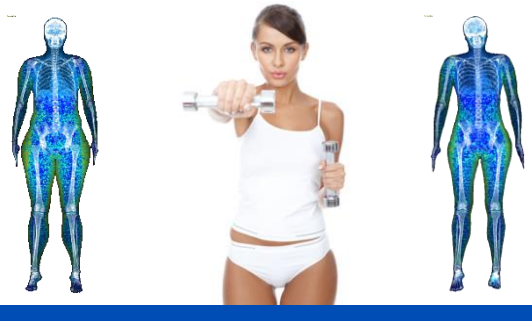
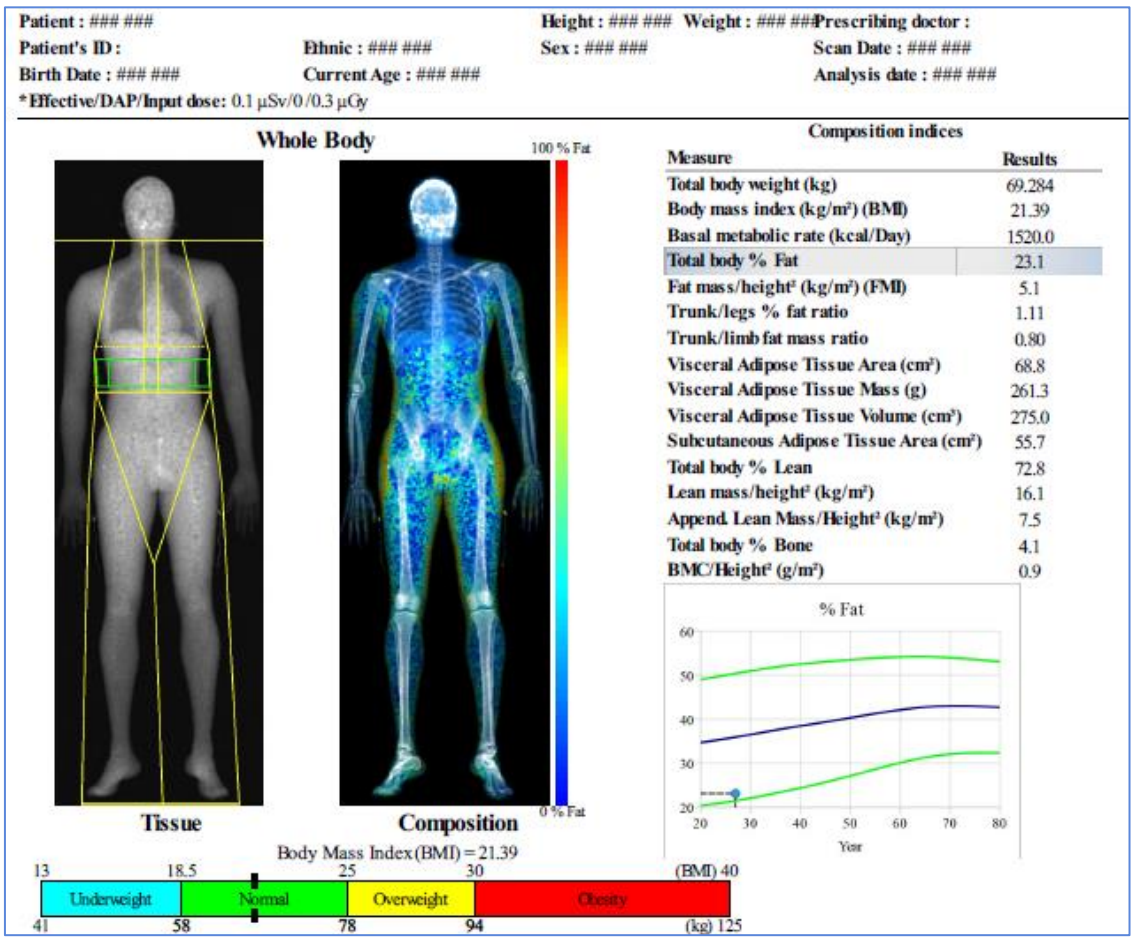
UNDERSTANDING DXA BODY COMPOSITION RESULTS





IMAGES

TISSUE IMAGE (ON LEFT)

The tissue image forms the basis of defining the body's soft tissue densities. It also divides the body into segments for more detailed analysis of each limb or torso region.

BODY COMPOSITION IMAGE (ON RIGHT)

Colours represent the fat density of the adipose tissue: warmer (yellow and red) is the colour, the denser is the adipose tissue.

