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Anthropometric Techniques

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Abstract - This tutorial of Anthropometry is designed to give an overview of various anthropometric traits and indices providing indication of the general health and nutritional status of a person or a population. The main anthropometric procedures are briefly presented along with explanatory figures and tables, when necessary.

Abstract - Questa guida di Antropometria è progettata per fornire una panoramica dei diversi caratteri antropometrici e indici che possono fornire indicazioni utili sullo stato di salute generale e nutrizionale di una persona o di una popolazione. Le principali procedure antropometriche sono brevemente presentate, impiegando, quando necessario, figure e tabelle esplicative.

1. Introduction

Measuring the human body is one method of assessing the general health and nutrition status of an individual or a population. The study and technique of measuring human body is called *Anthropometry*. The procedure requires adherence to specific international rules, starting from the International Congress held in Geneva in 1912 (Fig.1) when the International Convention for the unification of anthropometric measurements in living was signed. Measurements are taken at particular anatomical sites (anthropometric landmarks) by an anthropometric equipment.

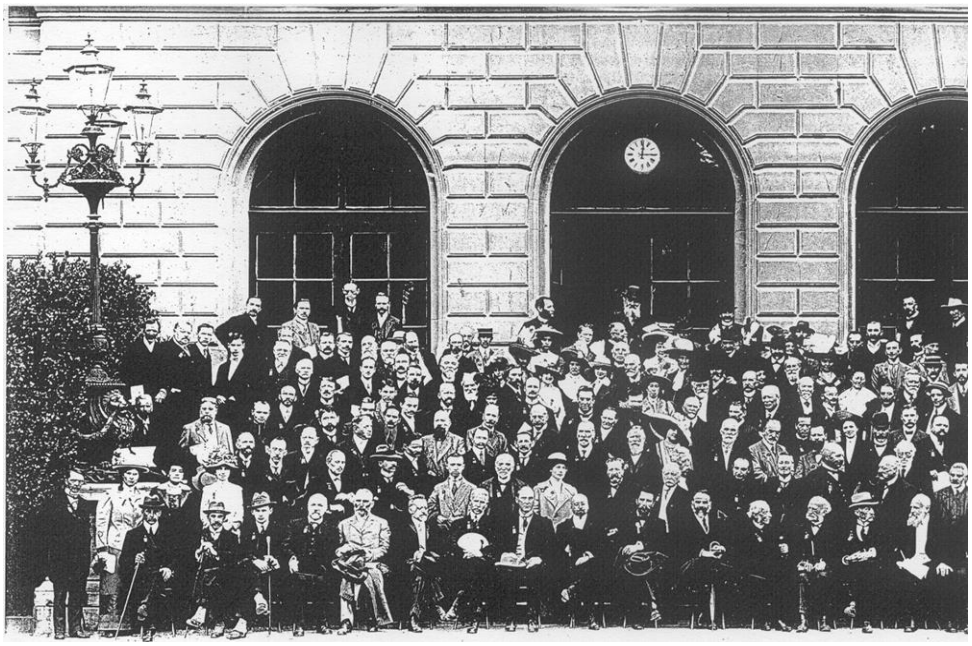

Figure 1- The International Congress of Geneva (1912) (from the archive of the former Institute of Anthropology, University of Bologna, Italy).

2. Techniques for main body measurements

- **STATURE**

Instrument: Stadiometer (anthropometer or altimeter)

Description: This height is the distance (measured in cm) between the highest point of the subject's head (*vertex*) and the sole of the feet (*planta*). It's one of the anthropometric measurements utilized for the calculus of Body Mass Index (BMI).

Procedure:

1. Ask the subject to remove his/her shoes and anything that would interfere with the stature measurement (i.e. glasses).
2. Ask the subject to place his/her feet flat and together in the center of the base of the board
3. Subject's legs have to be straight with heels and calves against the board.

