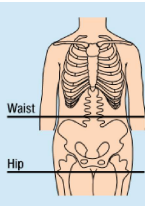
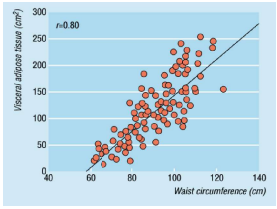
Waist-to-Hip Ratio

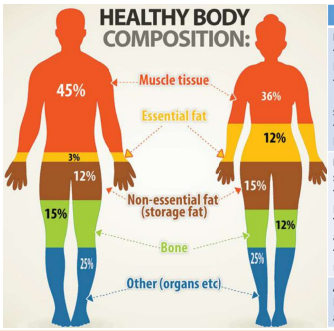




		Disease Risk Related to Obesity			
	Age (yrs)	Low	Moderate	High	Very High
MEN	20-29	<0.83	0.83-0.88	0.89-0.94	>0.94
	30-39	<0.84	0.84-0.91	0.92-0.96	>0.96
	40-49	<0.88	0.88-0.95	0.96-1.00	>1.00
	50-59	<0.90	0.90-0.96	0.97-1.02	>1.02
	60-69	<0.91	0.91-0.98	0.99-1.03	>1.03
WOMEN	20-29	<0.71	0.71-0.77	0.78-0.82	>0.82
	30-39	<0.72	0.72-0.78	0.79-0.84	>0.84
	40-49	<0.73	0.73-0.79	0.80-0.87	>0.87
	50-59	<0.74	0.74-0.81	0.82-0.88	>0.88
	60-69	<0.76	0.76-0.83	0.84-0.90	>0.90

Epidemiological studies have mainly used anthropometric variables such as the ratio of waist to hip circumferences (waist:hip ratio) to estimate the proportion of abdominal adipose tissue.
Sophisticated imaging techniques such as magnetic resonance imaging and computed tomography, however, can distinguish, with a high level of precision, intra-abdominal or visceral fat depot from subcutaneous abdominal fat.

Body composition



Essential Fat – Nonessential Fat – Adipose Tissue

Essential Fat – the fat in the body necessary for normal body functioning (3-5% in men; 8-12% in women) – differences resulting from hormonal differences and childbearing factors. Essential body fat can be found throughout the body (heart, lungs, liver, spleen, kidneys, muscle, central nervous system,...). If percentage fat falls below this levels serious adverse health effects might ensue. This can become an issue for athletes (e.g. bodybuilding) who have to keep their body fat levels low near competition time.

Nonessential Fat – extra fat or fat reserves stored in the body. This storage fat includes the subcutaneous adipose tissue as well as visceral fat tissue ⇔ this fat type should be kept low for health and athletic purposes.
There is a strong association between obesity (especially intra-abdominal = visceral fat) and increased risk of coronary artery disease, typ2 diabetes, hypertension, certain types of cancer and other diseases related to nonessential fat accumulation.

Adipose Tissue – Connective tissue in which fat is stored. The human body has the same number of fat cells all of the time and excess calories are stored in the fat cells of adipose tissue.

Although body fat is often in the focus of assessment, lean tissue mass and its components (fluid, muscle and bone) are at least as important. Low levels of lean mass and loss lean tissue contribute to metabolic complications both directly and indirectly, through impaired functional capacity and reduced physical activity and energy expenditure ⇔ greater risk of fat gain.

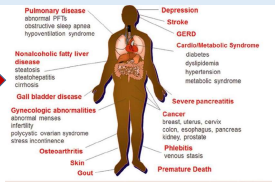
Waist-to-Hip Measurement Standards for Men and Women
V.H. Heyward, 2010

Population	Age	Low	Moderate	High	Very high
Men	20-29	< 0.83	0.83 – 0.88	0.89 – 0.94	> 0.94
	30-39	< 0.84	0.84 – 0.91	0.92 – 0.96	> 0.96
	40-49	< 0.88	0.88 – 0.95	0.96 – 1.00	> 1.00
	50-59	< 0.90	0.90 – 0.96	0.97 – 1.02	> 1.02
	60-69	< 0.91	0.91 – 0.98	0.99 – 1.03	> 1.03
Women	20-29	< 0.71	0.71 – 0.77	0.78 – 0.82	> 0.82
	30-39	< 0.72	0.72 – 0.78	0.79 – 0.84	> 0.84
	40-49	< 0.73	0.73 – 0.79	0.80 – 0.87	> 0.87
	50-59	< 0.74	0.74 – 0.81	0.82 – 0.88	> 0.88
	60-69	< 0.76	0.76 – 0.83	0.84 – 0.90	> 0.90

- In 2016, more than 1.9 billion adults aged 18 years and older were overweight. Of these over 650 million adults were obese.
- In 2016, 39% of adults aged 18 years and over (39% of men and 40% of women) were overweight.
- Overall, about 13% of the world's adult population (11% of men and 15% of women) were obese in 2016.
- The worldwide prevalence of obesity nearly tripled between 1975 and 2016.