COMPOSITION INDICES RELATED TO FAT

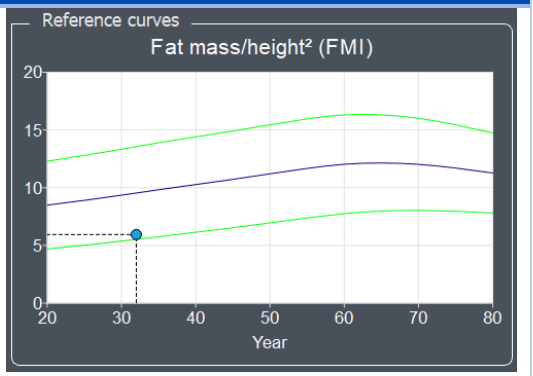
FAT MASS INDEX (FMI) OR FAT MASS/HEIGHT² (KG/M²)

Fat Mass Index (FMI) is an indicator to measure the patient's fat mass relative to his own height. This key index uses measured mass value to determine real fat distribution in a patient's body.

FMI is more accurate than BMI (Body Mass Index). FMI is a more specific indicator of the individual health status rather than the BMI. The FMI is a measure of the total fat rather than a relative amount of fat expressed as a %.

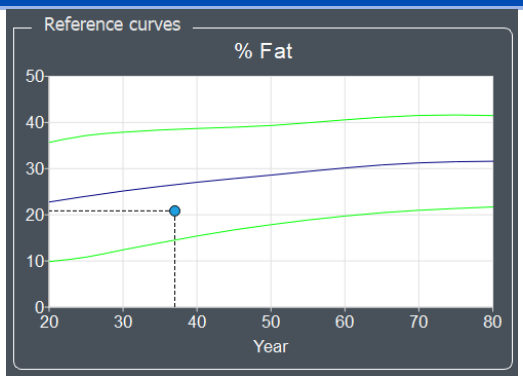
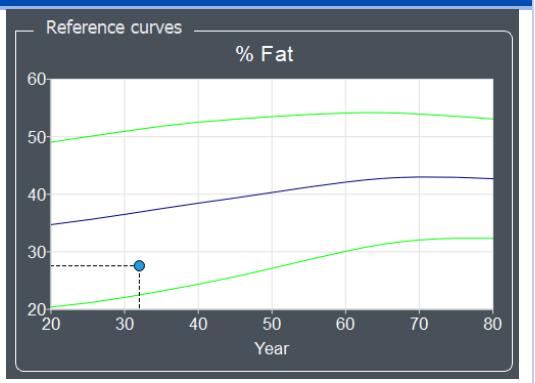
Cut-offs: *"Dual Energy X-Ray Absorptiometry Body Composition Reference Values from NHANES", Plos One, 4(9), September 2009, Thomas L. Kelly, Kevin E. Wilson, Steven B. Heymsfield*

FMI	SEVERE FAT DEFICIT	MODERATE FAT DEFICIT	MILD FAT DEFICIT	NORMAL	EXCESS FAT	OBESE CLASS I	OBESE CLASS II	OBESE CLASS III
Male	<2	2 to <2.3	2.3 to <3	3 to 6	>6 to 9	>9 to 12	>12 to 15	>15
Female	<3.5	3.5 to <4	4 to <5	5 to 9	>9 to 13	>13 to 17	>17 to 21	>21

Fat Mass Index	Male	Female
NHANES reference curves		

TOTAL BODY % FAT

The total body % Fat is the percentage the fat tissue makes up within the body. This includes muscle subcutaneous and visceral fat. Fat is also referred to as Adipose Tissue.

Total body % fat	Male	Female
NHANES reference curves		

Other classifications possible (not used in DMS Imaging DXA software):

- **General body fat % categories**

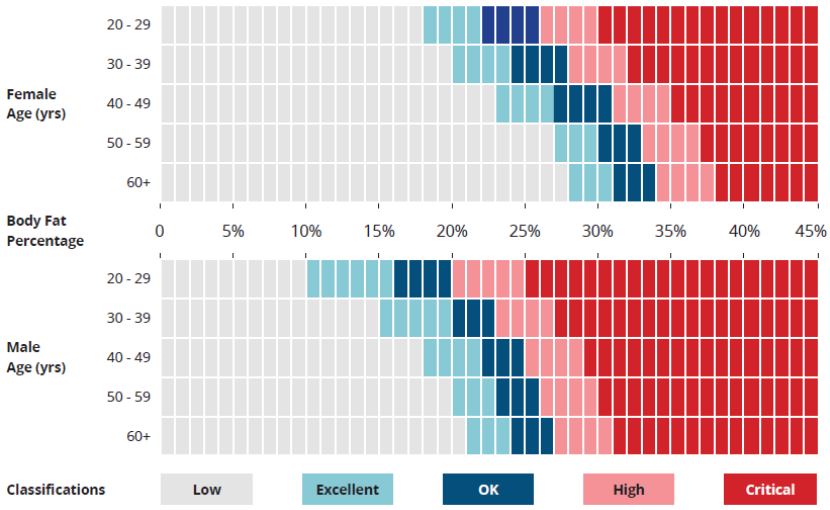
Cut-offs: *Exercise AC. Ace Lifestyle & Weight Management Consultant Manual, The ultimate Resource for Fitness Professionals. American Council on Exercise; 2009*

Classification	Women (% fat)	Men (% fat)
Essential fat	10 – 13%	2 to 5%
Athletes	14 – 20%	6 – 13%
Fitness	21 – 24%	14 – 17%
Average	25 – 31%	18 – 24%
Overweight/Obese	>31%	>24%

.

