Background of medical bioimpedance analysis

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)


seca

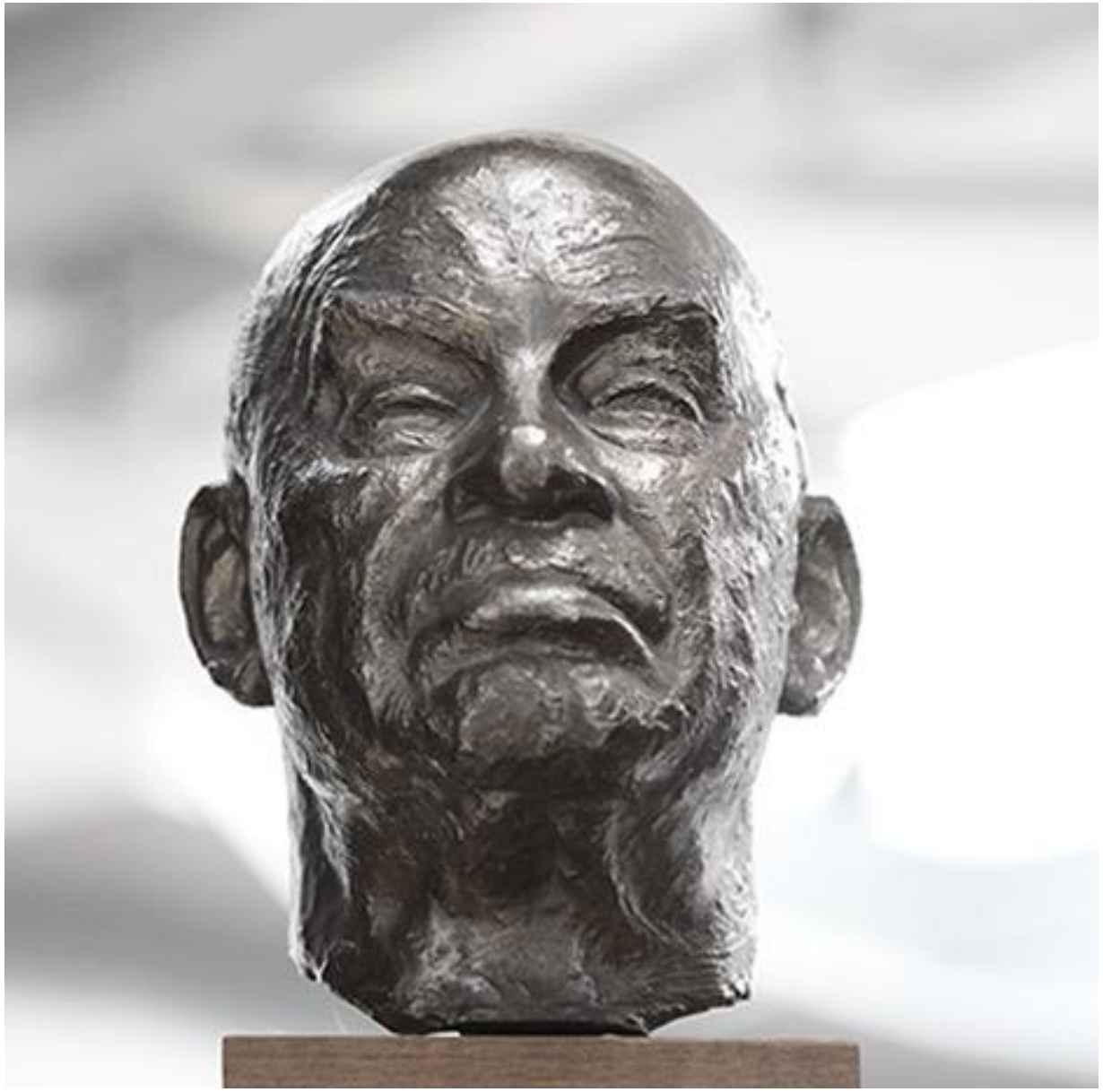
Looking back:
1840

Birth of the world market leader

Looking back: 1888

Business goes into the hands of today‘s owners, the Vogel family.

The mechanical engineer Frederik Vogel bought the scale factory in 1888, expanded the product portfolio and created the brand name “seca”, which he registered in 1897.



Looking back:
1904

Move to today‘s current location in Hamburg Wandsbek.

Looking back:
1934

The next generation. Robert Vogel leads the company through the difficult times of the Second World War and soon thereafter starts rebuilding.

Looking back:
1970

Sönke Vogel became the new managing director of seca and introduced a major strategic change to the company.

With the new claim “Precision for Health” and a unique focus to medical application seca sets worldwide standards.

Looking back:
2010

The fourth generation. seca remains market leader. Today the company is run by three managing directors, the brothers Robert and Frederik Vogel, and Thomas Wessels.

Production sites in Germany & China

seca group

seca deutschland

seca france

seca united kingdom

seca north america

seca schweiz

seca zhong guo

seca nihon

seca méxico

seca austria

seca polska

seca middle east

seca brasil

seca suomi

seca américa latina

seca asia pacific

seca danmark

seca benelux

seca lietuva

Exclusive Partner &
Distributor network
in more than 110 countries

Worldwide
market share
of more than 60%.

