

Muscle is Muscle, right?

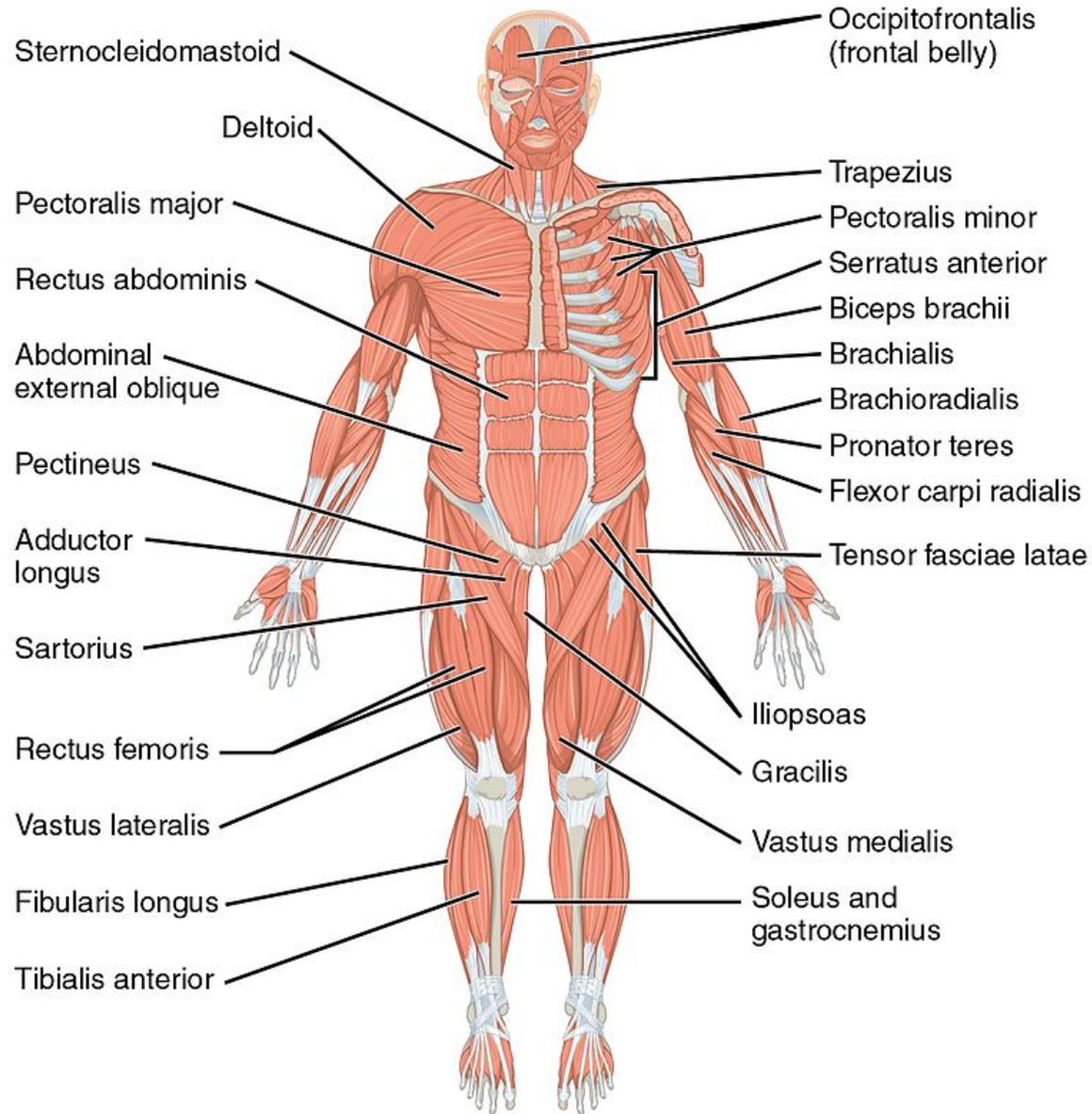
An explanation of different muscle parameters used in the diagnosis of Sarcopenia & Malnutrition



Michael Johannes Maisch, MD

Disclosure

- Financial Relationships:
 - Chief Medical Advisor at **seca** Hamburg, Germany
- Nonfinancial Relationships:
 - Member of ESPEN (European Society for Clinical Nutrition and Metabolism)
 - Member of DGEM (German Society for Nutritional Medicine)
 - Member of DAG (German Society for Obesity)
 - Member of DGIM (German Society for Internal Medicine)
 - Member of DGHO (German Society for Hematology and Oncology)
 - Member of DGGG (German Society for Obstetrics and Gynecology)
 - Member of IPS (International Prehabilitation Society)

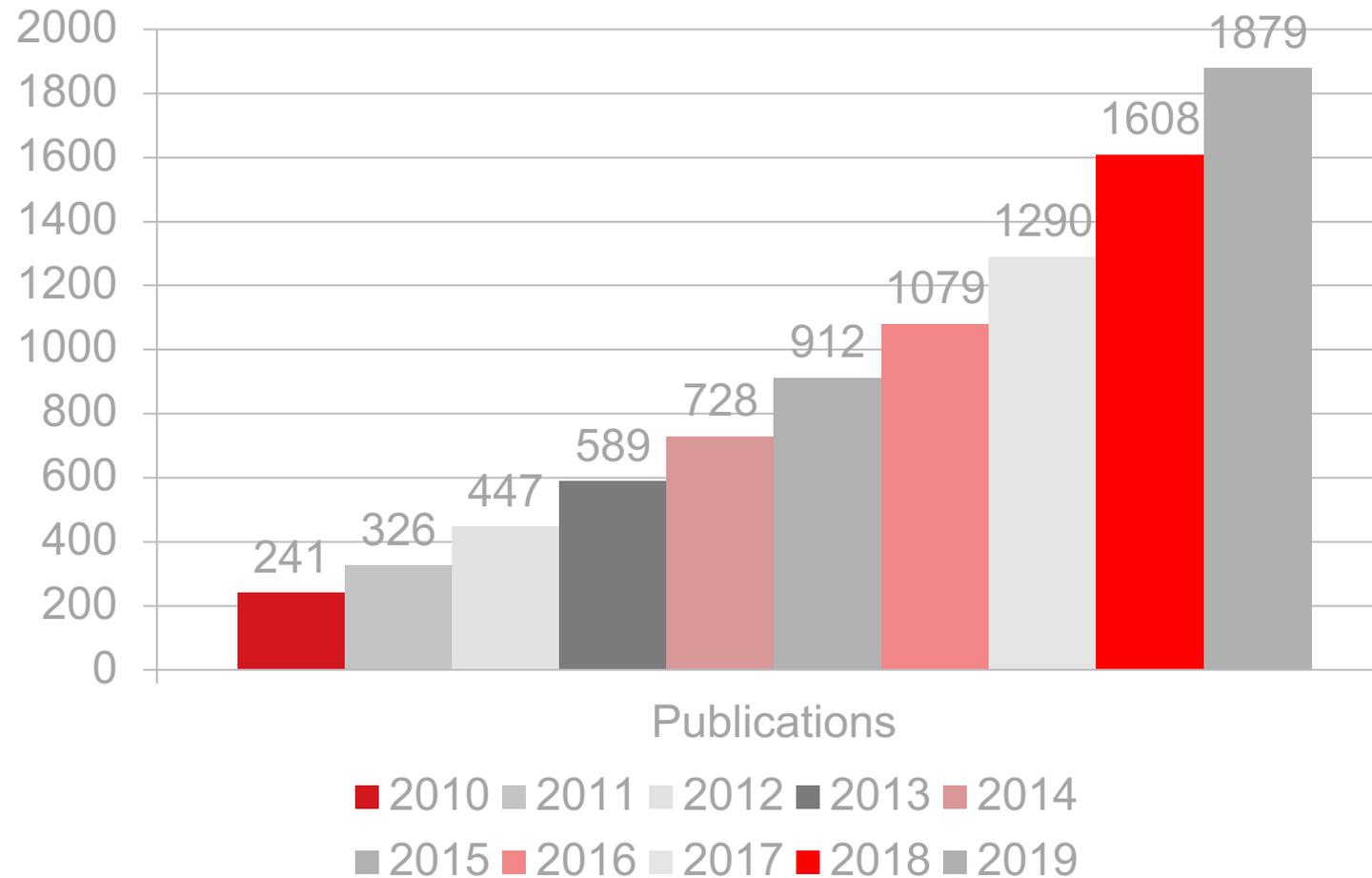


Muscle

- Everyone knows what muscle is
- So why this lecture?