- **Body fat % reference chart**

Cut-offs: *Am J Clin Nutr. 2000 Sep; 72(3):694-701. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Mrgatroyd PR, Sakamoto Y.*



Android/Gynoid % fat ratio

Android fat is the distribution of human adipose tissue mainly around the trunk and upper body, in areas such as the abdomen, chest, shoulder and nape of neck. Accumulation of fat in this area lends itself to an "apple shape" body type.

Gynoid fat is the concentration of fat in the hips, upper thighs, and buttocks. It is where stubborn fat deposits reside in a "pear shape" body type.

The android/gynoid fat ratio is a regional fat distribution analysis which classifies 2 body types: apple-shape (>1) and pear shape (<1). This waist/hip ratio helps specialists to prevent metabolic and cardiovascular disease risk.

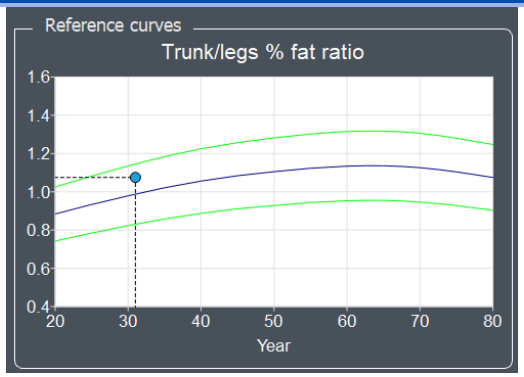
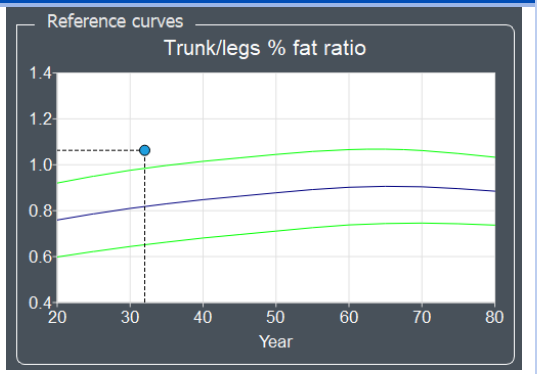
Increased Risk of Disease	Male	Female
<60 years old	*>0.95*	*>0.82*
60 – 69 years old	*>1.03*	*>0.90*

Example of clinical applications:
"Android fat distribution is associated with an increased insulin resistance in obese children and adolescents. An android to gynoid fat ratio based on dual-energy x-ray absorptiometry measurements is a useful and simple technique to assess distribution of body fat associated with an increased risk of insulin resistance."

"Effect of Android to Gynoid Fat Ratio on Insulin Resistance in Obese Youth", Archives of Pediatrics and Adolescent Medicine, 163(9), 2009, Julien Aucouturier, Martine Meyer, David Thivel, et al

TRUNK/LEGS % FAT RATIO

Trunk/Legs %Fat Ratio = %Fat Trunk / % Fat Legs
This ratio is also called Fat Mass Ratio (FMR). It reveals a specific fat distribution opposed to measuring total fat mass alone. This rating helps professionals interpret patient physiology. This measure looks at a specific pattern of fat distribution opposed to measuring total fat as alone. A higher proportion of fat concentrated in the trunk region poses a higher risk for metabolic and cardiovascular related diseases.

Trunk/legs % fat ratio	Male	Female
NHANES reference curves		

Other classification possible (not used in DMS DXA software):

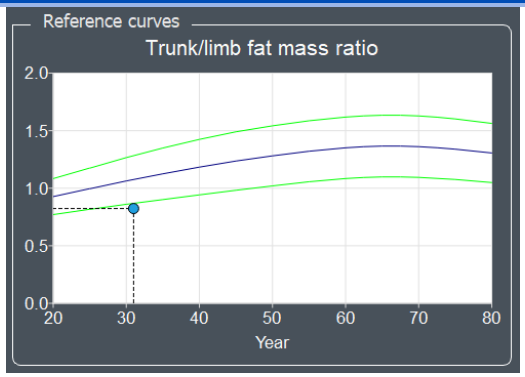
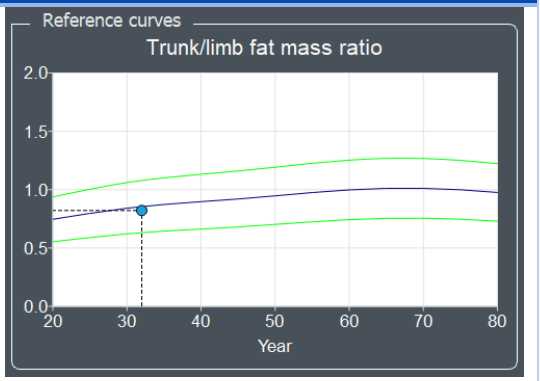
Men: the FMR standard value is equal to 1.3 +/- 0.2