4. Arrange the subject's head in the Frankfort horizontal plane (Fig. 2) -it passes through the upper margin of the auditory canal and the lower margin of the orbit-. This plane has to be parallel to the floor.
5. Make sure that the subject's shoulders are level, the hands are at his/her side and that the head, shoulders blades and buttocks are against the measuring device. The subject has to maintain a fully erect position (upright straightened).
6. Push gently down the movable block until it touches the mid-sagittal plane of the subject's head, compressing the hair.
7. Read the measurement to the nearest 0.1 cm.

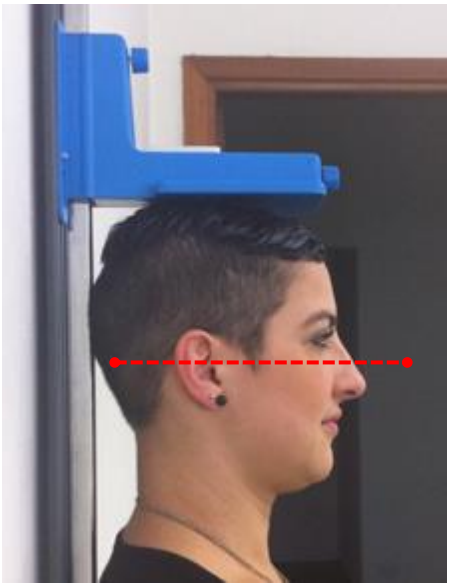

Figure 2 – Correct position on subject's head. The red line states the Frankfort orientation plane.

- **WEIGHT**

Instrument: Weighting scale.

Description: The weight is considered one of fundamental anthropometric traits, together with stature. It's one of the anthropometric measurements utilized for the calculus of Body Mass Index (BMI).

Procedure:

1. Ask the subject to remove his/her shoes and anything that would interfere with the weight measurement (i.e. wallet, keys etc.).
2. He/she has to wear light clothes.
3. Make sure that the subject is standing still over the center of the platform with the body weight equally distributed between both feet.
4. Read the measurement to the nearest 0.1 kg (Fig. 3).

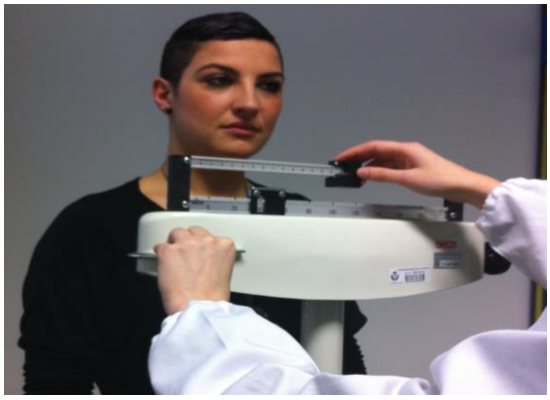

Figure 3 – Measurement of the weight with a platform-beam weighting scale.

- **WAIST GIRTH**

Instrument: Non-stretchable tape

Description: It measures the narrowest part of the torso. It's one of the anthropometric measurements necessary for the calculus of Waist To Hip Ratio (WHR). It is useful to assess health risk (table 1).

Procedure:

1. Ask the subject to stand erect with the abdomen relaxed, the arms at the side of the body and the feet together.
2. He/she has to wear light clothes.

3. Stand in front of the subject and put the tape around him/her in the narrowest part of the torso if determinable (otherwise halfway between the lower costal border and the iliac crest), without compressing the skin with the tape (Fig. 4).
4. Make sure that the plane of the tape is horizontal.

Figure 4 – Waist girth.

5. Make sure that the subject is breathing normally. In case you can ask the subject to count.
6. Read the measurement to the nearest 0.1 cm.

Table 1 - World Health Organisation waist girth sex-specific cut-off points.

Waist girth (cm)		**Risk of metabolic complications**
Men	**Women**	
≥ 94	≥ 80	Increased
≥ 102	≥ 88	Substantially increased

Source: WHO (2000)

- **HIP (GLUTEAL) GIRTH**

Instrument: Non-stretchable tape

Description: It measures the maximum protuberance of the buttocks. It's one of the anthropometric measurements necessary for the calculus of Waist To Hip Ratio (WHR).