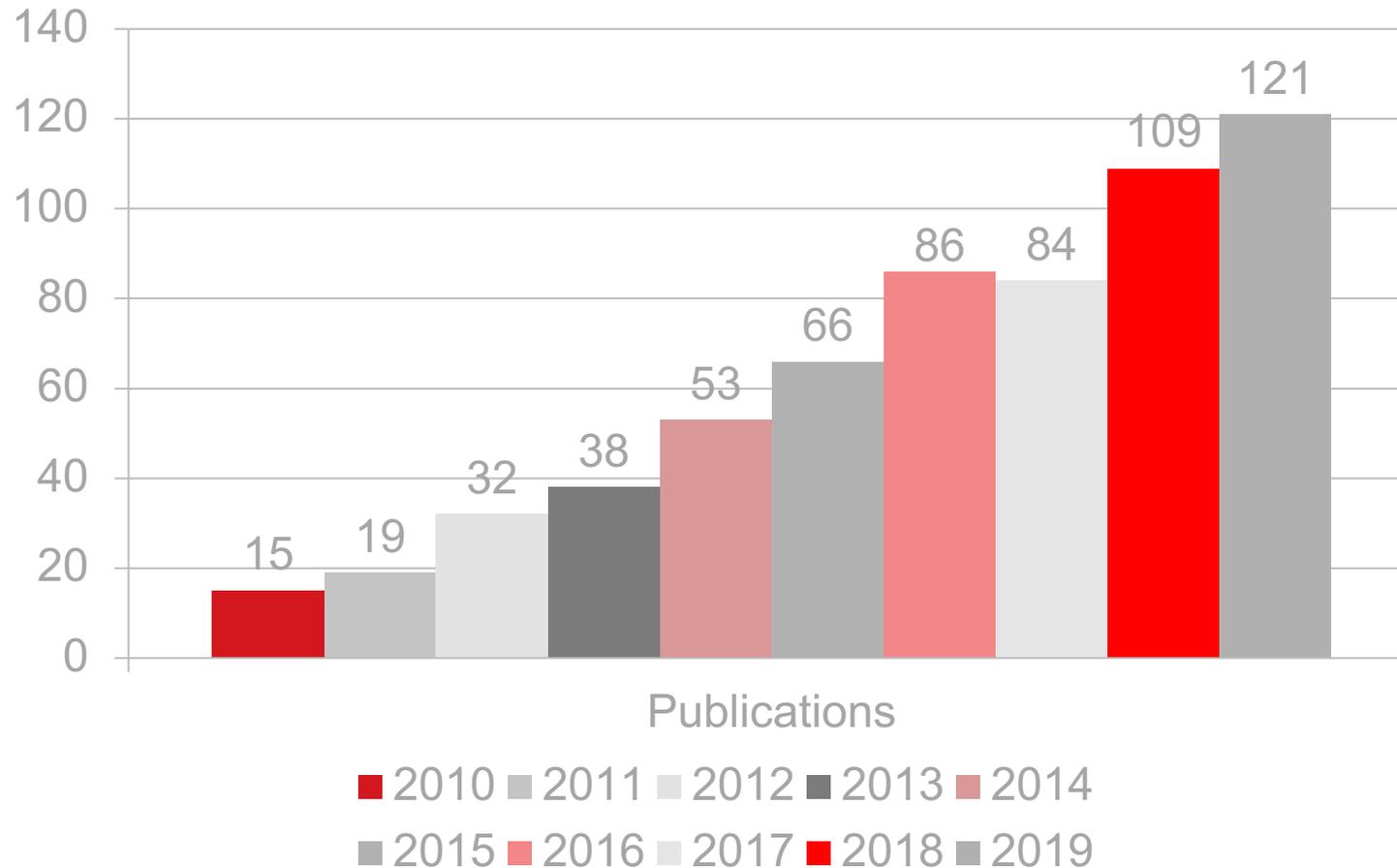
Sarcopenia

Search results of "sarcopenia" on pubmed



Sarcopenic obesity

Search results of “sarcopenic obesity“ on pubmed



Sarcopenia & sarcopenic obesity 2005

Clin Nutr. 2005 Feb;24(1):133-42.

Increased length of hospital stay in underweight and overweight patients at hospital admission: a controlled population study.

Kyle UG¹, Pirlich M, Lochs H, Schuetz T, Pichard C.