Cut-offs: *"Total body composition by DXA of 241 HIV-negative men and 162 HIV-infected men: proposal of reference values for defining lipodystrophy." Journal of Clinical Densitometry, vol 8, no 3, 287-292, 2005, Bonnet, E., C. Delpierre, et al.*

Example of clinical applications:
This index could be useful for the assessment of lipodystrophy in special populations, such as HIV-infected people, but is not particularly useful or informative in the general population. Indeed, antiretroviral agents may cause a redistribution of fat mass termed lipodystrophy.

TRUNK/LIMB FAT MASS RATIO

Trunk/Limbs Fat Ratio = Fat Mass Trunk / Fat Mass Limbs
Index useful to determine body homogenization, including legs & arms. Trunk/limb fat mass distribution changes are important to measure overtime as lowering this number shows an improvement in stubborn fat within the trunk region. As the previous index, this ratio may have a role in defining metabolic syndrome of lipodystrophy, for HIV-infected people for example.

Trunk/limb fat mass ratio	Male	Female
NHANES reference curves		

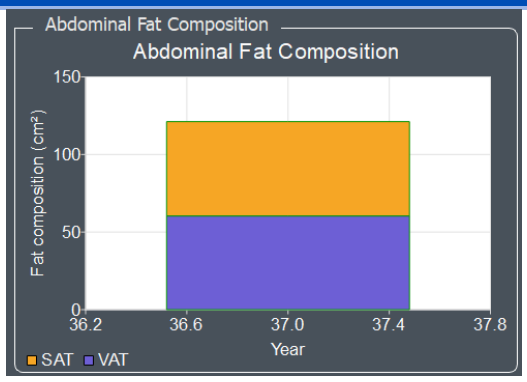
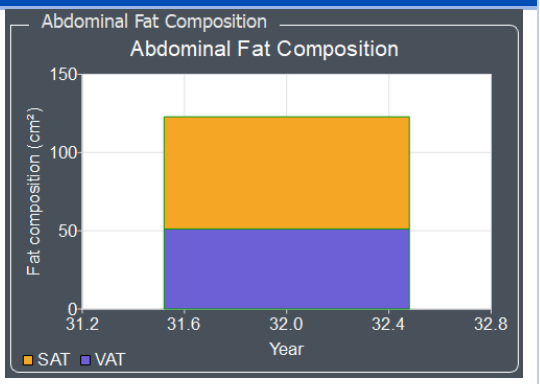
VISCERAL ADIPOSE TISSUE

In the abdomen, fat is distributed into two different ways: visceral fat and subcutaneous fat.

Subcutaneous fat is the layer of adipocytes directly located under the skin. Despite its non-aesthetic aspect, subcutaneous fat is safe for health. Its main function is energy storage.

Visceral fat refers to the deep layer of body fat surrounding the organs in the intra-abdominal region. Research has shown that visceral fat cells are "active" and influence how hormones are delivered. An excess amount of visceral fat poses the highest risk associated with cardiometabolic disorders including ischaemic heart disease, arterial hypertension, type 2 diabetes, dyslipidaemia, atherosclerosis, and certain types of cancers such as chest cancer in post-menopausal women.

CT is the gold standard to measure VAT. DXA VAT measurement is highly correlated to CT VAT and has several advantages such as a wider availability, less cost and less dose radiation.

Visceral Adipose Tissue	Male	Female
Repartition visceral and subcutaneous fat		

1. Visceral adipose tissue area or VAT area (cm^2)

It is the area, in cm^2, of the VAT estimated in the mean area of the subsection of the android area. This area is in the anterior-posterior plan.

Example of clinical applications:
"An increased VAT area is longitudinally associated with an increased risk of incident metabolic syndrome (MS), while SAT may have possible protective effects on the incidence of individual components of MS, such as BP and fasting glucose."

"*Body Fat Distribution and the Risk of Incident Metabolic Syndrome: A Longitudinal Cohort Study*", *Scientifc Reports, September 2017, Hyuktae Kwon, Donghee Kim & Joo Sung Kim*

2. Visceral adipose tissue mass or VAT mass (g)

It is the mass, in gram, of the total visceral adipose tissue in a subsection of the android area.

3. Visceral adipose tissue volume or VAT volume (cm^3)

It is the volume, in cm3, of the total visceral adipose tissue in a subsection of the android area.

