
<ul style="list-style-type: none"> ■ No decrease in food/nutrient intake; ■ < 5% weight loss; ■ No/minimal symptoms affecting food intake; ■ No deficit in function; ■ No deficit in fat or muscle mass 	<ul style="list-style-type: none"> ■ Definite decrease in food/nutrient intake; ■ 5% - 10% weight loss without stabilization or gain; ■ Mild/some symptoms affecting food intake; ■ Moderate functional deficit or recent deterioration; ■ Mild/moderate loss of fat and/or muscle mass 	<ul style="list-style-type: none"> ■ Severe deficit in food/nutrient intake; ■ > 10% weight loss which is ongoing; ■ Significant symptoms affecting food/ nutrient intake; ■ Severe functional deficit ■ OR *recent significant deterioration obvious signs of fat and/or muscle loss

		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)		
<p>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.</p>			

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	
<p>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.</p>			

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

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

**Score 0
Low Risk**

Routine clinical care

**Score 1
Medium Risk**

Observe

**Score 2 or more
High Risk**

Develop treatment pathway