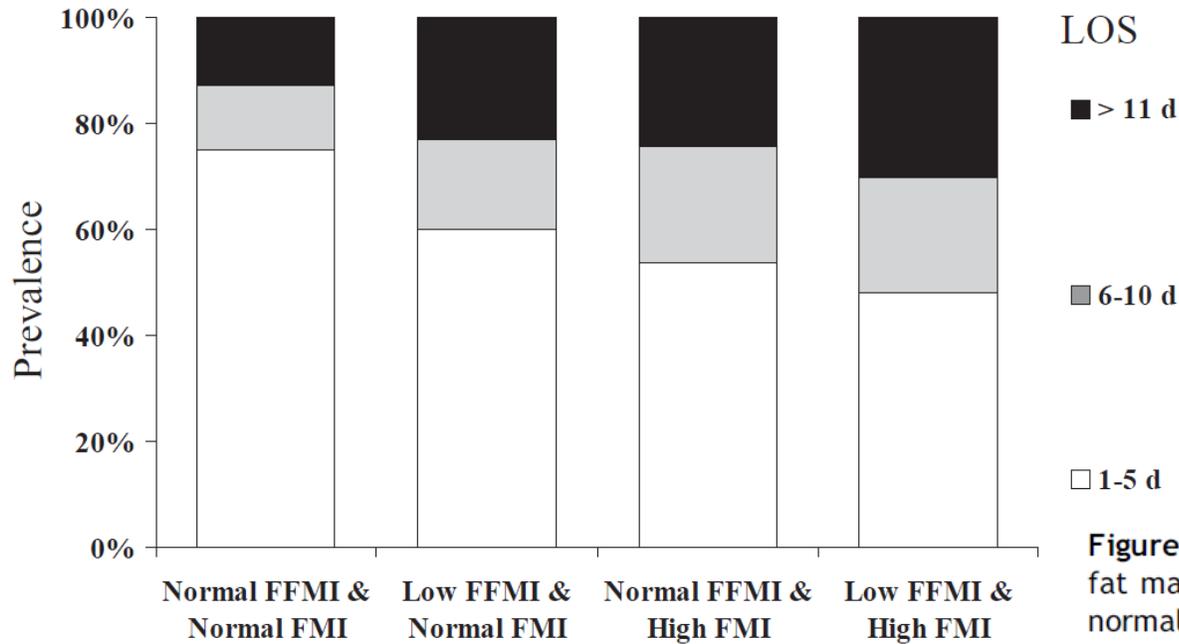


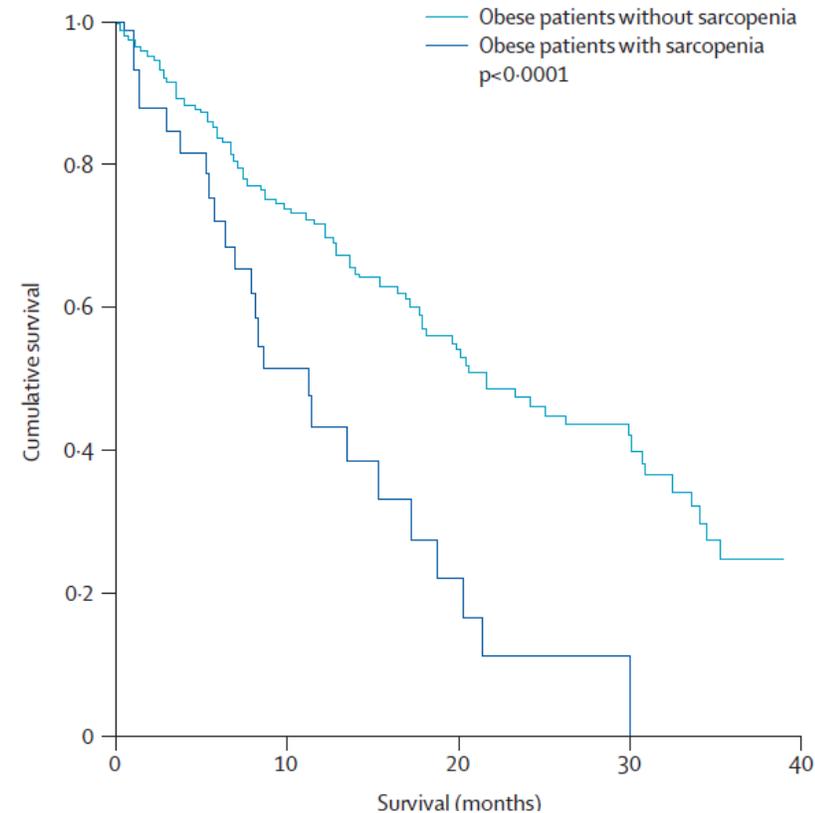
Figure 1 Prevalence (%) of fat-free mass index and body fat mass index at hospital admission. Prevalence (%) of normal FFMI and normal FMI, low FFMI and normal FMI, normal FFMI and high FMI and low FFMI and high FMI in 1707 patients hospitalized for 1–5, 6–10 and ≥ 11 days. The proportion of patients hospitalized ≥ 11 days was highest in patients with low FFMI and high FMI. χ^2 49.7, degrees of freedom 6, $P < 0.001$.

Clinical implications of sarcopenia & sarcopenic obesity

[Lancet Oncol.](#) 2008 Jul;9(7):629-35. doi: 10.1016/S1470-2045(08)70153-0. Epub 2008 Jun 6.

Prevalence and clinical implications of sarcopenic obesity in patients with solid tumours of the respiratory and gastrointestinal tracts: a population-based study.

[Prado CM¹](#), [Liefers JR](#), [McCargar LJ](#), [Reiman T](#), [Sawyer MB](#), [Martin L](#), [Baracos VE](#).

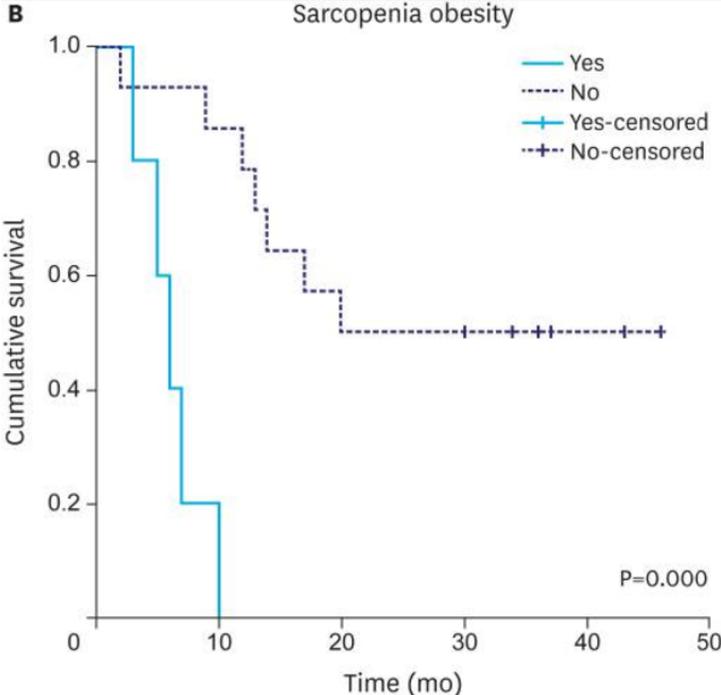


Clinical implications of sarcopenia & sarcopenic obesity

J Gastric Cancer. 2017 Mar;17(1):74-87. doi: 10.5230/jgc.2017.17.e8. Epub 2017 Mar 14.

Body Composition as a Prognostic Factor of Neoadjuvant Chemotherapy Toxicity and Outcome in Patients with Locally Advanced Gastric Cancer.

Palmela C¹, Velho S², Agostinho L³, Branco F⁴, Santos M⁵, Santos MP¹, Oliveira MH⁶, Strecht J³, Maio R⁵, Cravo M¹, Baracos VE⁷.



Definition and diagnosing of sarcopenia

Clin Nutr. 2015 Jun;34(3):335-40. doi: 10.1016/j.clnu.2015.03.001. Epub 2015 Mar 9.

Diagnostic criteria for malnutrition - An ESPEN Consensus Statement.

Cederholm T¹, Bosaeus I², Barazzoni R³, Bauer J⁴, Van Gossum A⁵, Klek S⁶, Muscaritoli M⁷, Nyulasi I⁸, Ockenga J⁹, Schneider SM¹⁰, de van der Schueren MA¹¹, Singer P¹².

Clin Nutr. 2017 Feb;36(1):49-64. doi: 10.1016/j.clnu.2016.09.004. Epub 2016 Sep 14.

ESPEN guidelines on definitions and terminology of clinical nutrition.

Cederholm T¹, Barazzoni R², Austin P³, Ballmer P⁴, Biolo G⁵, Bischoff SC⁶, Compher C⁷, Correia I⁸, Higashiguchi T⁹, Holst M¹⁰, Jensen GL¹¹, Malone A¹², Muscaritoli M¹³, Nyulasi I¹⁴, Pirlich M¹⁵, Rothenberg E¹⁶, Schindler K¹⁷, Schneider SM¹⁸, de van der Schueren MA¹⁹, Sieber C²⁰, Valentini L²¹, Yu JC²², Van Gossum A²³, Singer P²⁴.

Clin Nutr. 2019 Feb;38(1):1-9. doi: 10.1016/j.clnu.2018.08.002. Epub 2018 Sep 3.

GLIM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community.

Cederholm T¹, Jensen GL², Correia MITD³, Gonzalez MC⁴, Fukushima R⁵, Higashiguchi T⁶, Baptista G⁷, Barazzoni R⁸, Blaauw R⁹, Coats A¹⁰, Crivelli A¹¹, Evans DC¹², Gramlich L¹³, Fuchs-Tarlovsky V¹⁴, Keller H¹⁵, Llido L¹⁶, Malone A¹⁷, Mogensen KM¹⁸, Morley JE¹⁹, Muscaritoli M²⁰, Nyulasi I²¹, Pirlich M²², Pisprasert V²³, de van der Schueren MAE²⁴, Siltharm S²⁵, Singer P²⁶, Tappenden K²⁷, Velasco N²⁸, Waitzberg D²⁹, Yamwong P³⁰, Yu J³¹, Van Gossum A³², Compher C³³, GLIM Core Leadership Committee; GLIM Working Group.