mBCA science center powered by seca
medical Body Composition Analysis

Prof. Dr. Dr. Anja Bosy-Westphal

Hohenheim University, Stuttgart

Nutritional scientist, professor of applied nutrition and dietetics, PhD and MD

Member of the Medical Advisory Board

Dr. Stephen Wootton

University of Southampton, Southampton

Associate Professor in Human Nutrition, BSc (Hons), PhD

Member of the Medical Advisory Board

Prof. Dr. Matthias Pirlich

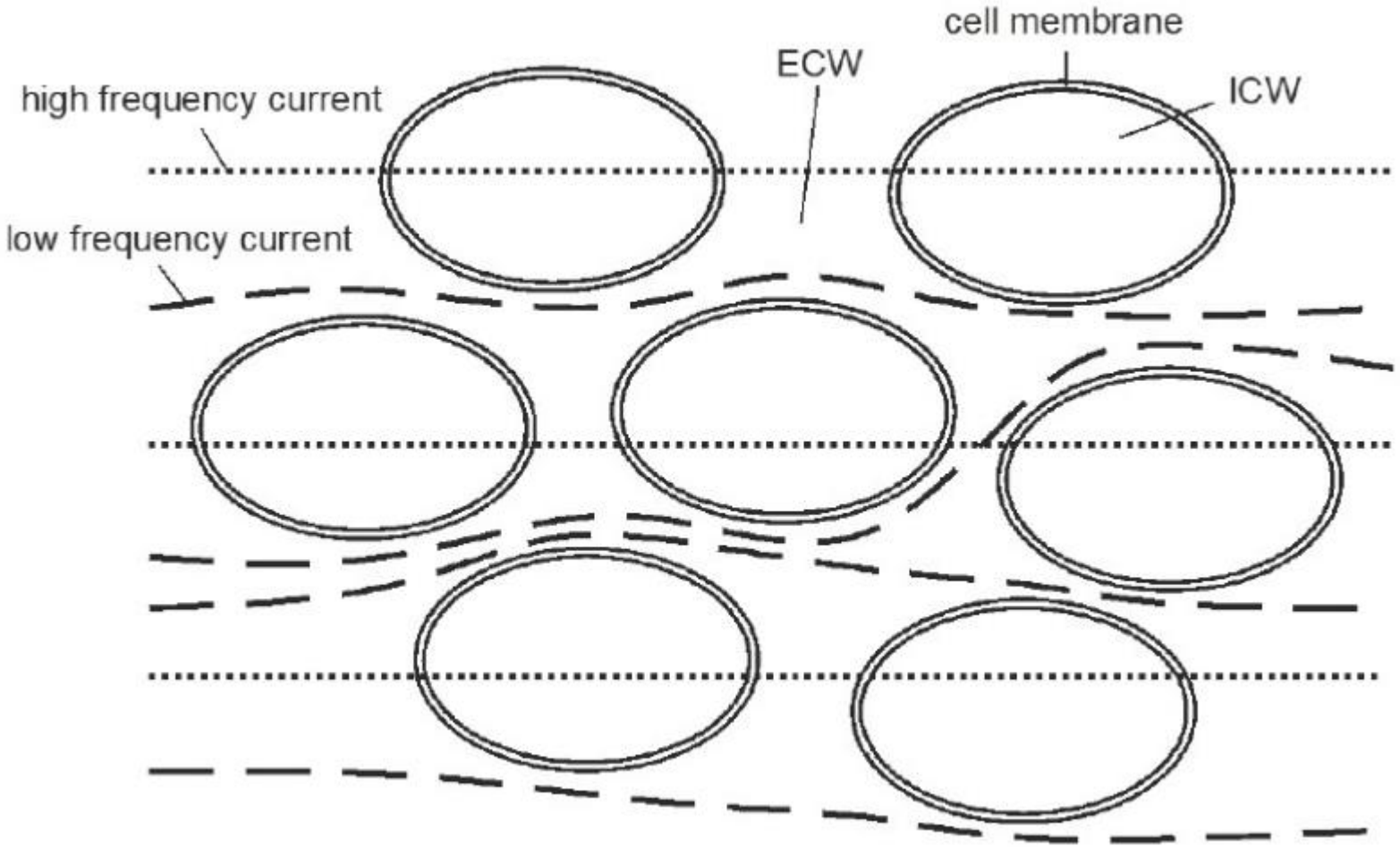
General Secretary for the European Society for Clinical Nutrition and Metabolism (ESPEN)

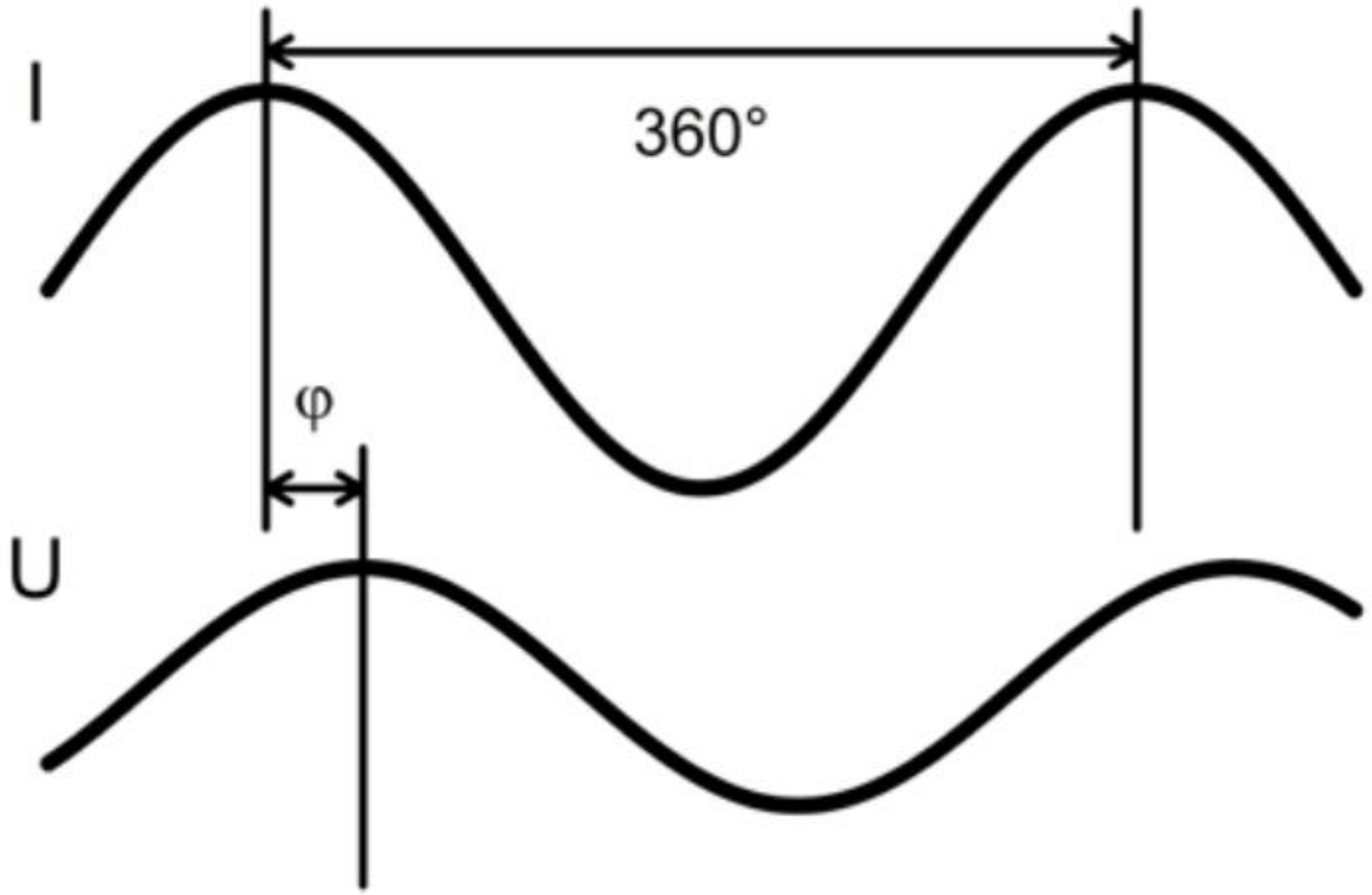
Physician, Gastroenterologist, Endocrinologist, PhD and MD