- In 2019, an estimated 38.2 million children under the age of 5 years were overweight or obese.
- Once considered a high-income country problem, overweight and obesity are now on the rise in low- and middle-income countries, particularly in urban settings.
- Over 340 million children and adolescents aged 5-19 were overweight or obese in 2016.
- The prevalence of overweight and obesity among children and adolescents aged 5-19 has risen dramatically from just 4% in 1975 to just over 18% in 2016.
- The rise has occurred similarly among both boys and girls: in 2016 18% of girls and 19% of boys were overweight.
- While just under 1% of children and adolescents aged 5-19 were obese in 1975, more 124 million children and adolescents (6% of girls and 8% of boys) were obese in 2016.

Classifying your client's disease risk
Obesity is a risk factor for linked to several diseases



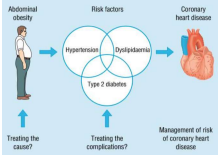
Assessing Body Composition

Body composition is a term that describes the relative proportions of fat, bone and muscle mass in the human body.

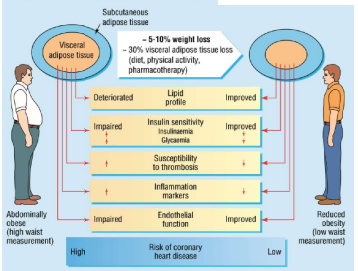
Body composition is a key component of an individual's health and fitness profile and one of the major health-related components of fitness.
Assessing your client's or athlete's relative body fat (%BF) = proportion of fat tissue within the human body, fat distribution, lean tissue mass, limb lengths and circumferences are important to:

- Classifying your client's disease risk (obesity is a risk factor for linked to several diseases like type 2 diabetes mellitus, hypertension, hyperlipidemia, cardiovascular disease, certain types of cancer, low back pain, osteoarthritis,...).
- Estimating a healthy body weight and formulating dietary and training strategies
- Estimating competitive body weight and composition for athletes participating in sports that use body weight classifications for competition (e.g. weightlifting, boxing, judo, bodybuilding,...) – but all fitness components depend on body composition to some extend.
- Monitoring the growth of children and adolescents and identifying those at risk of over-fatness or under-fatness, respectively
- Assessing changes in body composition associated with ageing, malnutrition, and certain diseases, and monitoring the effectiveness of nutrition and exercise interventions in counteracting these changes.

Modified from Heyward, 2006 (Advanced Fitness Assessment and Exercise Prescription) and Ratamoss, 2012 (in NSCA's Guide to Tests and Assessments)
Going & Davis, 2001 (in: ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription).



Contribution of abdominal obesity (increased waist measurement) as therapeutic target for better management of risk of coronary heart disease.



Potential benefits of moderate (5-10%) weight loss in high risk patients with cluster of atherothrombotic, pro-inflammatory metabolic abnormalities associated with hypertriglyceridaemic waist. Weight loss in abdominally obese patients is associated with selective mobilization of diabetogenic and atherogenic visceral adipose tissue, even 5-10% weight loss is associated with preferential mobilization of visceral adipose tissue, leading to simultaneous improvement in all metabolic markers of coronary heart disease risk. Thus simultaneous metabolic improvements associated with mobilization of visceral adipose tissue may contribute substantially to reduced risk of acute coronary event in high risk patients.

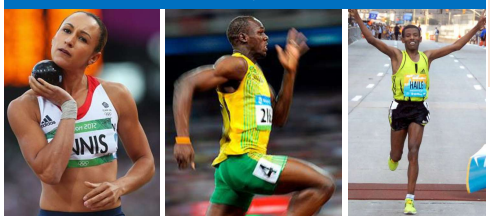
Despres et al., 2001

An increase in **lean body mass** contributes to strength and power development.

A sufficient level of **lean body mass** also contributes to speed, quickness and agility performance.

On the other hand additional weight (in form of **nonessential fat**) provides greater resistance to athletic motion and can limit endurance, balance, coordination, range of motion.