Definition and diagnosing of sarcopenia

[J Am Med Dir Assoc](#). 2014 Feb;15(2):95-101. doi: 10.1016/j.jamda.2013.11.025.

Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia.

[Chen LK](#)¹, [Liu LK](#)², [Woo J](#)³, [Assantachai P](#)⁴, [Auyeung TW](#)³, [Bahyah KS](#)⁵, [Chou MY](#)⁶, [Chen LY](#)², [Hsu PS](#)⁷, [Krairit O](#)⁸, [Lee JS](#)³, [Lee WJ](#)⁹, [Lee Y](#)¹⁰, [Liang CK](#)⁶, [Limpawattana P](#)¹¹, [Lin CS](#)¹², [Peng LN](#)², [Satake S](#)¹³, [Suzuki T](#)¹⁴, [Won CW](#)¹⁵, [Wu CH](#)¹⁶, [Wu SN](#)¹⁷, [Zhang T](#)¹⁷, [Zeng P](#)¹⁷, [Akishita M](#)¹⁸, [Arai H](#)¹⁹.

[J Am Med Dir Assoc](#). 2016 Aug 1;17(8):767.e1-7. doi: 10.1016/j.jamda.2016.05.016. Epub 2016 Jun 29.

Recent Advances in Sarcopenia Research in Asia: 2016 Update From the Asian Working Group for Sarcopenia.

[Chen LK](#)¹, [Lee WJ](#)², [Peng LN](#)³, [Liu LK](#)³, [Arai H](#)⁴, [Akishita M](#)⁵; [Asian Working Group for Sarcopenia](#).

[J Am Med Dir Assoc](#). 2011 May;12(4):249-56. doi: 10.1016/j.jamda.2011.01.003. Epub 2011 Mar 4.

Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. International working group on sarcopenia.

[Fielding RA](#)¹, [Vellas B](#), [Evans WJ](#), [Bhasin S](#), [Morley JE](#), [Newman AB](#), [Abellan van Kan G](#), [Andrieu S](#), [Bauer J](#), [Breuille D](#), [Cederholm T](#), [Chandler J](#), [De Meynard C](#), [Donini L](#), [Harris T](#), [Kannt A](#), [Keime Guibert F](#), [Onder G](#), [Papanicolaou D](#), [Rolland Y](#), [Rooks D](#), [Sieber C](#), [Souhami E](#), [Verlaan S](#), [Zamboni M](#).

[Age Ageing](#). 2010 Jul;39(4):412-23. doi: 10.1093/ageing/afq034. Epub 2010 Apr 13.

Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People.

[Cruz-Jentoft AJ](#)¹, [Baeyens JP](#), [Bauer JM](#), [Boirie Y](#), [Cederholm T](#), [Landi F](#), [Martin FC](#), [Michel JP](#), [Rolland Y](#), [Schneider SM](#), [Topinková E](#), [Vandewoude M](#), [Zamboni M](#); [European Working Group on Sarcopenia in Older People](#).

[Age Ageing](#). 2019 Jan 1;48(1):16-31. doi: 10.1093/ageing/afy169.

Sarcopenia: revised European consensus on definition and diagnosis.

[Cruz-Jentoft AJ](#)¹, [Bahat G](#)², [Bauer J](#)³, [Boirie Y](#)⁴, [Bruyère O](#)⁵, [Cederholm T](#)⁶, [Cooper C](#)⁷, [Landi F](#)⁸, [Rolland Y](#)⁹, [Sayer AA](#)¹⁰, [Schneider SM](#)¹¹, [Sieber CC](#)¹², [Topinkova E](#)¹³, [Vandewoude M](#)¹⁴, [Visser M](#)¹⁵, [Zamboni M](#)¹⁶; [Writing Group for the European Working Group on Sarcopenia in Older People 2 \(EWGSOP2\), and the Extended Group for EWGSOP2](#).

Definition and diagnosing of sarcopenia

- a. Primärliteratur AWGOS
- a. Primärliteratur AWGOS2
- b. Primärliteratur IWGS
- d. Primärliteratur EWGOSP
- e. Primärliteratur GLIM
- a. AWGOS Sarcopenia in Asia . consensus report of the Asian Working Group for Sarcopenia.
- a. AWGOS2 Recent Advances in Sarcopenia Research in Asia - 2016 Update From the Asian Working Group for Sarcopenia
- a. What is the best adjustment of appendicular lean mass for predicting mortality or disability among Japanese elderly?
- b. Sarcopenia - an undiagnosed condition in older adults. International working group on sarcopenia.
- c. International Clinical Practice Guidelines for Sarcopenia (ICFSR) Screening, Diagnosis and Management
- c. The FNIH sarcopenia project - rationale, study description, conference recommendations, and final estimate
- d. EWGSOP Sarcopenia - European consensus on definition and diagnosis
- d. EWGSOP2 Sarcopenia -revised European consensus on definition and diagnosis
- e. GLIM 2018
- 3) The FNIH sarcopenia project - rationale, study description, conference recommendations, and final estimate
- 8) Prevalence of sarcopenia estimated using a bioelectrical impedance analysis prediction equation
- 12) SARC-F A Simple Questionnaire to Rapidly Diagnose Sarcopenia
- 74) Assessing appendicular skeletal muscle mass with bioelectrical impedance analysis in free-living elderly men and women
- 125) Total and appendicular lean mass reference ranges for Australian men and women
- 14) Epidemiology_of_sarcopenia_in_elderly_Japanese
- 15) Prevalence of sarcopenia in community-dwelling Japanese older adults.
- 15-15) Difficulties with physical function associated with obesity, sarcopenia, and sarcopenia
- 16) Development of a simple screening test for sarcopenia in older adults
- 16-9) Association between muscle mass and disability in performing instrumental activities of daily living
- 18) Incidence and predictors of sarcopenia onset in community-dwelling elderly Japanese
- 8) Espen Consensus Statement
- 8b) Fat-free mass index and fat mass index percentiles
- 17) Recent Advances in Sarcopenia Research in Asia - 2016 Update From the Asian Working Group on Sarcopenia
- 17a) Asian Workinggroup on Sarcopenia
- 17b) Epidemiology of sarcopenia in elderly Japanese
- 17c) Association between sarcopenia and higher-level functional capacity in daily living in community-dwelling elderly
- 20) Frailty in older adults - evidence for a phenotype.
- 21) Screening for undernutrition in geriatric practice - developing the short-form mini-nutritional assessment
- 24 b) = 20 b) Appendicular skeletal muscle mass - effects of age, gender, and ethnicity.
- 24) = 20) Epidemiology of sarcopenia among the elderly in New Mexico.
- 25) = 21) Agreement and Predictive Validity Using Less-Conservative Foundation for the National Institutes of Health
- 6) Effects of exercise and amino acid supplementation on body composition and physical function in community-dwelling elderly
- 13) Association between sarcopenia and higher-level functional capacity in daily living in community-dwelling elderly
- 13b) Association between muscle mass and disability in performing instrumental activities of daily living
- 15) The loss of skeletal muscle strength, mass, and quality in older adults -the health, aging and body composition study
- 16) Association between body composition and pulmonary function in elderly people - the Korean Longitudinal Study
- 39) Prevalence of Sarcopenia Estimated Using a Bioelectrical Impedance Analysis Prediction Equation in Community-dwelling Elderly
- 39-22) Estimation of skeletal muscle mass by bioelectrical impedance analysis.
- 40) Comparison of DEXA-derived body fat measurement to two race-specific bioelectrical impedance equations in healthy elderly
- 5) Epidemiology of sarcopenia among the elderly in New Mexico.
- 18) Sarcopenia - alternative definitions and associations with disability
- 71) Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment
- 72) Sarcopenia in elderly men and women - the Rancho Bernardo study.
- 98) (Rosetta) Appendicular skeletal muscle mass - effects of age, gender, and ethnicity.
- 100) Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women.