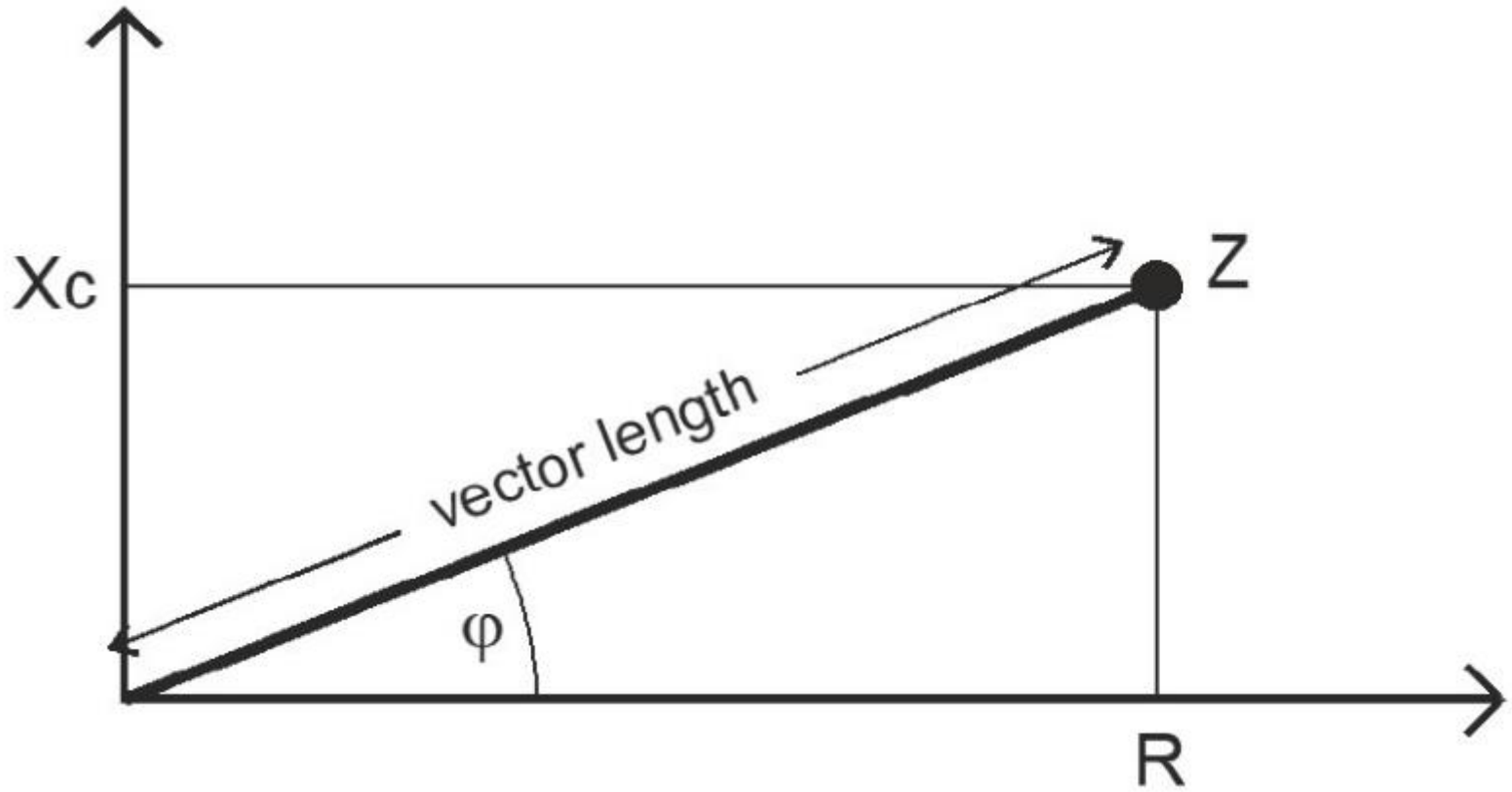
Member of the Medical Advisory Board

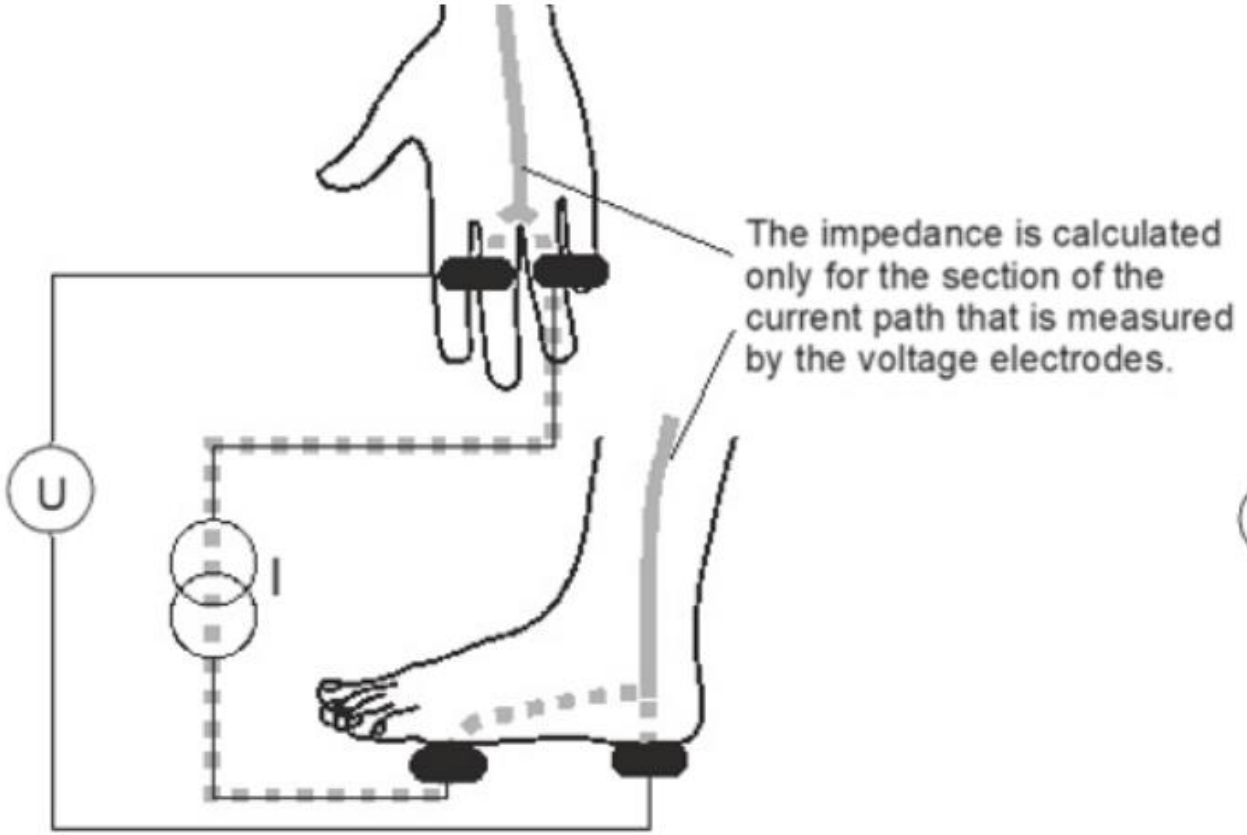
Bioimpedance Analysis

What is bioimpedance analysis?