Procedure:

1. Subjects have to wear light clothes. Ask him/her to remove anything that would interfere with the measurement (i.e. cell-phone or wallet in the pockets).
2. Ask the subject to stand erect with the abdomen relaxed, the arms at the side of the body and the feet together.

3. Stand at the side of the subject so you can see the maximum posterior extension of the buttocks.

Figure 5 – Hip (gluteal) girth.

4. Put the tape at the maximum extension of the buttocks (Fig. 5).
5. Make sure that the plane of the tape is horizontal and that you are not compressing the skin with the tape.
6. Read the measurement to the nearest 0.1 cm.

- **MID-UPPER ARM GIRTH (relaxed)**

Instrument: Non-stretchable tape

Description: It is the girth of the upper arm (hanging in a relaxed position) taken in the midpoint between the acromion process of the scapula and the olecranon process of the ulna.

Procedure:

1. In order to calculate the midpoint of the subject's left arm ask him/her to bend the elbow to make a right angle.
2. The measurement have to be taken on the left arm.

3. Touch with your fingertips the acromion process of the scapula (the body protrusion on the posterior of the upper shoulder) and the olecranon process of the of the ulna (the tip of the elbow).
4. Using a non-stretchable tape measure the distance between the two landmarks (the acromion and the olecranon). Read the number at the tip of the elbow to the nearest centimeter and divide this number by two to estimate the midpoint. If you want you can mark the midpoint with an indelible ink.
5. Ask the subject to relax his/her arm.
6. Put the tape around the subject's arm at the midpoint (Fig. 6).
7. Make sure that the tape is not too tight or too loose and that its plane is perpendicular to the line of the arm.
8. Read the measurement to the nearest 0.1 cm.

Figure 6 – Mid-upper arm girth (relaxed).

- **TRICEPS SKINFOLD THICKNESS**

Instrument: Skinfold thickness caliper

Description: It is a rapid and simple method used to estimate the percentage of body fat. It is the amount of skin and subcutaneous adipose tissue, opportunely separated from the muscle, measured in the midpoint between the acromion process of the scapula and the olecranon process of the ulna.

Procedure:

1. In order to calculate the midpoint of the subject's left arm ask him/her to bend the elbow to make a right angle.
2. The measurement have to be taken on the left arm.
3. Touch with your fingertips the acromion process of the scapula (the body protrusion on the posterior of the upper shoulder) and the olecranon process of the of the ulna (the tip of the elbow).

4. Using a non-stretchable tape measure the distance between the two landmarks (the acromion and the olecranon). Read the number at the tip of the elbow to the nearest centimeter and divide this number by two to estimate the midpoint. You may mark the midpoint with an indelible ink.
5. After that, have the subject's left arm relaxed and hanged at the side of his/her body.
6. Palpate the subject's measuring site at the posterior surface of the arm (over the triceps muscle) and try to recognize and to separate the muscle from the adipose tissue and the skin.
7. Grasp with your left hand, between thumb and forefinger, a vertical pinch of skin and subcutaneous fat at the previous site, separating it gently from the underlying muscle.
8. Put with your right the skinfold caliper at the measuring point, not pulling away the grasp of the skinfold (Fig. 7).
9. The skinfold has to be vertical.
10. Read the measurement in the caliper after 4 seconds from the full pressure to the nearest 1 mm.

Figure 7 – Triceps skinfold thickness taken with a Lange Skinfold Caliper.

3. Anthropometric Indices

When two measurements are used together, they are called an *Index.* The anthropometric index can provide important information on health and nutritional status of a person. Indexes generally have a classification system that helps in the interpretation of data.

- **BODY MASS INDEX (BMI)**

Description: Body mass index (BMI) is calculated as body weight/height^2 (kg/m^2) and is used to assess each subject's weight status. It is also known as Quetelet's Index. To classify adults as underweight, normal weight, overweight and obese are used the World Health Organization (WHO,

2000) cut-off points (Table 2). Table 3 shows the use of waist girth associated with overweight and obesity for defining diseases risk, in particular type 2 diabetes, hypertension and CVD (NHLBI Obesity Education Initiative (2000).