Definition and diagnosing of sarcopenia



Review

Reference Values for Skeletal Muscle Mass – Current Concepts and Methodological Considerations

Carina O. Walowski ¹, Wiebke Braun ¹, Michael J. Maisch ², Björn Jensen ², Sven Peine ³,
Kristina Norman ^{4,5}, Manfred J. Müller ¹ and Anja Bosy-Westphal ^{1,*}

Definition and diagnosing of sarcopenia

GLIM

Table 2
Examples of recommended thresholds for reduced muscle mass.

	Males	Females	
Appendicular Skeletal Muscle Index (ASMI, kg/m ²) [15]	<7.26	<5.25	
ASMI, kg/m ² [24] ^a	<7	<6	EWGSOP
ASMI, kg/m ² [17] ^b			
DXA	<7	<5.4	AWGS
BIA	<7	<5.7	AWGS
Fat free mass index (FFMI, kg/m ²) [8]	<17	<15	ESPEN
Appendicular lean mass (ALM, kg) [25]	<21.4	<14.1	
Appendicular lean mass adjusted for BMI = ALM/BMI [26]	<0.725	<0.591	

DXA = dual energy x-ray absorptiometry, BIA = bioelectrical impedance analysis.
BMI = body mass index.

^a Recommendations from European Working Group on Sarcopenia in Older People 2 (EWGSOP2); personal communication Alfonso Cruz-Jentoft.

^b Recommendations from Asian Working Group for Sarcopenia (AWGS) for Asians.

ASMI

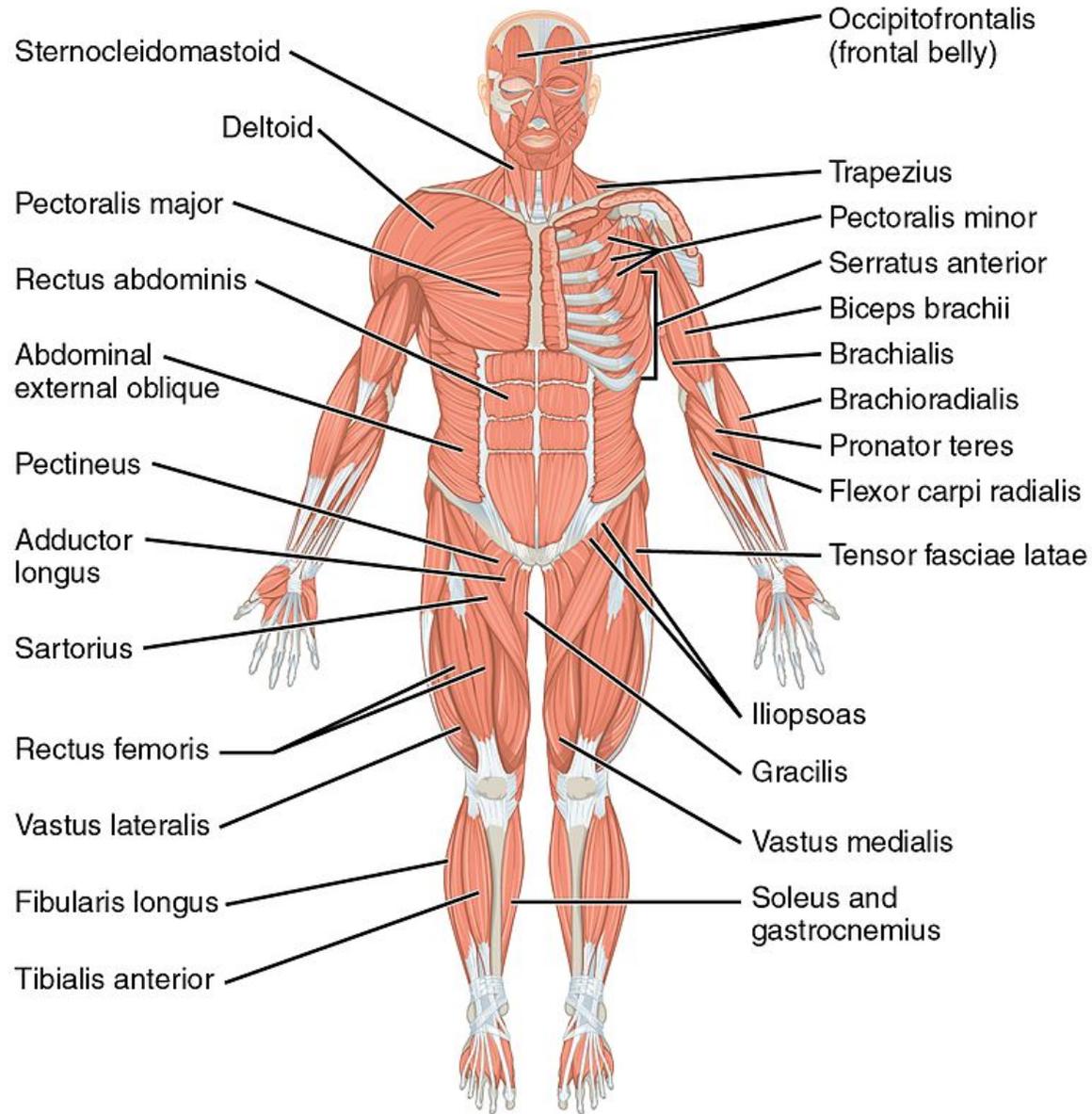
Appendicular Skeletal Muscle Index

FFMI

Fat-Free Mass Index

ALM

Appendicular Lean Mass

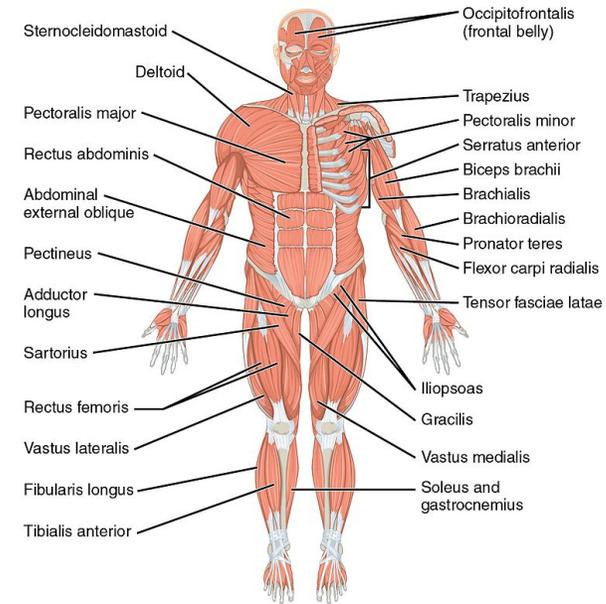


Muscle....