Example of clinical applications:
"Excess VAT volume can contribute to the development and growth of new colorectal adenomas and is a better predictor of colorectal adenoma occurrence at follow-up colonoscopy than BMI, WC, and SAT volume."

"*Visceral Adipose Tissue Volume and the Occurrence of Colorectal Adenoma in Follow-up Colonoscopy for Screening and Surveillance*", *Nutrition and cancer, 69(5), 739-745, July 2017, Bun Kim, Byung Chang Kim, Su Youn Nam, Ji Hyung Nam, Kum Hei Ryu, Bum, Joon Park, Dae Kyung Sohn, Chang Won Hong, Kyung Su Han & Hyun Bum Kim*

4. Subcutaneous adipose tissue area or SAT area (cm^2)

It is the area, in cm^2, of the total subcutaneous adipose tissue in a subsection of the android area.

Example of clinical applications:
"Although the VAT area was longitudinally associated with the incidence of each component of MS, the SAT area was inversely associated with the risk of high blood pressure, fasting blood sugar, and triglycerides, with marginal significance." "SAT may have a protective effect against the incidence of individual MS components."

"*Body Fat Distribution and the Risk of Incident Metabolic Syndrome: A Longitudinal Cohort Study*", *Scientifc Reports, September 2017, Hyuktae Kwon, Donghee Kim & Joo Sung Kim*

COMPOSITION INDICES RELATED TO LEAN

TOTAL BODY % LEAN

The percentage your lean tissue makes up within the body. This includes muscle and organs.

Example of clinical applications:

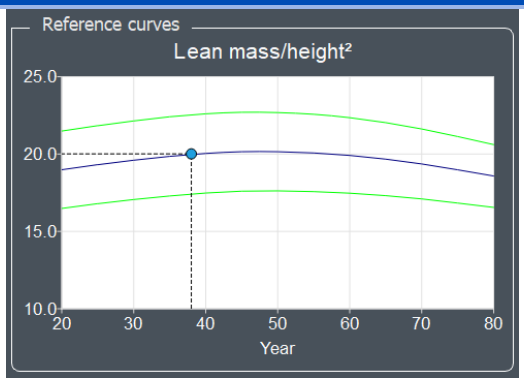
Lean Mass measured by DXA in children with Duchenne muscular dystrophy is highly correlated with muscle strength and function.

"Assessment of whole body composition with dual energy duchenne muscular dystrophy: correlation of lean body mass with muscle function", Muscle & Nerve, 19, 777-779, 1996, Palmieri, Bertorini et al.

LEAN MASS/HEIGHT² (KG/M²) OR LEAN MASS INDEX (LMI)

The lean mass index (LMI) refers to the total body lean mass (kg) relative to the height. As FMI, this index uses measured mass value to determine real lean distribution in a patient's body.

LMI values can be a good reflective tool to measure changes over time for certain population groups. This may be significantly relevant to individuals with low body weight or have been affected by certain medical conditions including muscular dystrophy, sarcopenia, and anorexia. It is also particularly useful for those in body building activities as an increase in this number is indicative of an increase in muscle over time.

Lean Mass Index	Male	Female
NHANES reference curves		

Example of clinical applications:
Guidelines for interpreting DXA total body exams have been published for children with growth hormone deficiency and anorexia nervosa. These guidelines include normalizing total lean tissue mass for height. This methodology allows differentiation of the origin of a skeletal deficit, "for example, short stature and primary, secondary, and mixed bone defects."

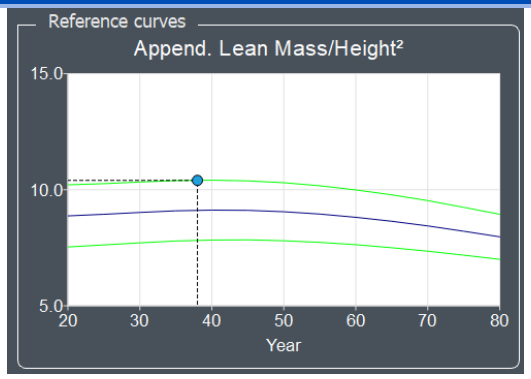
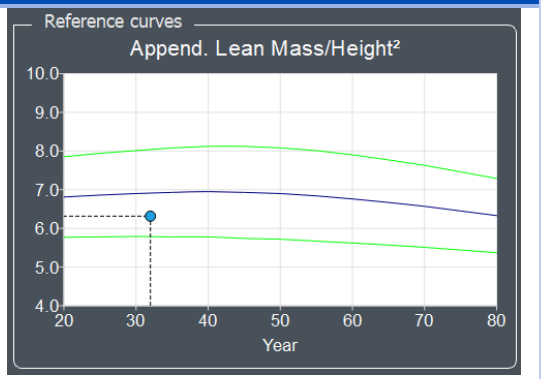
"Importance of lean mass in the interpretation of total body densitometry in children and adolescents.", The Journal of Pediatrics, 143, 81-88, 2003, W. HOGLER et al.