Table 2 - WHO cut-off points for BMI associated with the risk of comorbidities.

Classification	**BMI (kg/m^2)**	**Risk of comorbidities**
Underweight	< 18.5	Low (but risk of other clinical problems increases)
Normal range	18.5 to 24.9	Average
Overweight	≥ 25	
Pre-obese	25.0 to 29.9	Increased
Obese class 1	30.0 to 34.9	Moderate
Obese class 2	35.0 to 39.9	Severe
Obese class 3	≥ 40.0	Very severe

Source: WHO (2000).

Table 3 - Diseases risk associated with combined BMI and waist girth cut-off points sex-specific.

Classification	**BMI**	**Obesity class**	**Disease risk***	
			Men waist girth < 102 cm Women waist girth < 88 cm	Men waist girth > 102 cm Women waist girth > 88 cm
Underweight	< 18.5			
Normal	18.5 to 24.9			
Overweight	≥ 25		Increased	High
Obesity	25.0 to 29.9	I	High	Very high
		II	Very high	Very high
Extreme obesity	30.0 to 34.9	III	Extremely high	Extremely high

* Disease risk for type 2 diabetes, hypertension and CVD.
Source: NHLBI Obesity Education Initiative (2000).

- **WAIST TO HIP RATIO (WHR)**

Description: Waist to hip ratio (WHR) may help in an evaluation of subject's adiposity and fat distribution. It is calculated as waist girth, that

reflects changes in subcutaneous and visceral fat, divided to hip girth, indicative of variations in bone structure, gluteal muscle and subcutaneous gluteal fact. It therefore indicate the risk of metabolic complications. The World Health Organization (WHO) cut-off points (WHO, 2000) are used to evaluate if the subject is at low risk of metabolic complications or at increased risk (Table 4).

Table 4 - World Health Organisation waist-hip ratio sex-specific cut-off points.

Waist-Hip Ratio		**Risk of metabolic complications**
Men	**Women**	
< 0.90	< 0.85	Increased
≥ 0.90	≥ 0.85	Substantially increased

Source: WHO (2000)

- **ARM FAT INDEX (AFI %)**

Description: Arm fat index (AFI) is based on measurements of the upper arm girth and triceps skinfold thickness (Frisancho, 2008). In the table below (Table 5), the formulae used for the calculus of AFI (%), passing through other indices, are listed.

Table 5 – Formulae for the calculus of upper arm area (TUA), upper arm muscle area (UMA), upper arm fat area (UFA) and arm fat index (AFI) (C: middle upper-arm girth; Ts: skinfold thickness in cm).

Index	**Formula**
Total Upper Arm Area (TUA)	$(C^2) / (4\pi)$
Upper Arm Muscle Area (UMA)	$[C – (Ts \cdot \pi)]^2 / (4\pi)$
Upper Arm Fat Area (UFA)	TUA – UMA
Arm Fat Index (AFI %)	(UFA / TUA) ·100

Source: Frisancho (2008).

5. Other anthropometric techniques

- **BIOELECTRIC IMPEDANCE**

Instrument: Bioelectrical impedance analyzer (Fig. 8)

Description: It is a rapid and accurate method used for the evaluation of fat free mass (FFM), fat mass (FM) and other body composition and nutritional status indicators (i.e. total body water, total muscle area, body cellular mass, etc.). Bioelectric impedance analysis(BIA) measures the resistance and the reactance of a body at the passage of a weak current of electricity in controlled conditions and according to a codified methodology (Gualdi-Russo et al, 1997; Gualdi-Russo, Toselli, 1997). It is based on the principle that FFM and FM do not have the same electrolyte concentrations so they conduct the alternating electric current at low frequency differently. The measurement should be made within 10 minutes from when the subject lies supine.