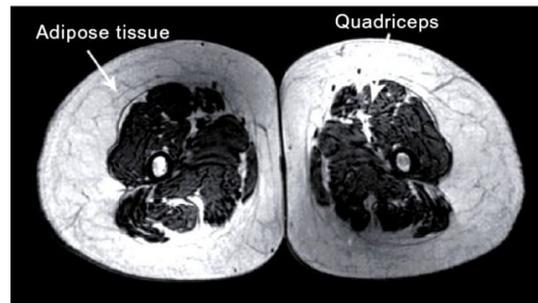
Methodology



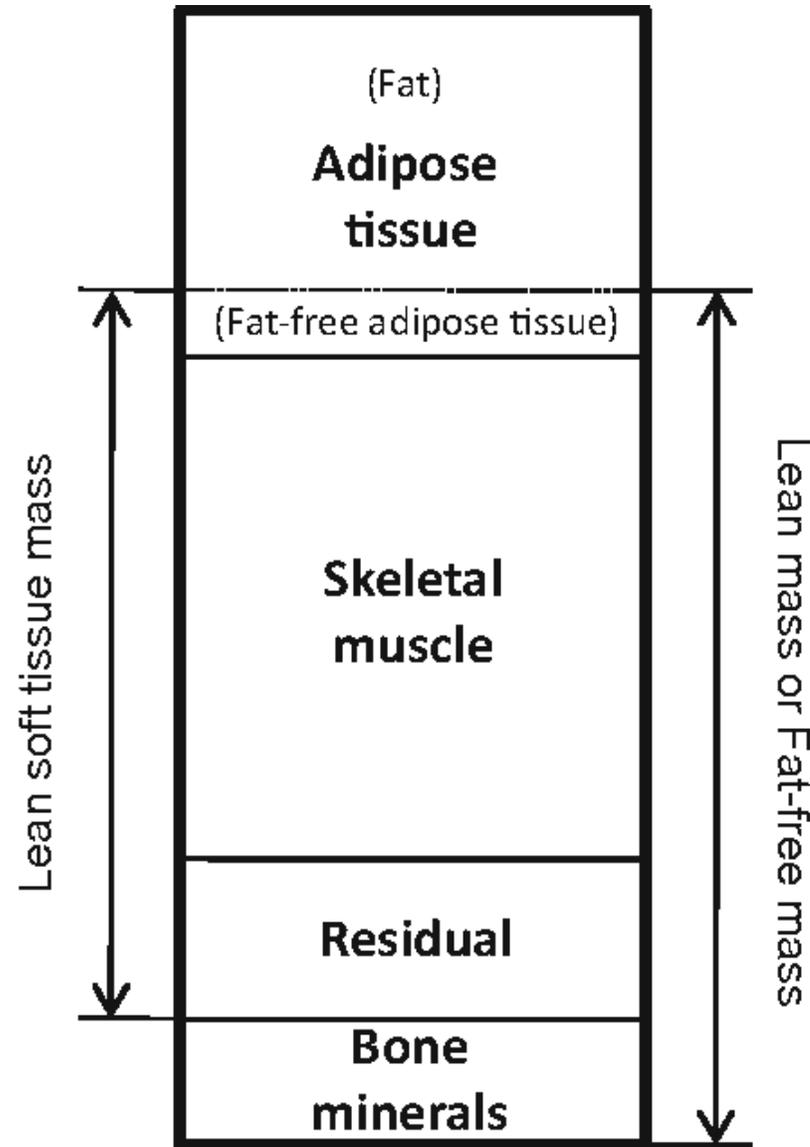
Whole body MRI



Whole body muscle mass



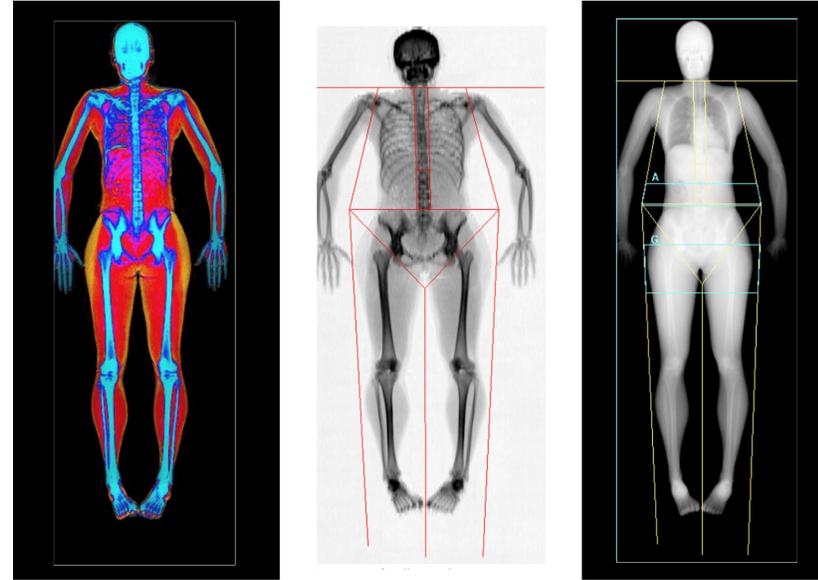
Methodology



Methodology



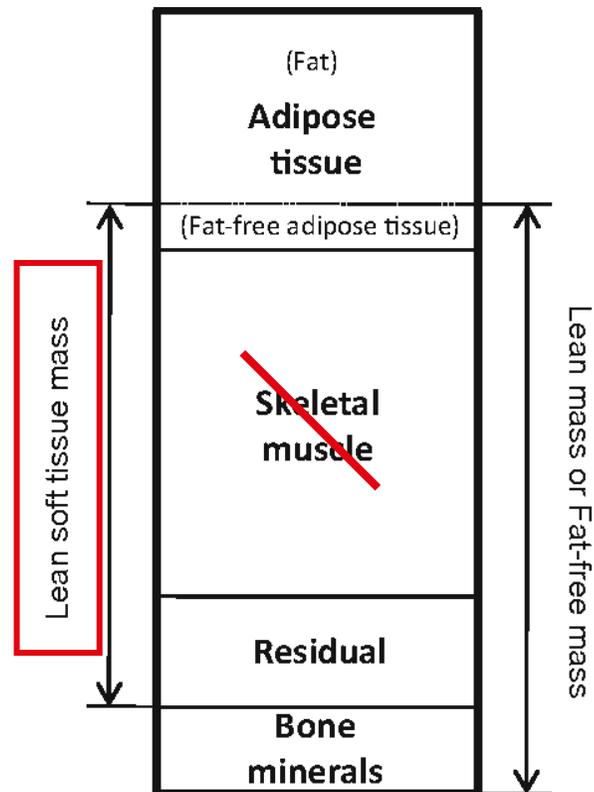
DXA



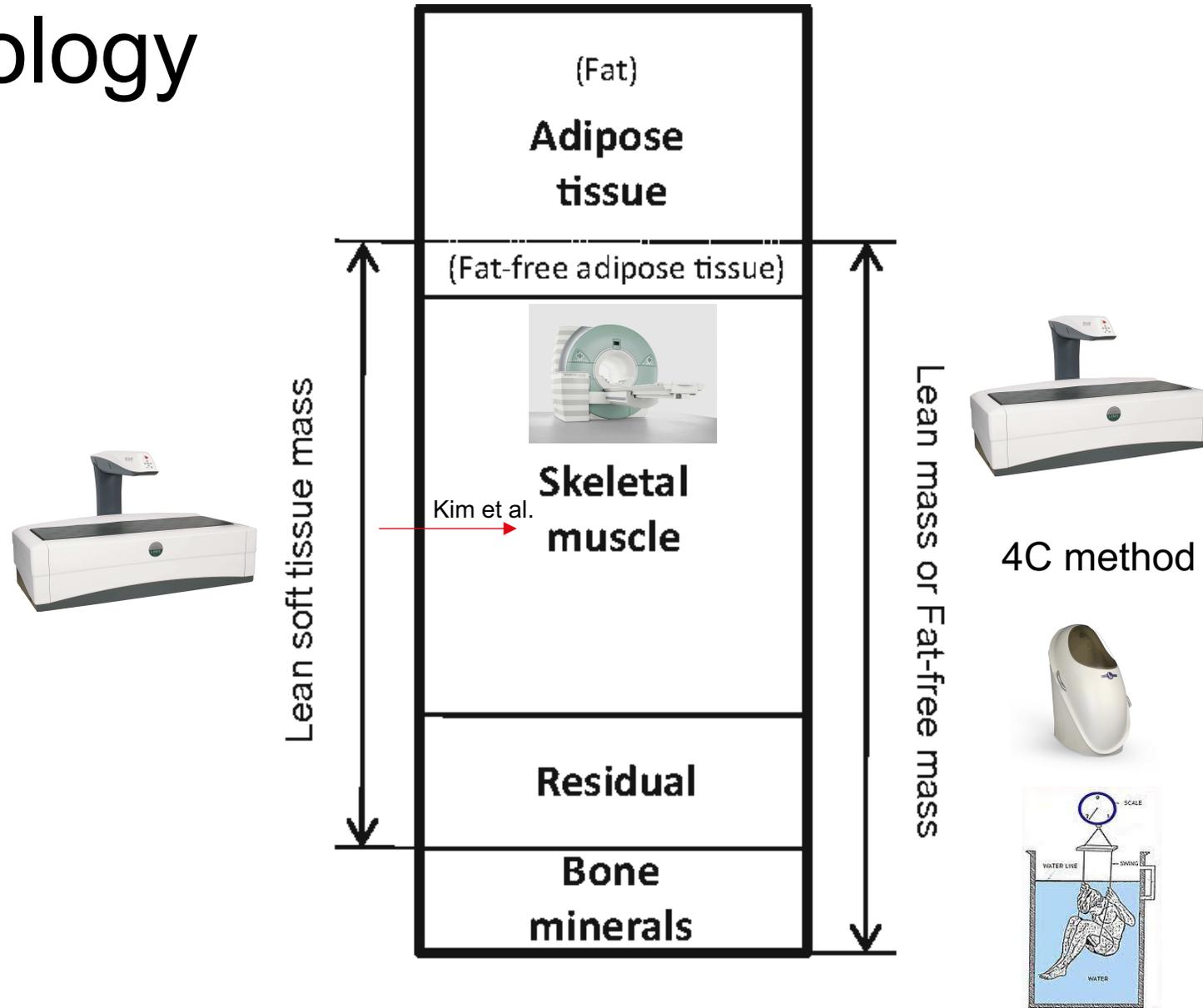
Fat-Free Mass
Appendicular Lean Soft Tissue
Appendicular Skeletal Mass Index

