ANTHROPOMETRIC VARIABLES AND INDICES

MEASUREMENT INSTRUCTIONS FOR IASMS ANTHROPOMETRY COURSES

In addition to the SAT measurements, a chore set of anthropometric characteristics is important for assessing the physique of a person, in particular of athletes with their specific body shapes and body compositions, which are often associated with high performance in their sport.

Units and accuracy: Body mass is measured in kilograms (± 0.1 kg), all body dimensions are measured in meters [m], with three decimals (i.e. a reading resolution of 1 mm).

Anthropometric data included in the meta data set of the *NISOS - BCA Software* (*Body Composition Analysis*)
For detailed description of sites, see [1]. Anatomical descriptions are based on the anthropology standard text book of Martin R, Saller K [2].

Anthropometric variables:

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 (maximum arm girth, flexed and tensed)
T	[m]	Thigh girth (mid-thigh girth measured at the FT site)
C	[m]	Calf girth (measured at the MC site)
U	[m]	Upper body girth (is measured under the armpit at mid-tidal expiration

Anthropometric 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]	Cormic index:	*S=s/h*
S_R	[1]	Reference value of *S*, for men: $S_{R,M}$=0.525 for women: $S_{R,F}$=0.530	
W/h	[1]	Waist index (ratio of waist-to-stature)	
a/h	[1]	Arm span-to-stature ratio (also termed '*ape index'*)	
A_B/m	[cm^2 kg^{-1}]	Ratio: arm cross-sectional area (at max. biceps girth) to body mass *m*	
A_T/m	[cm^2 kg^{-1}]	Ratio: thigh cross-sectional area (at FT) to body mass *m*	

Anthropometric measurements:
Body mass *m*: use calibrated waiving scales (accuracy of 0.1 kg). For calibration (calibration function) use reference weights with an accuracy < 0.1 kg. Measurement is done in sport shorts and a T-shirt.
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.
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, similarly to measuring *h*.

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 (ECAI) is easier to identify by palpation [2]; in adults, the EACI-point of a person with *h*=1.70, is typically 10 mm above the ASIS-point (90%LOA=±2 mm). Therefore, leg length *l* can be determined as: $l_{ASIS} = l_{EACI}$ - 0.010 m, for taller persons: $l_{ASIS} = l_{EACI}$ - 0.012m, for smaller ones: $l_{ASIS} = l_{EACI}$ - 0.008m, for children: $l_{ASIS} = l_{EACI}$ - 0.005m).
Arm span *a*: the person stands in upright position, with the back to the wall, and arms maximally extended horizontally. The distance is measured from a corner of the wall to the middle finger of the other arm.
Waist girth *W*: 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 (90°), hands in supinated position, and the biceps maximally tensed.
Thigh girth *T*: measured perpendicular to the axis of the thigh at the site FT [1], with the foot on a height-adjustable supporting surface (support box) such that the thigh axis is in horizontal and the lower limb in vertical position.
Calf girth *C*: measured at the MC site [1], perpendicular to the axis of the lower limb, with the foot on a height-adjustable supporting surface (support box) such that the thigh axis is horizontal and the lower limb vertical.
Upper body girth *U*: measured under the armpit at mid-tidal expiration.

Indices of primary importance - a brief description
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 body shape, which impacts the *BMI* substantially [3]. Large epidemiological studies have shown that deviations of *S* from median values are associated with *BMI*-deviations up to 5 *BMI*-units [4]. The *MI* overcomes these shortcomings [3].
Waist index *W/h*: the waist-index 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* [5].

References:
[1] Müller et al. Br J Sports Med, 2016. [2] Martin R, Saller K: Lehrbuch der Anthroplogie, Gustav Fischer Verlag, Stuttgart,1957. [3] Müller et al. Beyond BMI, IASMS, 2025, ISBN 978-3-200-10400-6. [4] Norgan N. Eur J Clin Nutr, 1994. [5] Ashwell et al. PLOS ONE, 2014.
Recommended text books: [2]. Lippert H. Anatomie am Lebendigen, Springer 1989. Stewart A., Sutton L. Body composition in sport, exercise and health. Routledge 2012.