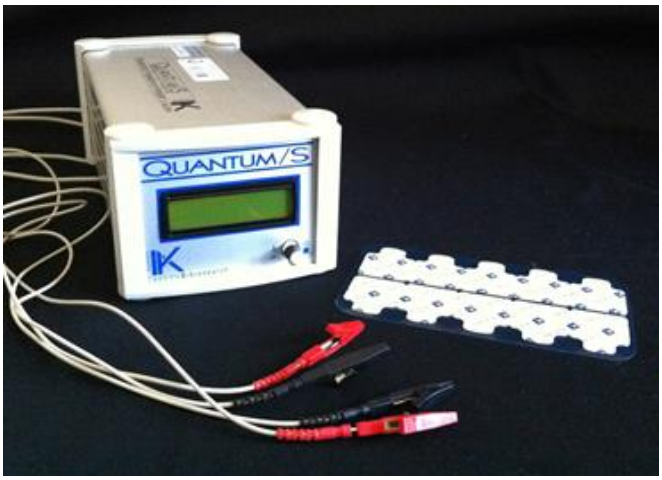

Figure 8 – Bioelectrical impedance analyzer.

Patient's Conditions:

1. To be without food and alcohol for at least 4 hours.
2. Urinary bladder must be empty.
3. Not to have played physical activity for at least 2 hours.
4. Not to use diuretics.
5. Not to have pacemaker, titanium prosthesis or hearing aid.
6. Not to wear any metallic stuff (i.e. bracelets, necklaces, keys);
7. To breathe normally.

Procedure:

1. Tell the subject to lay out in a supine position with arm and feet spread apart and without shoes and socks.
2. Upper arm have to be far at least 30° from the body and leg wide apart 30° one to each other.
3. The subject must not touch his/her body with the hands or any metallic stuff.
4. Put the black electrodes (Fig. 9):
   - on the dorsal aspect of the right wrist between the radial and ulnar distal epiphyses;
   - on the anterior aspect of the right foot between the medial and the later malleolus.
5. Put the red electrodes (Fig. 9):
   - on the distal epiphysis of the third metacarpal;
   -on the distal epiphysis of the third metatarsal. Electrodes have to be wide apart between 4 cm one to each other.
6. Connect the red and black pliers with the electrodes and push the button of the bioelectrical impedance analyzer.

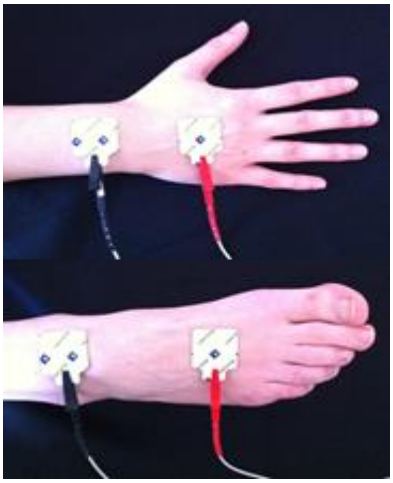

Figure 9 – Correct position of the electrodes in the right hand and right foot.

7. Read the results of Resistance (Rz), Reactance (Xc) and Phase angle (φ) in the monitor.
8. Insert subject's stature, weight, resistance and reactance in the dedicated software.
9. In the figure 10, an example of the results that you will obtain inserting the data resulting from the BIA in the software was reported.