Appendicular Lean Mass/Height² (kg/m²)

It refers to the lean mass in the limbs (arms and legs) relative to the height.
ALM = (arms + legs lean mass)/height²

Several designations exist: Appendicular Lean Mass Index = Skeletal Lean mass index = Appendicular Lean Mass/Height² = Appendicular Skeletal Muscle Mass/Height²

This index is seen as a surrogate for Sarcopenia. Sarcopenia is a degenerative disease related to loss of muscular mass, quality, and strength. It may be clinically relevant for obese people or old people.

Appendicular Lean Mass	Male	Female
NHANES reference curves		

Several studies are using this index, among them:

- **BAUMGARTENER**

Cut-offs: *Baumgartner, R. N., et al. "Epidemiology of Sarcopenia among the Elderly in New Mexico." American Journal of Epidemiology, vol. 147, no. 8, Oxford University Press (OUP), Apr. 1998, pp. 755–763. Crossref, doi:10.1093/oxfordjournals.aje.a009520.*

For Hispanic and Non-Hispanic white population, over 65 years old:

SARCOPENIA	Male	Female
Appendicular Lean Mass	<7.26	<5.45

- **AWGS – Asian Working Group for Sarcopenia**

Cut-offs: *Chen, Liang-Kung, et al. "Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia." Journal of the American Medical Directors Association, vol. 15, no. 2, Elsevier BV, Feb. 2014, pp. 95–101. Crossref, doi:10.1016/j.jamda.2013.11.025.*

For Asian population, over 60 or 65 years old according to definitions of elderly in each country:

SARCOPENIA	Male	Female
Appendicular Lean Mass	<7.0	<5.4
Gait Speed (m/s)	≤ 0.80	≤ 0.80
Grip Strength (kg)	<26	<18

- **EWGSOP – European Working Group on Sarcopenia in Older People**

Cut-offs: *Cruz-Jentoft, Alfonso J et al. "Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People." Age and ageing vol. 39,4 (2010): 412-23. doi:10.1093/ageing/afq034.*

For people over 65 years old:

PROBABLE SARCOPENIA	**Male**	**Female**
Appendicular Lean Mass	≥ 7.0	≥ 6.0
Gait Speed (m/s)	NA	NA
Grip Strength (kg)	<27	<16
SARCOPENIA	Male	Female
Appendicular Lean Mass	<7.0	<6.0
Gait Speed (m/s)	NA	NA
Grip Strength (kg)	<27	<16
SEVERE SARCOPENIA	Male	Female
Appendicular Lean Mass	<7.0	<6.0
Gait Speed (m/s)	≤ 0.80	≤ 0.80
Grip Strength (kg)	<27	<16

- **IWGS – International Working Group on Sarcopenia**

Cut-offs: *Fielding, Roger A et al. "Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. International working group on sarcopenia." Journal of the American Medical Directors Association vol. 12,4 (2011): 249-56. doi:10.1016/j.jamda.2011.01.003.*

SARCOPENIA	**Male**	**Female**
Appendicular Lean Mass	<7.23	<5.67
Gait Speed (m/s)	≤ 1.0	≤ 1.0

- **FNIH - Foundation for National Institutes of Health Sarcopenia Project**

Cut-offs: *Studenski SA, Peters KW, Alley DE et al (2014) The FNIH sarcopenia project: rationale, study description, conference recommendations, and final estimates. J Gerontol A Biol Sci Med Sci 69(5):547–558*

For people over 65 years old:

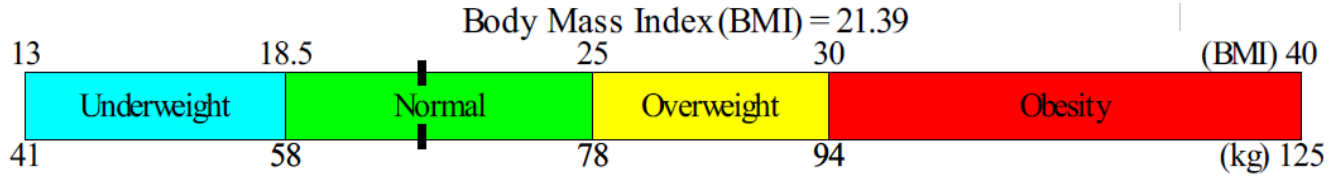
SARCOPENIA	**Male**	**Female**
Appendicular Lean Mass / BMI	<0.789	<0.512
Grip Strength (kg)	<26	<16

OTHER COMPOSITION INDICES

BODY MASS INDEX (BMI) OR TOTAL MASS/HEIGHT² (KG/M²)

Body Mass Index is a standardised ratio of weight to height that is used as a general indicator of health. This index is useful to determinate patient category (underweight, normal, overweight, obesity) and estimate disease probability. The BMI is the most famous population-level measure for indicating nutritional status in adults, as it is the same for both sexes and for all ages of adults. However, this tool can be misleading for individuals with higher amounts of lean tissue opposed to fat, especially athletes and highly active individuals*.