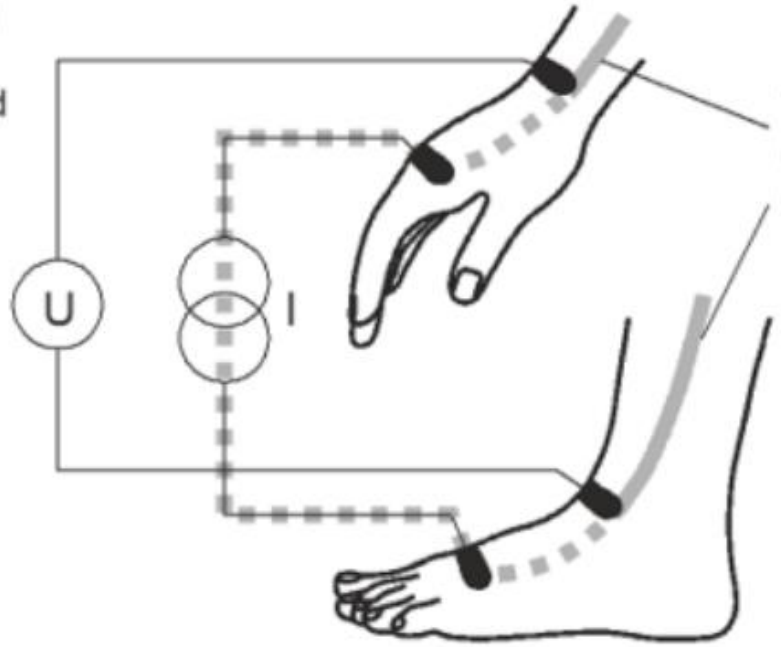

cell membrane
ECW
ICW
high frequency current
low frequency current


I
360°
φ
U


Xc
Z
vector length
φ
R



The impedance is calculated only for the section of the current path that is measured by the voltage electrodes.



The impedance is calculated only for the section of the current path that is measured by the voltage electrodes.

Validation

Normal ranges

Measured: R, Xc, height, waist cirumference and Weight*

direct

Impedance, Phase Angle and BIVA

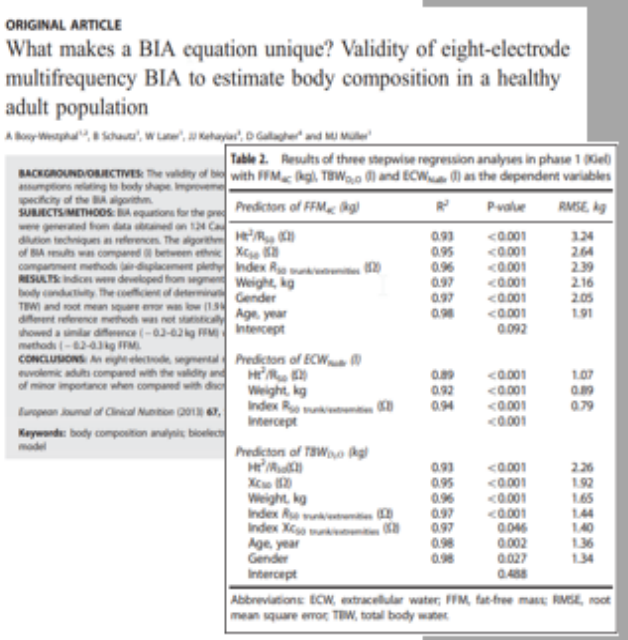
formulas

TBW, ECW, FM, SMM, VAT etc.

reference data

gender, age, ethnicity*

Normal ranges are required for immediate classification of measurements. Is my muscle mass normal or too low?



ORIGINAL ARTICLE

What makes a BIA equation unique? Validity of eight-electrode multifrequency BIA to estimate body composition in a healthy adult population

A Bosy-Westphal[1,2], B Schautz[1], W Later[1], JJ Kehayias[3], D Gallagher[4] and MJ Müller[1]

BACKGROUND/OBJECTIVES: The validity of bio… assumptions relating to body shape. Improveme… specificity of the BIA algorithm.

SUBJECTS/METHODS: BIA equations for the prec… were generated from data obtained on 124 Cau… dilution techniques as references. The algorithm… of BIA results was compared (i) between ethnic … compartment methods (air-displacement plethy…

RESULTS: Indices were developed from segment… body conductivity. The coefficient of determinati… TBW) and root mean square error was low (1.9… different reference methods was not statistically… showed a similar difference (−0.2–0.2 kg FFM) … methods (−0.2–0.3 kg FFM).

CONCLUSIONS: An eight-electrode, segmental … euvolemic adults compared with the validity and … of minor importance when compared with disc…

European Journal of Clinical Nutrition (2013) **67**,

Keywords: body composition analysis; bioelect… model

Table 2. Results of three stepwise regression analyses in phase 1 (IGel) with FFM_{IC} (kg), TBW_{DLO} (l) and ECW_{Multi} (l) as the dependent variables

Predictors of FFM_{IC} (kg)	R^2	*P-value*	*RMSE, kg*
Ht^2/R_{50} (Ω)	0.93	<0.001	3.24
Xc_{50} (Ω)	0.95	<0.001	2.64
Index $R_{50\ trunk/extremities}$ (Ω)	0.96	<0.001	2.39
Weight, kg	0.97	<0.001	2.16
Gender	0.97	<0.001	2.05
Age, year	0.98	<0.001	1.91
Intercept		0.092	
Predictors of ECW_{Multi} (l)			
Ht^2/R_{50} (Ω)	0.89	<0.001	1.07
Weight, kg	0.92	<0.001	0.89
Index $R_{50\ trunk/extremities}$ (Ω)	0.94	<0.001	0.79
Intercept		<0.001	
Predictors of TBW_{DLO} (kg)			
Ht^2/R_{50}(Ω)	0.93	<0.001	2.26
Xc_{50} (Ω)	0.95	<0.001	1.92
Weight, kg	0.96	<0.001	1.65
Index $R_{50\ trunk/extremities}$ (Ω)	0.97	<0.001	1.44
Index $Xc_{50\ trunk/extremities}$ (Ω)	0.97	0.046	1.40
Age, year	0.98	0.002	1.36
Gender	0.98	0.027	1.34
Intercept		0.488	

Abbreviations: ECW, extracellular water; FFM, fat-free mass; RMSE, root mean square error; TBW, total body water.

mBCA vs. Goldstandard

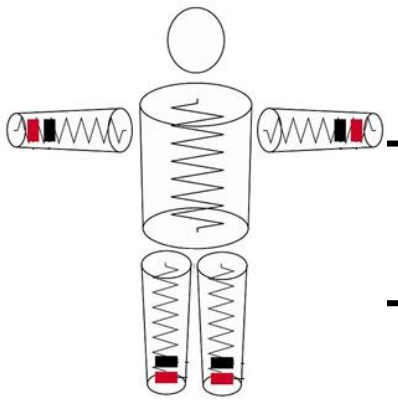
ARTICLE

Ethnic differences in fat and muscle mass and their implication for interpretation of bioelectrical impedance vector analysis

Editor's choice
Applied Psychology, Nutrition, and Metabolism

*Weight gives additional information about body compartments that do not or only very badly conduct the electrical current like an isolator, e.g. fat mass. Distribution of body composition changes with gender, age and ethnicity. That´s why adding these parameters improves the precision.

