

ANTHROPOMETRIC VARIABLES AND INDICES

MEASUREMENT INSTRUCTIONS FOR IASMS-COURSE PARTICIPANTS

In addition to the SAT measurements, a chore set of anthropometric characteristics is essentially important for assessing the physique of a person, in particular of athletes with their specific body shapes and body compositions.

The mass index *MI*: uses the sitting height-to-stature ratio $S=s/h$ (also termed Cormic index) to correct the body mass index BMI for the individual's sex and body shape, which impact the *BMI* substantially^[1]. Large epidemiological studies showed that deviations of S from median values are associated with *BMI*-deviations up to 5 BMI-units. The *MI* overcomes these shortcomings^[2].

The ratio W/h : is an important health parameter: a pronounced belly due to visceral adipose tissue (VAT) accumulation is known to be associated with increased health risks. The US method measures subcutaneous adipose tissue (SAT), but not VAT. Currently, there is no sufficiently accurate method available for measuring VAT (MRI has this potential, but a bespoke software is necessary for image segmentation and determination of the VAT volume and mass, and this scientific method is out of reach for practical applications). All other methods are more like guesses than serious measurement methods with very high error ranges, and inadequate for detecting the low values of VAT in lean persons like athletes or anorectic patients. In our scientific MRI-study, we used more than hundred MRI-slices to measure the VAT-mass (in kilograms). Results have shown that the distribution of VAT varies largely from one person to the other; thus, using just one or a few slices (this approach is used by several groups) cannot be assumed to be representative for the total VAT-mass. Currently, the best indicator for 'years of life lost' due to excessive VAT is the waist index W/h ^[3].

Other anthropometric variables and indices: are useful to characterise the physique of male and female persons; in particular athletes often have extreme physiques, which may be of relevance for high performance in their sport.

Anthropometric data included in the *NISOS - BCA Software meta data set*:

| | | |
|-------|------|--|
| m | [kg] | Body mass |
| h | [m] | Stature (body height) |
| s | [m] | Sitting height |
| l | [m] | Leg length (from the floor to the ASIS point) |
| l^* | [m] | Leg length (defined as: $l^*=h-s$) |
| a | [m] | Arm span |
| W | [m] | Waist girth |
| H | [m] | Hip girth (gluteal hip girth) |
| B | [m] | Biceps girth (arm girth flexed and tensed) |
| T | [m] | Thigh girth (mid-thigh girth at the height of the FT site) |

Indices:

| | | | |
|---------|-------------------------------------|--|---|
| MI | [kg m ⁻²] | Mass index: | Men: $MI=0.525 m/(sh)$ Women: $MI=0.530 m/(sh)$ |
| BMI | [kg m ⁻²] | Body mass index: | $BMI=m/h^2$ |
| S | [1] | <i>Cormic index</i> : | $S=s/h$ |
| S_R | [1] | Reference value of S | |
| W/h | [1] | Waist index (ratio of waist-to-stature) | |
| a/h | [1] | Arm span-to-stature ratio (is in some references termed <i>ape index</i>) | |
| A_B/m | [cm ² kg ⁻¹] | Ratio of biceps cross-sectional area to body mass (a measure of 'relative' force) | |
| A_T/m | [cm ² kg ⁻¹] | Ratio of thigh cross-sectional area (at FT; see: Müller et al. ^[3]) to body mass (a measure of 'relative' thigh force), and a measure of leg mass with respect to body mass (in some sports, low leg mass is a performance factor, e.g. in gymnastics). Def of LT: Müller et al. BJSM 2016. | |

**MEASUREMENT DESCRIPTIONS
FOR PARTICIPANTS**

Units and accuracy:

Body mass is measured in kilograms (± 0.1 kg), all dimensions are measured in meters, with three decimals (mm-accuracy).

Stature (body height) h : measured in fully upright position, inhaled, looking straight forward, arms hanging in relaxed position, lumbar spine touched by the measurer before the measurement to induce minimum bending.

Body mass m : use calibrated weighing scales with an accuracy of 0.1 kg. Calibration can best be done by using (if necessary, a series of) calibration weights; the resulting calibration function can be used to obtain accurate values.

Sitting height s :

The person is sitting on a box or a table with the feet supported such that the thigh axes are slightly above the horizontal, effecting that the person sits on the sitting bone (ischial tuberosity), not on the thigh muscles.

Motivate the person to stretch the vertebral column (the measurer touches the lumbar spine before the measurement) and to extend the upper body length; in this position, with the person looking forward, the distance between the supporting surface and the highest point of the head is measured, similar to measuring h .

Leg length l :

The leg length l is measured in standing position from the floor to the ASIS point (anterior superior iliac spine) in a comfortable upright standing position with the legs positioned in parallel, the arms are hanging down in relaxed position. The ASIS point can be palpated and marked on the skin surface (take care not to move the skin!); in case the palpation is difficult, rising the thigh to about the horizontal plane enables in most cases to palpate the ASIS-point at the tendon origin, and thus to mark the ASIS-point correctly when the foot is positioned on the floor again.

Optional procedure: in many cases, the extremitas anterior cristae iliacae (EACI) is easier to identify by palpation; in adults, the EACI-point of a person with $h=1.70$, is typically 10 mm above the ASIS-point ($SD=\pm 2$ mm, i.e. less than the uncertainty associated with markings of bony landmarks on the skin). Therefore, l can be determined as: $l_{ASIS} = l_{EACI} - 0.010$ m, for tall persons use: $l_{ASIS} = l_{EACI} - 0.012$ m, for small ones: $l_{ASIS} = l_{EACI} - 0.008$ m, and for children: $l_{ASIS} = l_{EACI} - 0.005$ m.

Waist girth W :

W is the minimum girth-value of a person standing in relaxed upright position, at mid-tidal expiration. In persons with larger bellies (thus, no minimum value available), measure the girth in the middle between the lowest point of the costal arch and the highest point of the iliac crest.

Hip girth H :

The subject should stand in upright position with the feet together and gluteal muscles relaxed. The girth is taken at the level of the greatest posterior protuberance of the buttocks (maximum girth).

Biceps girth B :

Maximum girth is (usually) measured at the right arm, with the upper arm in approximately horizontal position, with the forearm flexed (approximately 90°), hands in supinated position, making a fist, and the biceps maximally tensed.

Arm span a : the person stands in upright position, with the back to the wall, and arms maximally extended horizontally to both sides. The distance is measured (starting from a corner of the wall) to the middle finger of the other arm.

Thigh girth (T):

Measure the girth perpendicular to the axis of the thigh at the site FT^[4], with the foot on a height-adjustable supporting surface (support box) such that the thigh axis is in horizontal and the leg in vertical position.

References:

- [1] Norgan Eur J Clin Nutr. 1994
- [2] Müller et al. 2020
- [3] Ashwell et al. 2014
- [4] Müller et al. 2016