Ratamess, 2012



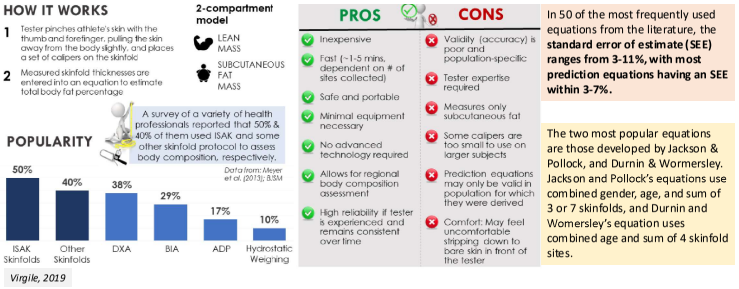
Body composition in athletes

Endurance athletes such as distance runners, cyclists, and triathletes benefit greatly from having **low** percent **body fat**.
Athletes such as gymnasts, wrestlers, high jumpers, pole vaulters, boxers, mixed martial artists, and weightlifters benefit greatly from having a **high strength-to-mass (and power-to-mass) ratio**. The bigger the body the greater the need to for all types of strength to tollerate the forces involved.

Recommended article:
https://www.nsca.com/education/articles/kinetic-select/sport-performance-and-body-composition/

Assessing body composition with skinfold measurements is by far the most prominent technique used by sport & fitness professionals. Various skinfold techniques and body composition estimation equations exist. In effort to standardize measurements, guidelines for the anatomical location of skinfold sites and measurement technique have been published, most recently by the International Society of Kinanthropometry (ISAK).

Skinfold Measurement

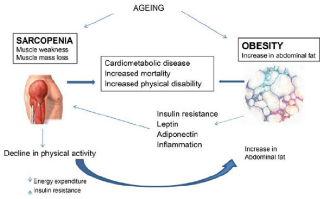


In 50 of the most frequently used equations from the literature, the **standard error of estimate (SEE) ranges from 3-11%, with most prediction equations having an SEE within 3-7%.**

The two most popular equations are those developed by Jackson & Pollock, and Durnin & Wormersley. Jackson and Pollock's equations use combined gender, age, and sum of 3 or 7 skinfolds, and Durnin and Womersley's equation uses combined age and sum of 4 skinfold sites.

Assessing changes in body composition associated with ageing - monitoring the effectiveness of nutrition and exercise interventions in counteracting these changes.

Energy expenditure, and therefore energy requirement, generally decreases with advancing age because of a decrease in basal metabolic rate (BMR) and physical activity. The effect of physical activity level is twofold: first it has a positive effect on the BMR, and second it has a positive effect on the fat-free body mass. Both effects involve an increase in the total energy expenditure with an increased level of physical activity. At energy balance this will lead to increased energy and nutrient intake, making especially the elderly less vulnerable to inadequate energy and nutrient intake. However, most elderly are not physical active at the recommended level ⇔ Together with the decreased BMR this will result in weight-gain.



Full anthropometric profile (ISAK)

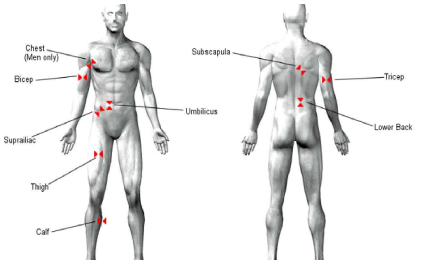
Basic	Skinfolds	Girths	Lengths	Breadths
Mass Stature Sitting height Arm span	Triceps Subscapular Biceps Iliac crest Supraspinale Abdominal Front thigh Medical calf	Head Neck Arm (relaxed) Arm (flexed & tensed) Forearm (maximum) Wrist (distal styloids) Chest (mesosternale) Waist (minimum) Gluteal (hips) Thight (1cm gluteral) Thight (mid tro-tib-lat) Calf (maximum) Ankle (minimum)	Acromiale-Radiale Radiale-Stylion Mid-stylion-dactylion Iliospinale height Trochanterion height Trochanterion-tibiale-laterale Tibiale laterale height Tibiale mediale sphyrion tibiale	Biacrominal A-P abdominal Depth Billiocristal Foot length Transverse chest A-P chest depth Humerus Bi-styloid Femur

For details see Norton, 2018 (recommended reading)

https://www.researchgate.net/publication/333585249_Standards_for_Anthropometry_Assessment

Skinfold Measurement

- One of the most popular and practical methods for estimating percent body fat.
- Based on the principle that the amount of subcutaneous fat is directly proportional to the amount of body fat.
- Relatively accurate provided that a trained technician performs the measurement using high-quality calipers.
- Number of sites needs to be predetermined based on the population tested and a
- regression equation (e.g. Jackson & Pollock) has to be used (3, 4, 7 sites).