Methodology

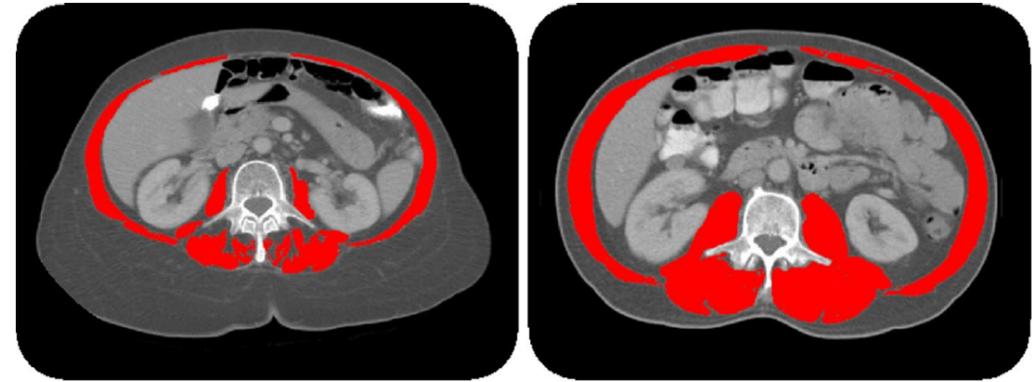
$$\text{Appendicular Skeletal Muscle Index (ASMI)} = \frac{\text{Appendicular Lean Soft Tissue [kg]}}{\text{Height}^2 [\text{m}^2]}$$



Methodology



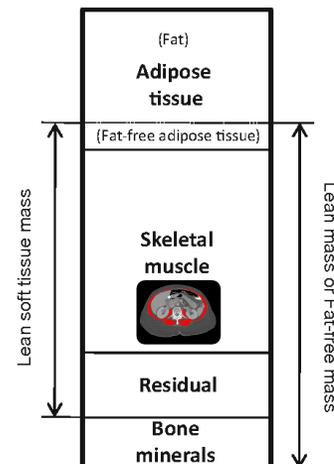
Methodology



81M
BSA = 1.59 m²
SMI = 31.8 cm²/m²

65M
BSA = 1.59 m²
SMI = 54.4 cm²/m²

CT

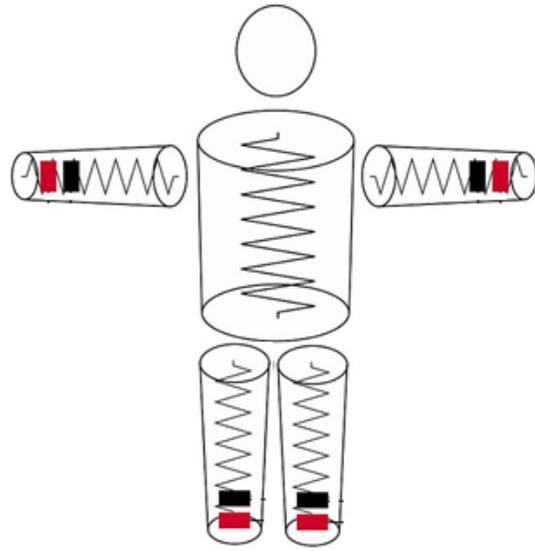


Muscle Mass Cross sectional area L3 (CSA)

$$SMI = \frac{CSA [cm^2]}{Height^2 [m^2]}$$

Psoas thickness (CT), quadriceps thickness (US)

Methodology – Bioimpedance Analysis (BIA)

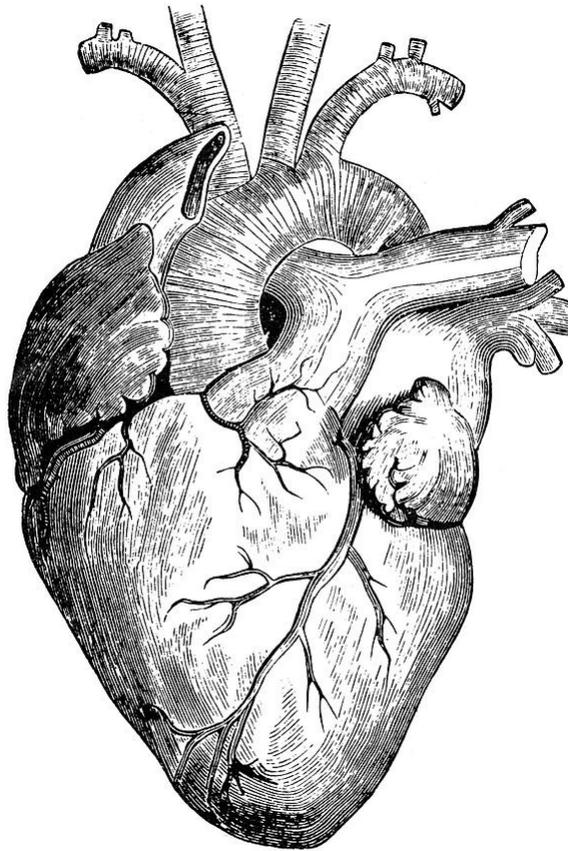
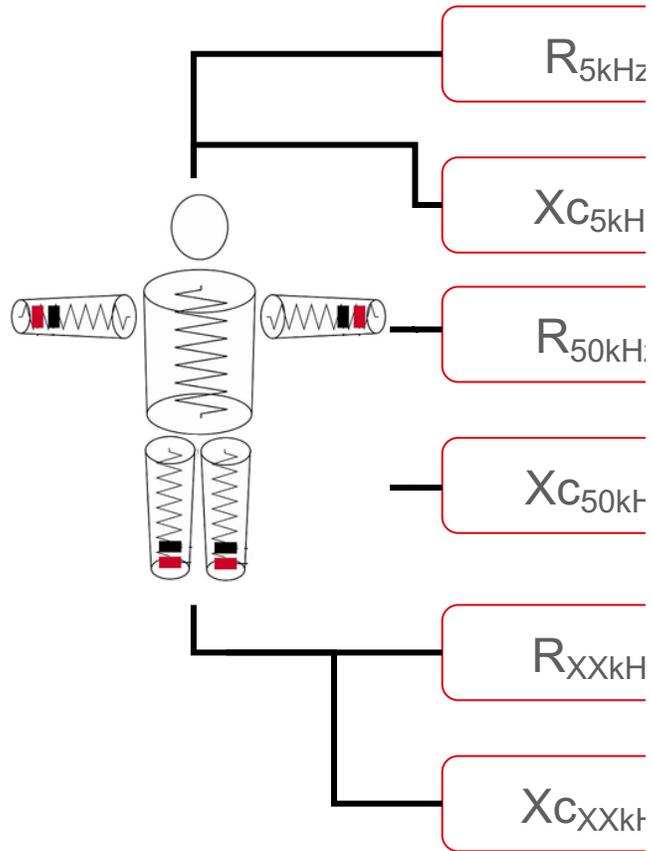


