10.3 Methods of assessment of nutrition status

Methods: anthropometrics, bioelectrical impedance analysis (BIA) and the creatinine-height index. The creatinine-height index is not a very useful measure and is not often used in clinical practice.

10.3.1 Anthropometrics

Measurement of height, weight, circumference, and lengths of various body regions as well as the skinfold thickness.

Body weight

Measure only in a standardised situation (patients dressed in underclothes, barefoot, and with an empty bladder)

Body height

With the patient standing up, using a standardised measuring stick.
The height of older patients who cannot stand up is estimated on the basis of the heel- knee height.

Body Mass Index (BMI, weight kg / height^2)

The most frequently used index for the description of nutritional status.
However, women and older persons have a higher percentage of body fat than others with the same BMI. In a muscular subject, the percentage of body fat is lower than that indicated by the BMI.

Measurement of skinfolds

The amount of body fat and skeletal muscle can be assessed using a combination of measurements of the thickness of cutaneous folds and body circumference.

Assumption: there is a relationship between subcutaneous fat and total body fat. Inter-individual variation: age, sex, and genetic factors.
The measurement is less exact in extremely adipose and extremely muscular subjects.
Validity is influenced by: the instrument used for measurement / caliper, the individual fat distribution, the experience of the examiner, and the formula used to calculate the body fat mass. Errors of measurement can be minimised when the measurement procedure is standardised (see method described below) and always carried out on the same side of the body.

Formula for the prediction of body fat mass

the sum of the thickness of four skinfolds (triceps + biceps + subscapular + suprailliac) ≤ 15 mm = lower limit, corresponding to 10.5% of fat in women and 4.8% of fat in men.

The measurement of the triceps skinfold (TSF) and of the upper arm circumference (UAC) also allows an estimation of the amount of arm muscle. Arm muscle area can be used as a marker of the amount of somatic/visceral protein.

The German Society for Nutrition Medicine defines the risk of protein deficiency at values below the 10th percentile of the age –specific norms as set by NHANES I. (data collection 1971-4)

Skinfold measurement – methods

Skinfolds	Orientation points	Method
Triceps	Middle of the upper arm between the acromion and the olecranon processes	The elbow is placed at a right angle; the middle of the upper arm is marked. The skinfold is grasped vertically and lifted off the muscle fascia 1 cm above the marked line
Biceps	At the height of the mark for the triceps	The skinfold is grasped vertically 1 cm above the marked line.
Subscapular	Line along the scapula in front of the inferior angle of the scapula	Fold along the scapula, diagonally, 1 cm below the inferior angle of the scapula
Suprailiacal	Illiac crest	Fold in the mid-axillary line, slanting, directly on top of the iliac crest

Instrument: caliper, pressure 10 g/mm^2, contact surface 20 – 40 mm^2
Method: Reading of the thickness follows about 5 seconds after closure of the forceps. The skinfold is grasped tightly during measurement. The end result is the average of three measurements.
Accuracy (3): ≤ 3.5% of total body fat
Precision (variation coefficient VC) (4): 5 – 10%

Triceps skinfold (TSF)
Limits (mm) for adults: 5th and 10th percentile—sex and age specific

Age group Years	Men 5th percentile	10th percentile	Women 5th percentile	10th percentile
18-18,9	4	5	10	12
19-24,9	4	5	10	11
25-34,9	5	6	10	12
35-44,9	5	6	12	14
45-54,9	6	6	12	16
55-64,9	5	6	12	16
65-74,9	4	6	12	14

Circumference Method

Circumference	Orientation point	Method
Upper arm circumference	Middle of the upper arm, between the acromion and olecranon processes	Mark middle of the upper arm. Place the tape horizontally around the hanging arm.

Measuring instrument: Non-elastic measuring band
Method: The tape is placed loosely. The tape is read with 1 mm accuracy.
Precision: (variation coefficient, VC): 5 – 10%

Upper arm circumference (UAC)
Limits (mm) for adults: 5th and 10th percentile – sex and age specific

Age group Years	Men 5th percentile	10th percentile	Women 5th percentile	10th percentile
18-18,9	24,5	26,0	22,2	22,7
19-24,9	26,2	27,2	22,1	23,0
25-34,9	27,1	28,2	23,3	24,0
35-44,9	27,8	28,7	24,1	25,1
45-54,9	26,7	28,1	24,2	25,6
55-64,9	25,8	27,3	24,3	25,7
65-74,9	24,8	26,3	24,0	25,2

Arm muscle circumference (AMC)
AMC (mm) = UAC (mm) – π x TSF (mm)
Limits AMC (mm) for adults: 5th and 10th percentile – sex and age specific.