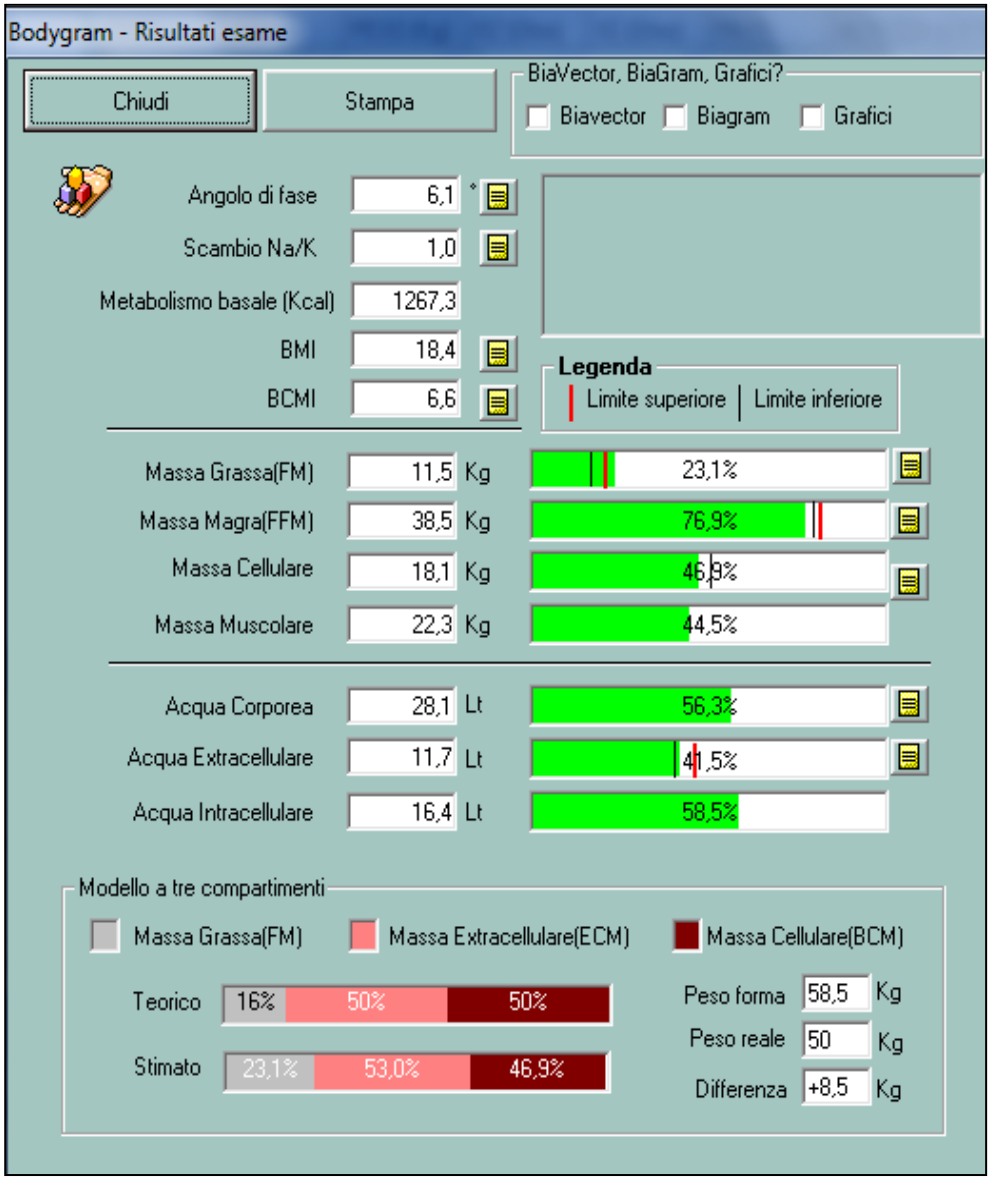

Figure 10 - BIA analyzer: the screen obtained using a specific software.

5. Conclusions

This appendix should have given you practical anthropometric guidance for the assessment of health and nutritional status in adults. The measurement procedures can seem simple, but adequate preparation and technical skills are needed to obtain reliable results. Especially in the case of skinfold thicknesses evaluation, at least two measurements should be carried out, so as to use the average value in any further calculation (wait several minutes between repetitions to reduce the effects of compressibility).

Anthropometric traits detectable on the human body are many. Those listed could be particularly useful in the case of the nutritional status assessment. They were recently collected during the survey of an international project on nutritional status of North-African immigrant women. The research in collaboration with EUNAM partners is still in progress, but the first interesting results confirm the validity of the anthropometric approach.

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