formulas



R_{5kHz}

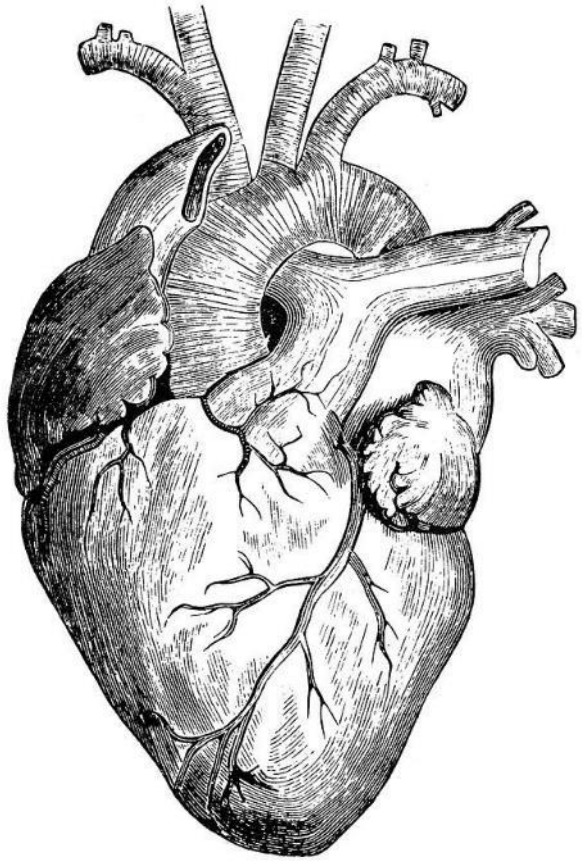
Xc_{5kH}

R_{50kH}

Xc_{50kH}

R_{XXkH}

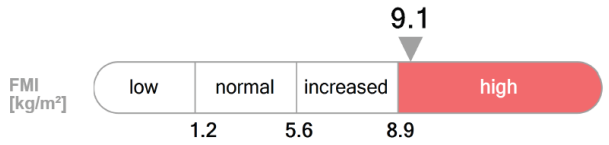
Xc_{XXkH}



Fat Mass

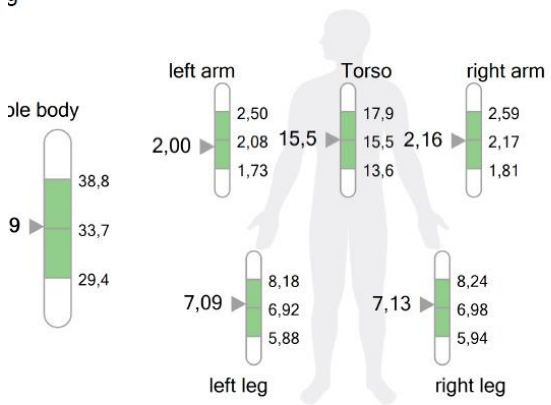
Fat Mass (FM):
31,28 kg (31,3 %)*

Fat Mass Index (FMI):
9,1 kg/m²

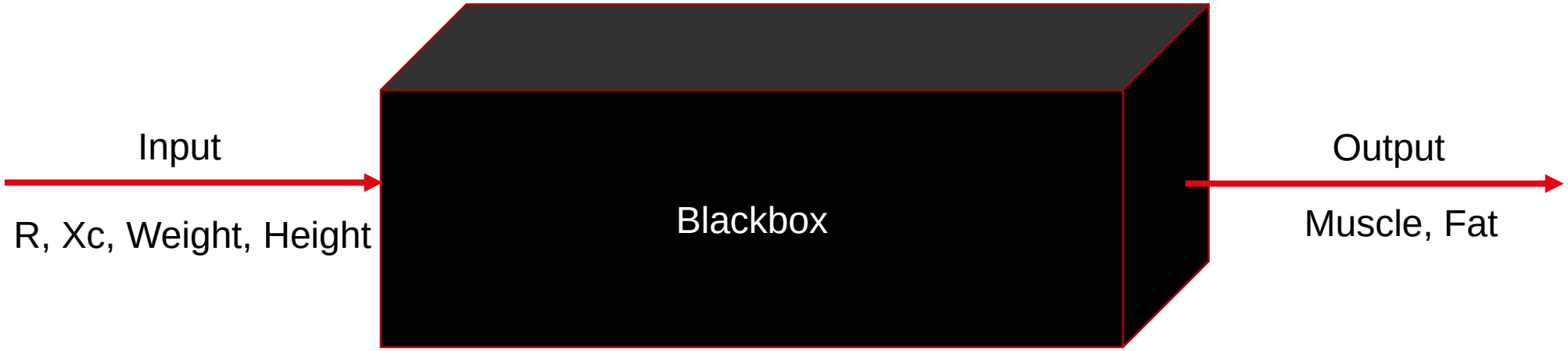


Muscle Mass

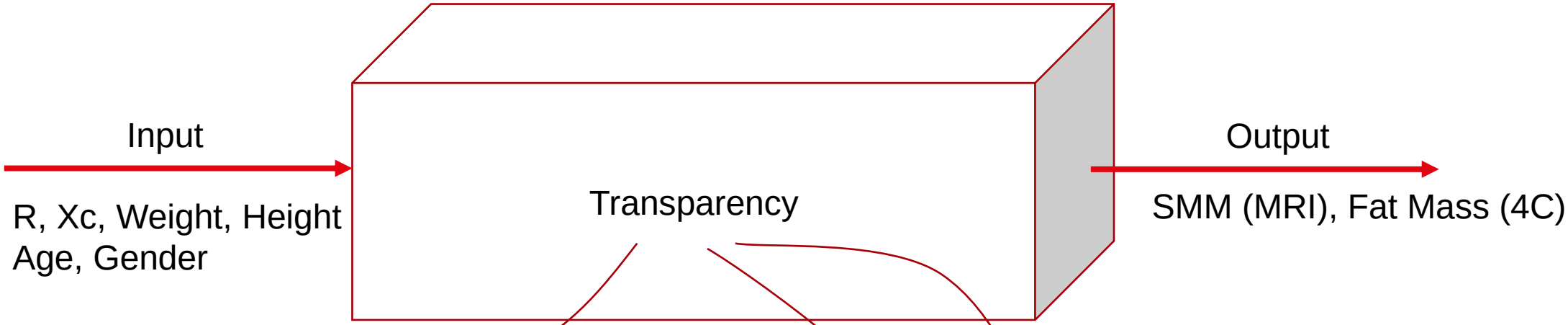
Muscle Mass:
g



Bioimpedance device



seca mBCA



study **What makes a BIA equation unique? Validity of eight-electrode multifrequency BIA to estimate body composition in a healthy adult population.**

Bosy-Westphal, A., Schautz, B., Later, W., Kehayias, J. J., Gallagher, D., & Müller, M. J. (2013). European journal of clinical nutrition, 67(S1), S. 14.

study **Quantification of whole-body and segmental skeletal muscle mass using phase-sensitive 8-electrode medical bioelectrical impedance devices**

A Bosy-Westphal, A., Jensen, B., Braun, W., Pourhassan, M., Gallagher, D., & Müller, M. J. (2017). European journal of clinical nutrition, 71(9), 1061.

study **Ethnic differences in fat and muscle mass and their implication for interpretation of bioelectrical impedance vector analysis.**

Jensen, B., Moritoyo, T., Kaufer-Horwitz, M., Peine, S., Norman, K., Maisch, M. J., ... & Fonz-Enríquez, E. (2018). Applied Physiology, Nutrition, and Metabolism, 44(6), S. 619-626.