Cut-offs: World Health Organization classification for adults



**Ranges presented according to BMI are not used for individual analysis when measured using DXA Body Composition analysis. FMI is a more specific tool used to indicate the health status as current research suggests that an accumulation of high body fat poses serious health risks, not total body weight.*

TOTAL BODY WEIGHT (KG)

Total body weight in kg.

BASAL METABOLIC RATE (KCAL/DAY)

BMR is the estimated quantity of kilocalories burned by a patient's body at rest over a 24-hour period. These basal functions include circulation, breathing, cell production, nutrient processing, protein synthesis, and ion transport. It doesn't consider any unnecessary movements or digestion efforts.

There are three available formulas in the software to calculate the BMR:

- **Katch-McArdle Formula**
  This formula considers the lean mass, which allows a very precise estimation of the basic metabolism.

  Men & Women = 370 + (21,6 x Total Lean Mass)

- **Mifflin-St Jeor Formula**
  This formula is based on the age, height and weight.

  Men = (10 x weight) + (6,25 x height) – (4,92 x age) + 5

  Women = (10 x weight) + (6,25 x height) – (4,92 x age) - 161

- **Harris Benedict Formula**
  This formula is based on the age, height and weight.

  Men = 77.607 + (13.702 x weight) + (4.923 x height) - (6.673 x age)

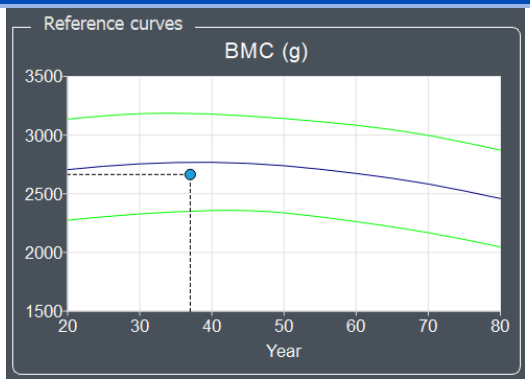
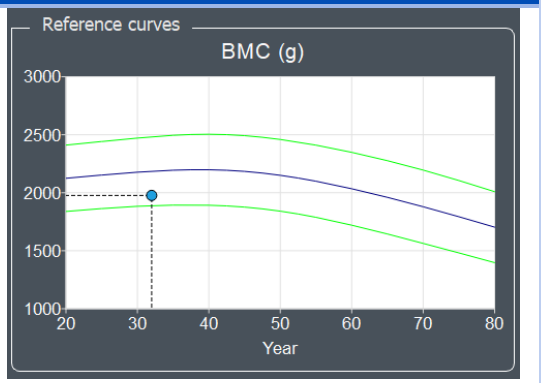
  Women = 667.051+ (9.74 x weight) + (1.729 x height) - (4.737 x age)

Total body % bone

The total body % Bone is the percentage of dry mineral bone that make up within the body. Total body % bone does not refer to the entire skeleton in the body, but only to the dry component of the bone.

Bone Mineral Content (BMC)

The Bone Mineral Content corresponds to the measured mass [g] of mineral substance in the bones.

Bone Mineral Content	Male	Female
NHANES reference curves		

The Bone Mineral Density (BMD) is the gold standard for the evaluation of bone disease such as osteoporosis. The whole body BMC could be an interesting information for the follow-up of some bone diseases.

BMC/height² (g/m²)

This ratio accounts for the skeletal weight and height. Monitoring this value will help identify changes in bone mass relative to stature.

Bone Mineral Density (BMD)

BMD = BMC / Bone Surface [g.cm-^{2}]
The Bone Mineral Density is referring to the amount of mineral matter per square centimetre of bones (g/cm^2). On specific regions (such as spine, femur or forearm), the BMD is used in clinical medicine as an indirect indicator of osteoporosis (bone disease) and fracture risk.

The Whole Body BMD could be useful for the follow-up of some metabolic and bone diseases.

Example of clinical application for Whole Body BMD:
A study of glucocorticoid-treated patients with congenital adrenal hyperplasia found that Total Body BMD was significantly decreased, which may increase fracture risk later in life.

"Reduced Bone Mineral Density and Increased Bone Metabolism Rate in Young Adult Patients with 21-Hydroxylase Deficiency", The Journal of Clinical Endocrinology & Metabolism, 91, 4453-4458, 2006), Sciannamblo M, Russo G et al.

BODY COMPOSITION REGIONAL MEASUREMENTS

The Region of Interest (ROI) table regionalises the measurements in the trunk, arms and legs, allowing to assess muscle symmetry and specific regional changes in fat and muscle mass over time. Arms will often have tissue imbalances up to 250 grams, while legs will have tissue imbalances up to 1 kg.