Age group Years	Men 5th percentile	10th percentile	Women 5th percentile	10th percentile
18-18,9	22,6	23,7	17,4	17,9
19-24,9	23,8	24,5	17,9	18,5
25-34,9	24,3	25,0	18,3	18,8
35-44,9	24,7	25,5	18,6	19,2
45-54,9	23,9	24,9	18,7	19,3
55-64,9	23,6	24,5	18,7	19,6
65-74,9	22,3	23,5	18,5	19,5

Arm muscle area
AMA (mm^2) = AMC / 4 π (mm)
Limits AMC (mm) for adults: 5th and 10th percentile – sex and age specific.

Age group	Men		Women	

Years	5th percentile	10th percentile	5th percentile	10th percentile
18-18,9	40,70	44,81	23,98	25,38
19-24,9	45,08	47,77	25,38	27,28
25-34,9	46,94	49,63	26,61	28,26
35-44,9	48,44	51,81	27,50	29,48
45-54,9	45,46	49,46	27,84	29,56
55-64,9	44,22	47,83	27,84	30,63
65-74,9	39,73	44,11	27,37	30,18

10.3.2 Bioelectrical impedance analysis (BIA)

The determination of the body composition (the percent and distribution of the various compartments of the body, e.g., fat mass, fat-free mass, muscle mass, body water) and its changes allow a differentiated diagnosis of malnutrition as well as the assessment of the efficacy of nutrition intervention and training programs.

A low-frequency alternating current is applied to two skin electrodes on the hands and two skin electrodes on the feet. The voltage drop in fluid-rich tissues is small, whereas the drop in fat tissues and bone is large.

There is a consistent relationship between the body height squared, resistance, and the total body water (TBW). BIA measures primarily body water; from this, the free fat mass (FFM) is determined.

Many different regression equations have been published for the calculation of the TBW. No single formula can be recommended. Percentile curves have not yet been published. The determination of TBW can be useful for the evaluation of hydration disorders.

There are many different prediction equations for the calculation of the individual parameters. Equations developed for a specific population are of only limited use when applied to other populations.

Most regression equations published were developed using healthy subjects assuming normal fluid and electrolyte balances. The use of these formulas for the determination of the body composition of patients with diseases and severe diseases with disorders of the fluid and electrolyte balances can lead to incorrect results. In practice, it is therefore necessary to know the formula used by the software in the measuring instrument in order to assess the validity of the method.

A regression equation (Genf Formula) for the calculation of the FFM was developed on the basis of the measurements of 5000 subjects (aged 15-98 years), BMI 16-47,1 kg/m^2).

Genf Formula –men and women

FFM = -4.104 + (height² / resistance x 0.518) + (weight x 0,231) + (0,130 x reactance) + 4.229 x sex [M=1, F=0]

Limits of fat-free mass (FFM) (kg) for adults. 5th and 10th percentile – sex and age specific

Age group Years	Men 5th percentile	10th percentile	Women 5th percentile	10th percentile
15-24	49,4	51,6	36,2	37,5
25-34	51,3	52,9	36,9	38,0
35-44	51,4	53,1	36,3	37,9
45-54	51,4	52,4	36,2	37,6
55-64	50,4	51,8	35,7	37,2
65-74	48,9	50,4	34,0	35,7
75-84	46,5	47,8	33,0	34,1
>85	46,4	46,9	27,7	30,2

Fat mass (FM)

The determination of fat mass is based on the difference between body weight and FFM, and is dependent upon various influencing factors such as hydration state and fat distribution. In adipose subjects, the trunk accounts for a greater proportion of body weight; the trunk, however, contributes a relatively minor amount to total body impedance, so that the fat mass is underestimated. Errors in the estimation of the free-fat mass lead to larger errors in the estimation of the FM.

Limits of fat mass in % of body weight for adults. 5^{th} and 10^{th} percentile – sex and age specific

Age group Years	Men 5^{th} percentile	10^{th} percentile	Women 5^{th} percentile	10^{th} percentile
15-24	9,3	10,7	19	20,4
25-34	11,0	12,4	17,7	19,5
35-44	11,0	13,0	17,8	19,4
45-54	11,8	14,1	18	20,8
55-64	12,0	13,8	21,4	24,4
65-74	14,6	17,2	24,4	27,3
75-84	15,5	18,0	25,9	29,1
>85	17,1	19,8	22,6	24,3

These limits are applicable only when the FFM has been calculated by the Genf Formula.
Fat mass = body weight – fat-free mass

The exact measurement of height (within 0.5 cm) and weight (within 0.1 kg) is important. A difference of 2.5 cm in the height results in an error in the TBW of 1 l. When the measurements are carried out under the above conditions, the variation coefficient is under 5%.