Predictors of FFM_{4C} (kg)	R^2	*P-value*	*RMSE, kg*
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Intercept		0.092	
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study

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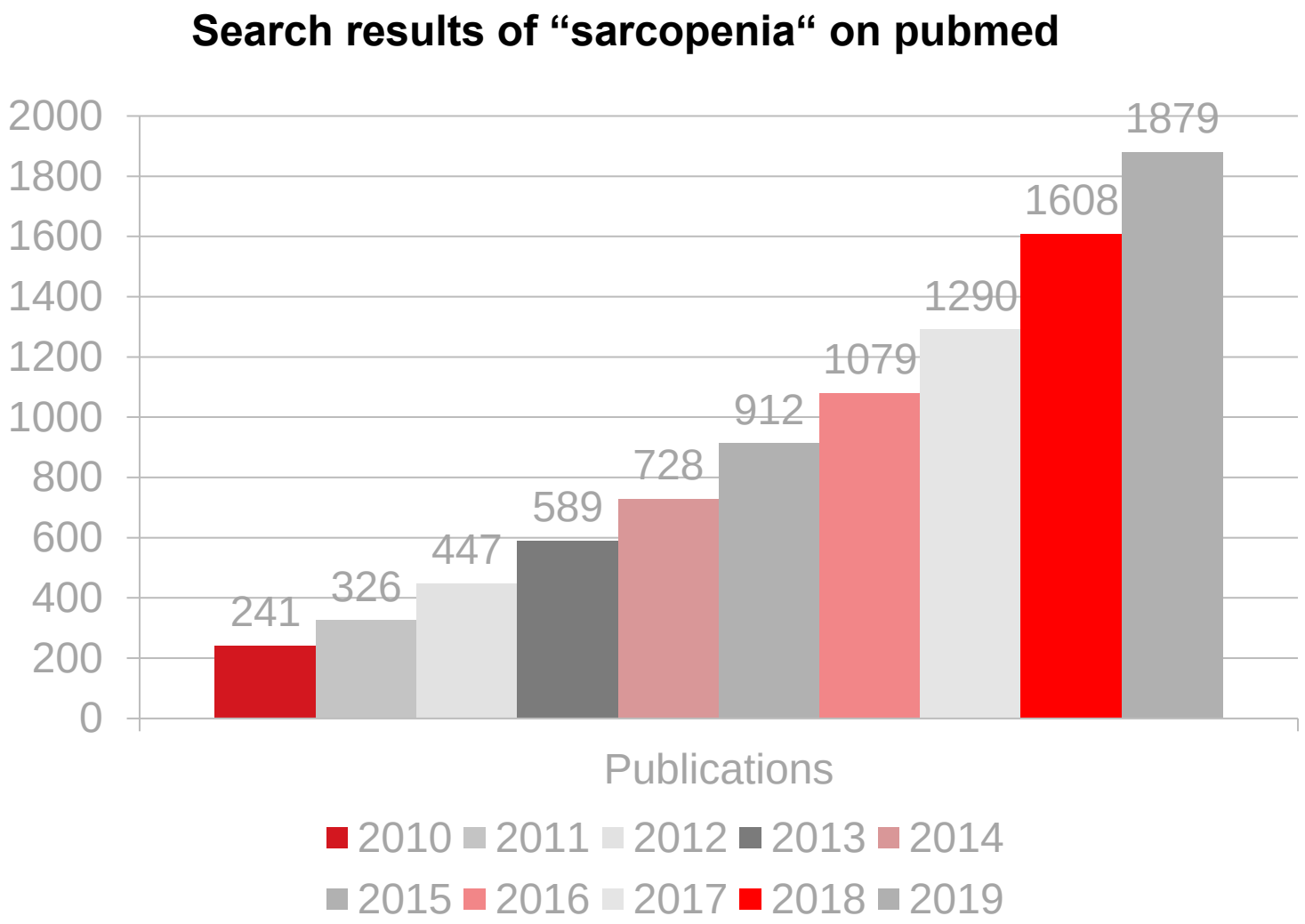
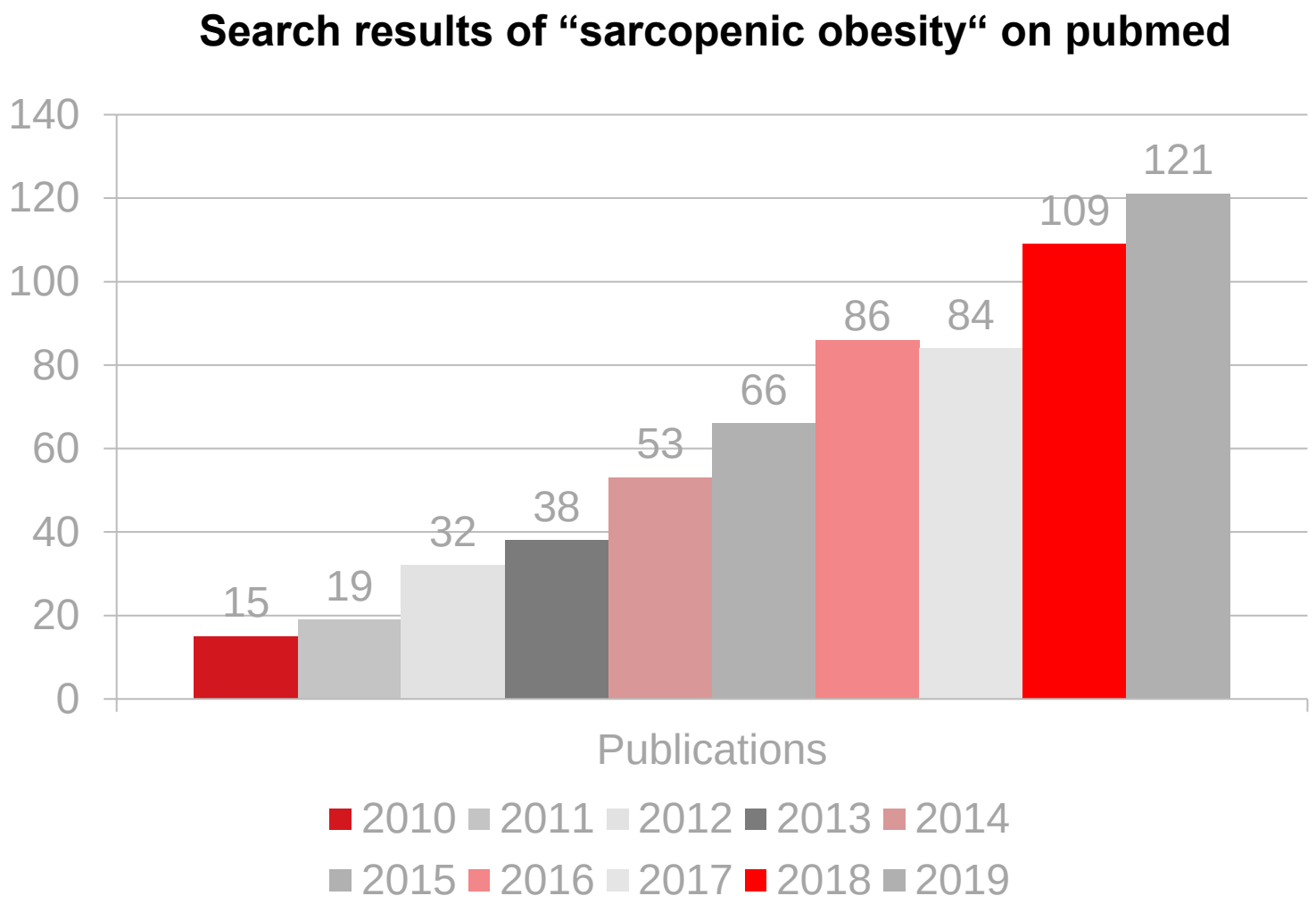
Bioimpedance Analysis and Muscle Mass