Home learning task !
How to perform a 7-site skinfold body fat measurement on a male
https://www.youtube.com/watch?v=hQWoq8D9xnE

Percent body fat (% BF) estimates and classifications and for different age groups

There are no universally accepted standards for % BF! Interpretation of %BF estimates is complicated as there are different methods used (not really comparable results) and all methods are indirect (error must be considered). Results can only be compared with reference values using the same method and an appropriate reference population.
⇒ Practitioners must choose from many classifications proposed by various authors.
⇒ % body fat standards vary with age, gender, ethnicity and activity status.

Rating male	18-25	26-35	36-45	46-55	56-65	> 66	age group
Very lean	4-7	8-12	10-14	12-16	15-18	15-18	
Lean	8-10	11-15	16-18	18-20	19-21	19-21	
Leaner than average	11-13	16-18	19-21	21-23	22-24	22-23	
Average	14-16	19-21	22-24	24-25	24-26	24-25	
Slightly high	18-20	21-24	25-26	26-28	26-28	25-27	
High	22-26	25-28	27-29	29-31	29-31	28-30	
Obese	> 28	> 30	> 30	> 32	> 32	> 31	

Rating female	18-25	26-35	36-45	46-55	56-65	> 66	age group
Very lean	13-17	11-18	15-19	18-22	18-23	16-18	
Lean	18-20	19-21	20-23	23-25	24-26	22-25	
Leaner than average	21-23	21-23	24-26	26-28	28-30	27-29	
Average	24-25	24-26	27-29	29-31	31-33	30-32	
Slightly high	26-28	27-30	30-32	32-34	34-36	33-35	
High	29-31	31-35	33-36	36-38	36-38	36-38	
Obese	> 33	> 36	> 39	> 39	> 39	> 39	

(Harmann & Garhammer, 2008)

Bioelectrical Impedance Analyses (BIA):

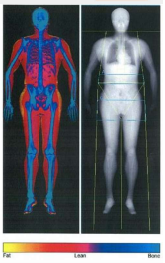
The underlying principle for BIA is that electrical conductivity in the body is proportional to the fat-free tissue of the body *(ACSM, 2007)*. A small electrical current is sent through the body, and the impedance to that current is measured. The conductivity differences among bodily tissues allows BIA to predict the breakdown of (1) lean mass, (2) fat mass, and (3) body water (lean tissue (water) = good conductor; fat = poor conductor.

- Accuracy among BIA devices varies greatly.
- Proper methodical requirements necessary:
- Not eaten within 4 hrs before the test; no exercise 12 hrs before the test; no alcohol or diuretics; completely voided the bladder within 30 minutes before the test,…

Dual Energy X-Ray Absorptiometry

Body Composion DEXA Result

Region	Bone Mineral Content (g)	Fat Mass (g)	Lean Mass (g)	Lean + BMC Mass (g)	Total Mass (g)	% Fat
L Arm	175.62	899.30	3062.80	3238.42	4137.72	21.7%
R Arm	195.28	892.20	3438.90	3634.18	4526.38	19.7%
Trunk	586.81	6113.10	26995.10	27581.91	33695.01	18.1%
L Leg	528.80	3040.80	9100.40	9629.20	12670.00	24.0%
R Leg	527.07	2983.00	9062.80	9589.87	12572.87	23.7%
Subtotal	2013.58	13928.40	51660.00	53673.58	67601.98	20.6%
Head	467.90	1153.90	3108.50	3576.40	4730.30	24.4%
Total	**2481.48**	**15082.30**	**54768.50**	**57249.98**	**72332.28**	**20.9%**



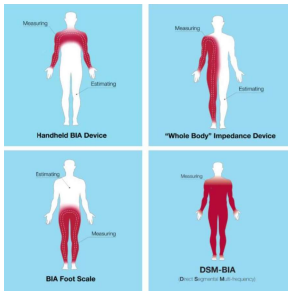
BMI (kg/height²) 25.4 Height (m) 1.686

Adipose Indices
Total Body% fat 20.9%
Fat Mass/Height² (kg/m²) 5.31
Trunk/Limb Fat mass ratio 0.78