	Body composition							
ROI	Tissues (%Fat)	Tissues (g)	Tissues Area (cm²)	Fat (g)	Lean (g)	BMC (g)	BMC Area (cm²)	Total mass (kg)
Left Arm	25.8	4743	2085.4	1223	3520	226.0	335.1	5.0
Right Arm	24.9	4590	1797.2	1141	3449	226.5	333.3	4.8
Left Ribs	19.5	7124	556.8	1386	5739	133.2	287.7	7.3
Right Ribs	19.0	7023	559.6	1333	5690	128.9	258.0	7.2
T Spine	16.4	2153	130.1	352	1801	118.2	127.1	2.3
L Spine	23.2	1117	55.6	259	857	58.3	53.5	1.2
Pelvis	26.0	13151	872.6	3419	9731	418.4	378.4	13.6
Left Leg	26.6	11620	2140.9	3088	8532	557.2	489.4	12.2
Right Leg	27.5	10907	2075.1	2996	7910	547.6	471.5	11.5
SubTotal	24.3	62429	10273.4	15199	47230	2414.5	2734.0	64.8
Head	20.0	4007	1480.3	801	3206	434.0	227.7	4.4
Total	24.1	66436	11753.7	16000	50436	2848.5	2961.7	69.3

TISSUES (% FAT)

It is the percentage of fat in the body excluding bones. This % is not the same as the total body fat % as it is not reflected by the total % of soft tissue.

TISSUES (G)

It represents the total amount of soft tissue between fat mass and lean mass only, excluding bone mineral content.

TISSUES (AREA)

Area of soft tissues detected on the exam.

FAT (G)

It represents the total fat mass in grams.

LEAN (G)

It represents the total muscle/lean mass in grams.

BMC (G)

It corresponds to mineral mass (g).

BMC (AREA)

Area of bone detected and used in the formula BMD = BMC/Area

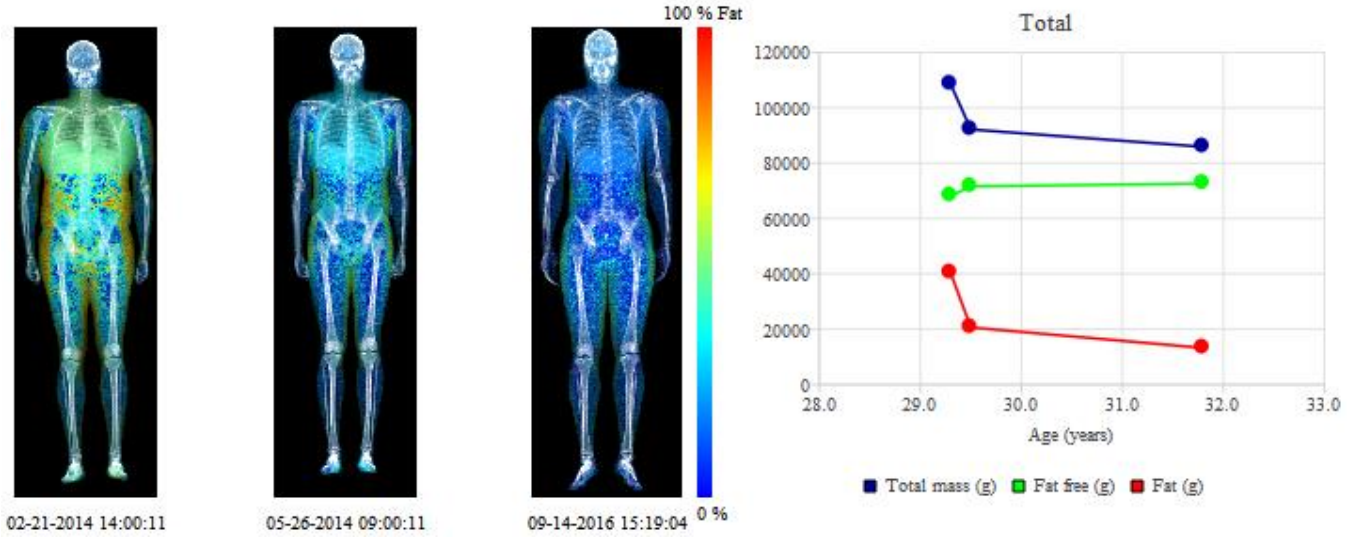
TOTAL MASS (KG)

It is the total weight in kg.

TREND REPORTS

Follow-up the progress overtime. Trend reports give an accurate measurement on how much the diet, trainings and so on could have affected the body composition, changes are reflected on the DXA image as well as changes in the total weight, lean mass and fat mass.

A visual representation of the body composition images will compare each scan side by side. Below is an example on improvements on body composition made overtime. Notice the difference in body shape and in warm colours representing fat tissues.



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