Sarcopenia


Search results of “sarcopenia“ on pubmed
2000
1800
1600
1400
1200
1000
800
600
400
200
0
241
326
447
589
728
912
1079
1290
1608
1879
Publications
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

Sarcopenic obesity



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 UG[1], Pirlich M, Lochs H, Schuetz T, Pichard C.

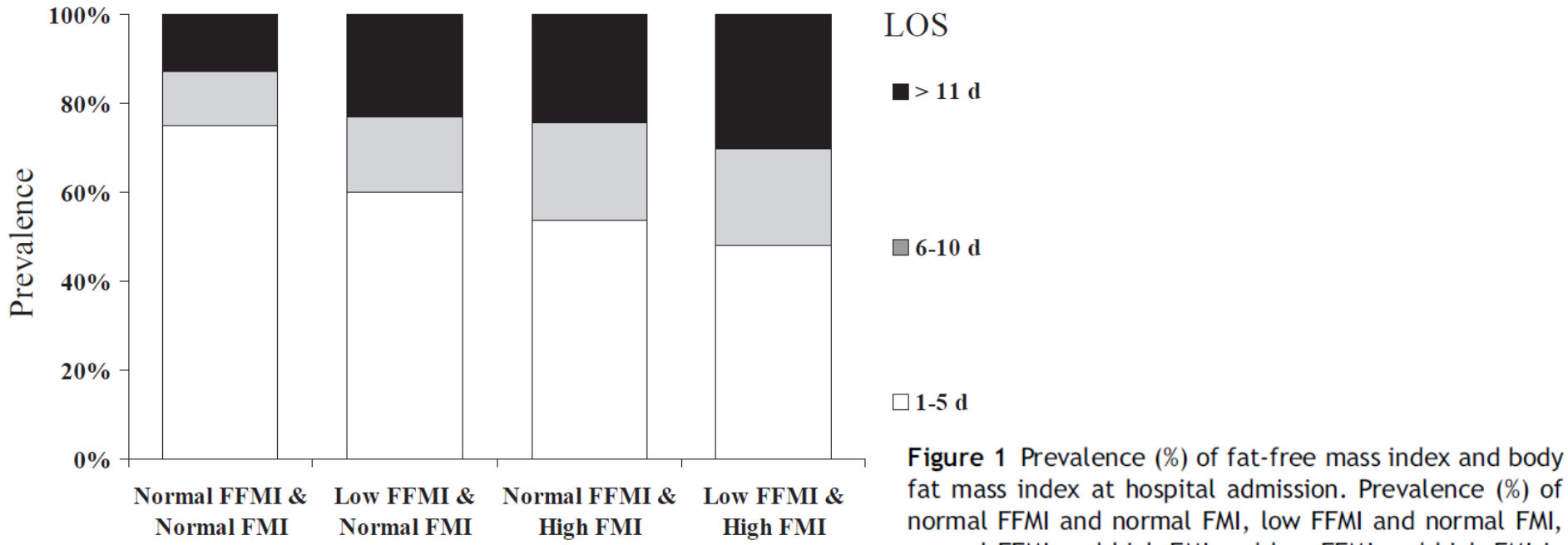


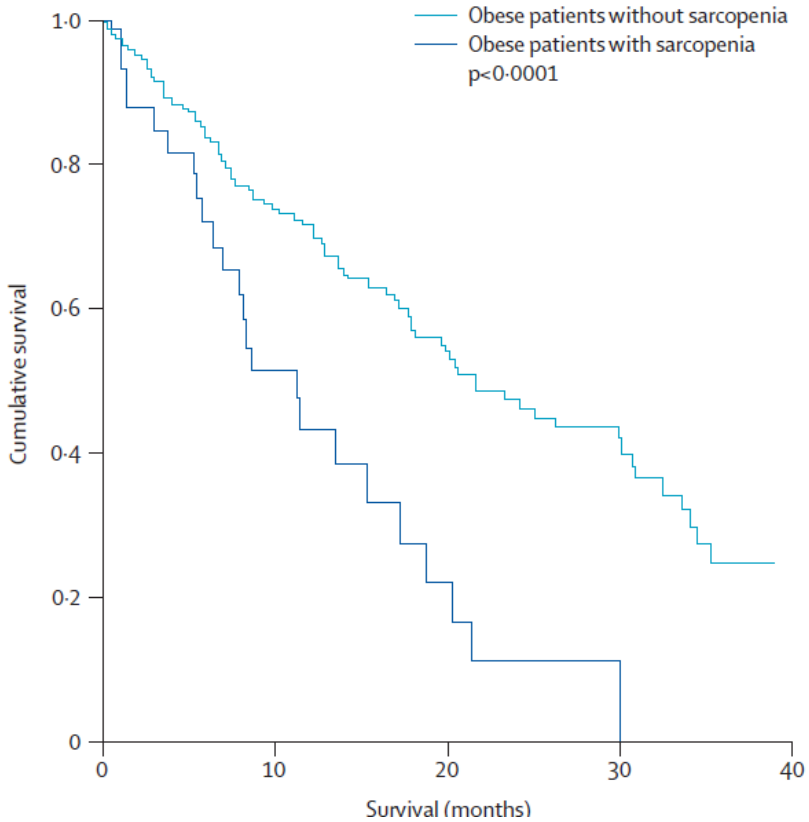
Figure 1 Prevalence (%) of fat-free mass index and body fat mass index at hospital admission. Prevalence (%) of normal FFMI and normal FMI, low FFMI and normal FMI, normal FFMI and high FMI and low FFMI and high FMI in 1707 patients hospitalized for 1–5, 6–10 and ⩾11 days. The proportion of patients 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 CM[1], Lieffers JR, McCargar LJ, Reiman T, Sawyer MB, Martin L, Baracos VE.