Lean + BMC Indices
Lean + BMC Mass/Height² (kg/m²) 20.14
Appendicular Lean + BMC Mass/Height² (kg/m²) 8.68

Single-frequency (SF-BIA)
single frequency ≤ 50 kHZ
cannot differentiat between between water inside and outside cells

Multiple-frequency (SF-BIA) = Bioelectrical spectroscopy
single frequency > 50 kHZ
Can additionally estimate intracellular water volumes



There are many different BIA devices, with the most popular being hand-to-hand (i.e. handheld), foot-to-foot (i.e. standing scale), hand-to-foot or "whole body" (i.e. adhesive electrodes or scale-handheld combo), and direct segmental (i.e. modern method using advanced technology).

Although many BIA equations have been investigated, **its accuracy/validity for estimating total body water and fatness is limited, particularly in athletes and trained individuals. BIA prediction inaccuracy typically sits between the 2-3% to 5-6% range, when compared with the most accurate assessment methods**. Although this is not always the case, BIA tends to underestimate the body fat percentage; it gives lower values, compared with more precise methods. It's also important to note that the error in precision tends to increase in individuals with higher body fat percentages

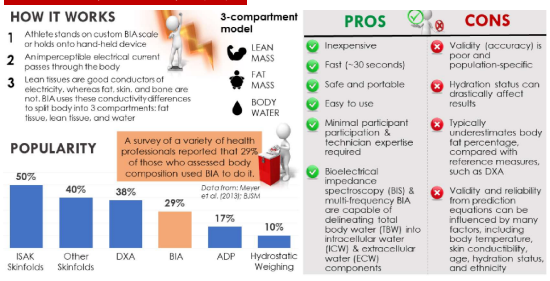
DXA(Dual Energy X-Ray Absorbtiometry)

Most common measure of Bone Mineral Content (BMC - g) and Bone Mineral Density (BMD – g/cm^2)

Accurate
Precise
Little Radiation Exposure

No measure of bone architecture
No differentiation between trabecular and cortical bone
2D estimate of bone's 3D structure

Bioelectrical Impedance Analyses (BIA):



BIA is one of the most widely utilized techniques for measuring body composition, with 29% of national and international sport professionals reporting its use for body composition assessment, in a 2013 survey. BIA was particularly popular in Europe, where it was the 2nd-most popular method for body composition assessment. Skinfold measurements came in at 1st, with 47-50% of European sport professionals utilizing this method, followed by BIA at 42% and, then, DXA at 35%.
BIA was not nearly as popular in the Americas or Oceania, with 15% and 14% of professionals reporting its use, respectively. Despite its lack of validity in athletes, its safety, affordability, and speed of data collection make BIA a practical body composition assessment option in the applied sports setting.

DXA = Dual energy x-ray absorptiometry

Passes filtered x-ray beams with two different photon energies (emitting a very small dose of ionizing radiation) through the body to produce pictures of the inside of the body, and is considered one of the **"gold standard"** methods for body composition assessment.
DXA can estimate the breakdown of (1) lean tissue mass, (2) fat mass, and (3) bone mineral density, by body segment, because each tissue differentiates photons differently.

DXA has many advantages. It is easy to administer (but in many counties only medical staff is allowed to this),
it is fast (approx. 5-25 minutes), accurate and comfortable for most subjects. However, DXA has some limitations.
The scanning bed is not designed for large people (this eliminates many sportsmen) and the devices are large and expensive.
There is a lack of standardization between different DXA devices ⇔ same device for repeated measurements required.
(body fat variation ≈ 1.7% using different devices).
DXA scans register usually higher body fat percentages (2-5%) compared to other procedures.

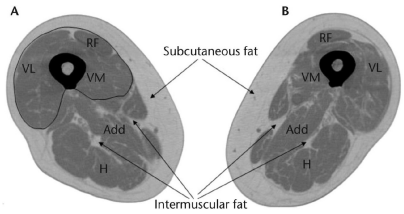
Air Displacement Plethysmography (ADP):

Body Volume can also be measured by air displacement rather than water displacement.
Offers several advantages over other methods (quick, comfortable, noninvasive) but is very expensive.
The volume of air displaced is equal to the body volume and is calculated by subtracting the volume of air remaining in the chamber when the subject is inside the chamber from the volume of air in the chamber when it is empty.