BIA

→
Formula Generation

- Skeletal Muscle Mass (MRI)
- Skeletal Muscle Mass (DXA → Formula)
- Fat-Free Mass (4C)
- Fat-Free Mass (DXA)
- Fat-Free Mass (ADP or UWW)
- Appendicular Skeletal Muscle Index (DXA)

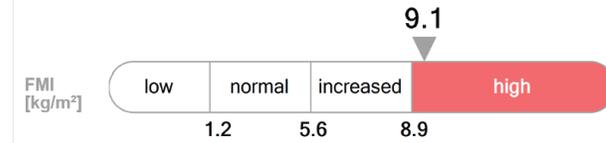
formulas



Fat Mass

Fat Mass (FM):
31,28 kg (31,3 %)*

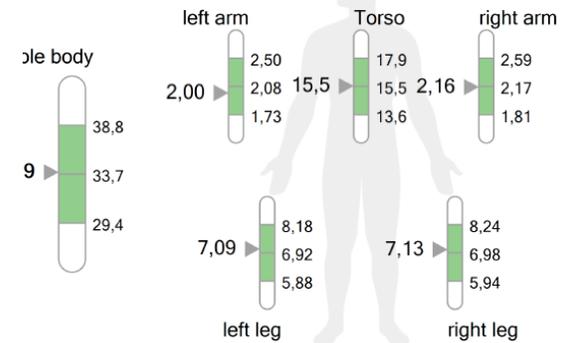
Fat Mass Index (FMI):
9,1 kg/m²



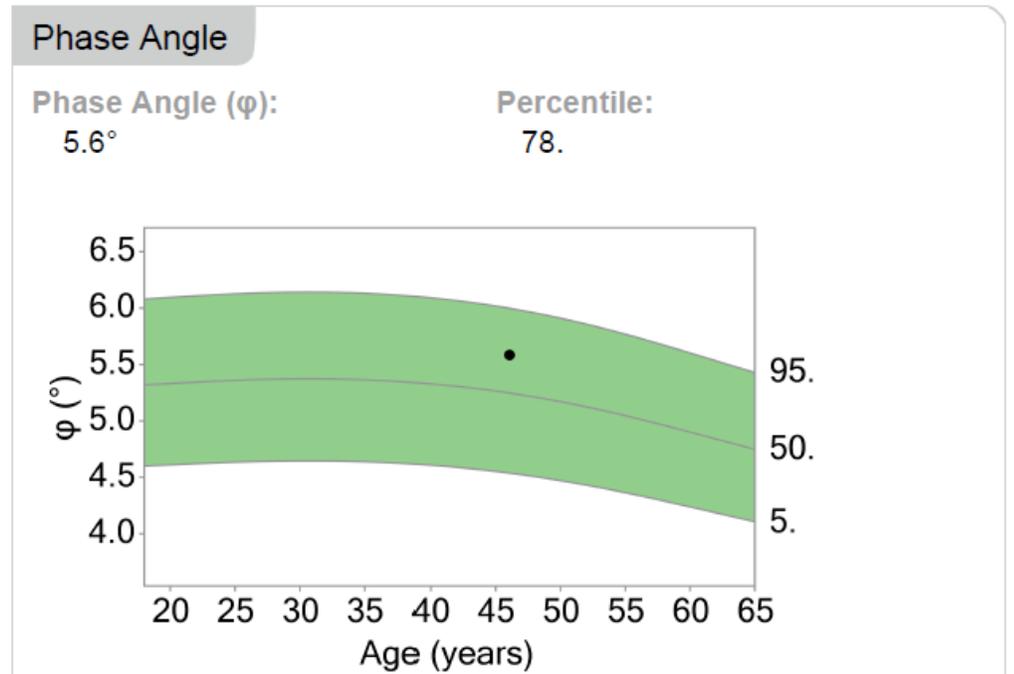
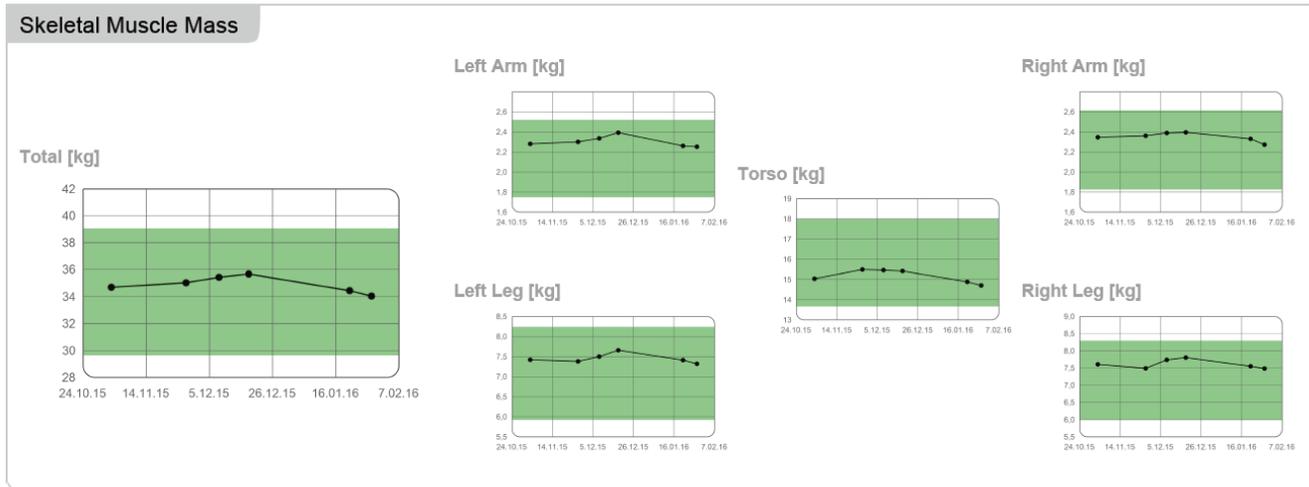
Muscle Mass

Muscle Mass:

g



Methodology – Bioimpedance Analysis (BIA)



Conclusion



Review

Reference Values for Skeletal Muscle Mass – Current Concepts and Methodological Considerations

Carina O. Walowski ¹, Wiebke Braun ¹, Michael J. Maisch ², Björn Jensen ², Sven Peine ³, Kristina Norman ^{4,5}, Manfred J. Müller ¹ and Anja Bosy-Westphal ^{1,*}

“In summary, published reference values for SM differ widely dependent on the outcome parameter and reference population. Results should consider the limitation of all proxies for total SM with respect to application in individual cases as well as for measurement of changes in SM.”

The adverse effects of obesity on muscle quality and function may lead to an underestimation of sarcopenia in obesity and therefore requires normalization of SM for FM.”