BODYGEE

Body Fat Measurement Methods

Body fat is not measured directly, but rather predicted, based on measurements of body properties. Laboratory methods are very accurate and serve as references (the "Gold Standard"). Field methods predict body fat by using mathematical formulas that have been derived from laboratory methods. They are less expensive and easier to use than laboratory methods, but also more error-prone.

LABORATORY METHODS	Measurement	Pros/Cons
Magnetic Resonance Imaging (MRI) / Computed Tomography (CT)	MRI/CT produces high resolution, anatomical images of the human body that allow assessment of the volume of fat and skeletal muscle as well as other internal tissues and organs	**PROS** most precise and accurate method **CONS** very expensive, requires long analysis process, difficult to access, exposure to radiation (CT)
Dual Energy X-ray Absorptiometry (DXA)	DXA measures the different attenuation of X-rays through the human tissue and distinguish between fat, bone mineral mass and fat free mass	**PROS** more cost and time efficient than MRI/CT, most frequently used as the "Gold Standard" **CONS** exposure to a small dose of radiation, difficult to access
Hydrodensitometry (Underwater Weighing UWW) / Air Displacement Plethysmography (ADP)	UWW and ADP measures body density and allows for the calculation of body fat, since the human lean mass has a different overall density compared to fat mass	**PROS** former "Gold Standard", based on simple calculations, cheaper and more widespread than DXA, MRI/CT **CONS** subjects are involved to a large extent, less accurate compared to other laboratory methods

FIELD METHODS	Measurement	Pros/Cons
BODYGEE **3D Photonic Scanning (3D Scan)**	3D scanning is a digitized optical method that generates a three-dimensional photonic image of the human body. Body fat is determined, either similarly to UWW/ADP, by measuring body density (via body volume and weight) or by a prediction equation that relates anthropometric data to body fat, assuming that anthropometric characteristics and body fat are linked	**PROS** includes visual feedback, less error-prone than other field methods, requires less stringent preparation **CONS** results can be affected by variations in clothing and pose *Accuracy: deviations of <3% body fat compared to laboratory methods. High re-test accuracy due to digitized anthropometry[1]
Bioelectric Impedance Measurement (BIA)	BIA measures the impedance of the body to a small electric current, in order to estimate body water. Prediction equations relate bioelectrical data to body fat. This is based on the assumption that the amount of body fat can be estimated, based on its different water content compared to other tissue	**PROS** rapid, easy to apply **CONS** results can be affected by hydration status (food intake, exercise) and measurement procedure (type of device, sensor placement) *Accuracy: deviations of <4.5% body fat compared to laboratory methods[2]
Skinfold Thickness Measurement (Caliper)	The skinfold thickness is measured at several standardized points on the body and then related to body fat, by means of a prediction equation. This is based on the assumption that the thickness of subcutaneous fat tissue is related to total body fat	**PROS** cheap, not demanding **CONS** needs trained personnel to ensure precision, physically uncomfortable *Accuracy: deviations of ~9% body fat compared to laboratory methods[3]

*based on scientific references:
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Garlie TN, Obusek JP, Corner BD, Zambraski EJ (2010) Comparison of body fat estimates using 3D digital laser scans, direct manual anthropometry, and DXA in men. Am J Hum Biol 22:695-701
Wang J, Gallagher D, Thornton JC, Yu W, Horlick M, Pi-Sunyer FX (2006) Validation of a 3-dimensional photonic scanner for the measurement of body volumes, dimensions, and percentage body fat. Am J Clin Nutr 83:809-816
(2) Moon JR (2013) Body composition in athletes and sports nutrition: an examination of the bioimpedance analysis technique. Eur J Clin Nutr 67 Suppl 1:S54-59
Pateyjohns IR, Brinkworth GD, Buckley JD, Noakes M, Clifton PM (2006) Comparison of three bioelectrical impedance methods with DXA in overweight and obese men. Obesity (Silver Spring) 14:2064-2070
(3) Wells JC, Fewtrell MS (2006) Measuring body composition. Arch Dis Child 91:612-617