ADP = Air displacement plethysmography.
The subject is required to sit inside an enclosed chamber (plethysmograph), most commonly measured via a device called the BOD POD, and is considered another "gold standard" method for body composition assessment. It estimates the subject's body volume from the air that gets displaced when the subject is in the chamber, and using Boyle's law (and the Siri equation), ADP estimates the breakdown of lean mass, and fat mass, inside the body.

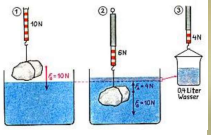
Computed Tomography Scans and Magnetic Resonance Imaging

These techniques produce scans that can noninvasively quantify tissue volume such as regional fat distribution. High costs but important and frequently used for research purposes.

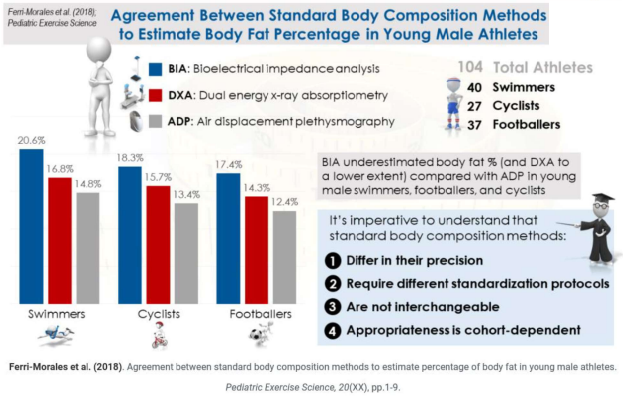


Hydrodensitometry - underwater weighing (UWW):

Has historically been considered the gold standard, for body composition analyses. Based on the Archimedes' principle where a body immersed in water encounters a buoyant force that results in weight loss equal to the weight of water displaced during immersion. Subtracting the body weight in water from the body weight on land provides the weight of the displaced water. Body fat contributes to buoyancy because the density of fat is less than water, whereas lean tissue mass exceeds the density of water *(McArdle et al., 2007)*



UWW = Underwater weighing.
The subject is required to exhale all of the air from their lungs (or as much as possible), and then be weighed underwater, which requires full body submersion.
UWW is considered another "gold standard" method for body composition assessment.
Conceptually, it's similar to ADP, but is based on Archimedes' principle and estimates the subject's body volume from the volume of water that gets displaced when underwater. UWW estimates the breakdown of (1) lean mass, and (2) fat mass, inside the body.



Ferri-Morales et al. (2018). Agreement between standard body composition methods to estimate percentage of body fat in young male athletes. *Pediatric Exercise Science, 20*(XX), pp.1-9.

Near-Infrared Interactance (NIR)

Is based on the principles of light absorption and reflection. Near infrared light is emitted at specific wavelengths and the absorption of the infrared beam is measured via a detector. Equations estimate percent body fat via optical density, gender, height, physical activity level, and body weight. Relatively high error rate (not recommended for healthy and athletic population).

Assessment	Advantages	Disadvantages
BMI	Easy to assess No special equipment required Noninvasive measurement	Not valid for athletes Does not factor large muscle mass
Girth	Easy to assess Minimal training needed Minimal equipment Quick test time Many formulas to select from Good indicator of size changes	Not always related to fat content Less accurate than other methods
Skinfold	Easy to use once properly trained Time efficient Noninvasive Relatively inexpensive Many equations to choose from	Prone to technician error Less accurate for very lean or obese Considers mostly subcutaneous fat Potential discomfort to subject
Hydrodensitometry	Gold standard Very accurate, valid and reliable	Time consuming Lot of equipment and space required High costs Requires in-depth examiner knowledge Can be uncomfortable Requires measurement of lung volume

Assessment	Advantages	Disadvantages
Air Displacement Plethysmography	Accurate, valid and reliable Easy to operate Short measurement time Relaxed atmosphere for subject	High costs Equipment not very accessible Minimal tight clothing required Not portable
Bioelectrical Impedance Analyses	Requires little technical expertise Fast testing procedure Very easy if scale-type or handheld models are used Easily transportable Does not require minimal clothing	Several confounding variables must be avoided High degree of error if procedures are not strictly followed
Near-Infrared Interactance	Safe and non-invasive Fast and convenient Portable Little Training needed	Least accurate assessment tool
DXA	Very accurate Low radiation exposure Comprehensive measurements Quick measurement time Gives regional measurements	Very expensive Limited access May require prescription from physician
CT / MRI	Very accurate Many applications	Very expensive Limited access Time consuming