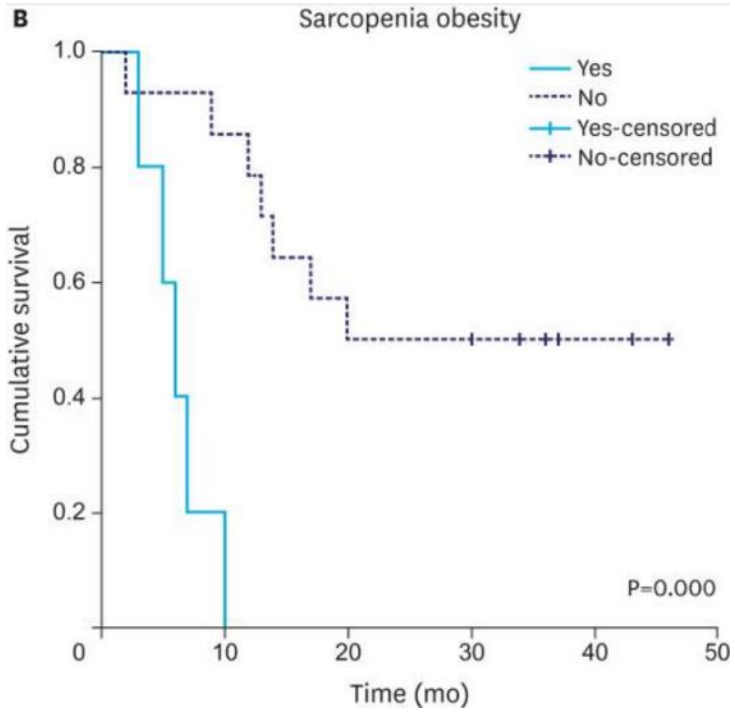


Clinical implications of sarcopenia & sarcopenic obesity

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 C[1], Velho S[2], Agostinho L[3], Branco F[4], Santos M[5], Santos MP[1], Oliveira MH[6], Strecht J[3], Maio R[5], Cravo M[1], Baracos VE[7].



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 T[1], Bosaeus I[2], Barazzoni R[3], Bauer [illegible][4], Van Gossum A[5], Klek S[6], Muscaritoli M[7], Nyulasi I[8], Ockenga J[9], Schneider SM[10], de van der Schueren MA[11], Singer P[12].

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 T[1], Barazzoni R[2], Austin P[3], Ballmer P[4], Biolo G[5], Bischoff SC[6], Compher C[7], Correia I[8], Higashiguchi T[9], Holst M[10], Jensen GL[11], Malone A[12], Muscaritoli M[13], Nyulasi I[14], Pirlich M[15], Rothenberg E[16], Schindler K[17], Schneider SM[18], de van der Schueren MA[19], Sieber C[20], Valentini L[21], Yu JC[22], Van Gossum A[23], Singer P[24].

Malnutrition

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 T[1], Jensen GL[2], Correia MITD[3], Gonzalez MC[4], Fukushima R[5], Higashiguchi T[6], Baptista G[7], Barazzoni R[8], Blaauw R[9], Coats A[10], Crivelli A[11], Evans DC[12], Gramlich L[13], Fuchs-Tarlovsky V[14], Keller H[15], Llido L[16], Malone A[17], Mogensen KM[18], Morley JE[19], Muscaritoli M[20], Nyulasi I[21], Pirlich M[22], Pisprasert V[23], de van der Schueren MAE[24], Siltharm S[25], Singer P[26], Tappenden K[27], Velasco N[28], Waitzberg D[29], Yamwong P[30], Yu J[31], Van Gossum A[32], Compher C[33]; 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.

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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.

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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.

seca

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 S
- a. What is the best adjustment of appendicular lean mass for predicting mortality or disability among Japanese
- 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, a
- 8) Prevalence of sarcopenia estimated using a bioelectrical impedance analysis prediction equ
- 12) SARC-F A Simple Questionnaire to Rapidly Diagnose Sarcopenia
- 74) Assessing appendicular skeletal muscle mass with bioelectrical impedance analysis in free
- 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 sarcopen
- 16) Development of a simple screening test for sarcopenia in older adults
- 16-9) Association between muscle mass and disability in performing instrumental activitie
- 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 Grou...
- 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 comm..
- 20) Frailty in older adults - evidence for a phenotype.
- 21) Screening for undernutrition in geriatric practice - developing the short-form mini-nutritional..
- 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 ..

- 6) Effects of exercise and amino acid supplementation on body composition and physical function in community-dw
- 13) Association between sarcopenia and higher-level functional capacity in daily living in community-dwelling elderl
- 13b) Association between muscle mass and disability in performing instrumental
- 15) The loss of skeletal muscle strength, mass, and quality in older adults -the health, aging and body composition st
- 16) Association between body composition and pulmonary function in elderly people - the Korean Longitudinal Stud
- 39) Prevalence of Sarcopenia Estimated Using a Bioelectrical Impedance Analysis Prediction Equation in Community-
- 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 he

- 5) Epidemiology of sarcopenia among the elderly in New Mexico.
- 18) Sarcopenia - alternative definitions and associations with
- 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.

seca

Definition and diagnosing of sarcopenia

nutrients

MDPI

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,*]

seca

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	
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.

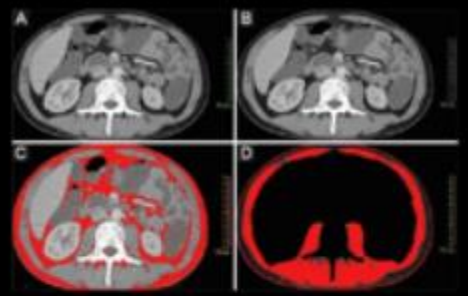
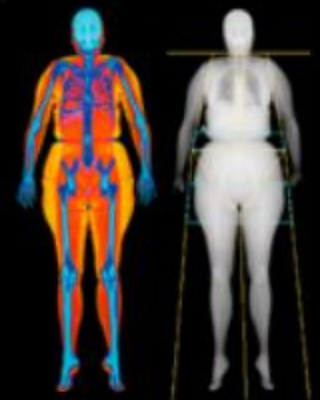
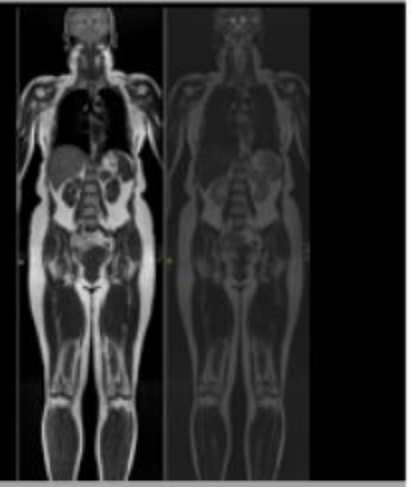
ASMI
Appendicular Skeletal Muscle Index

FFMI
Fat-Free Mass Index

ALM
Appendicular Lean Mass

97%

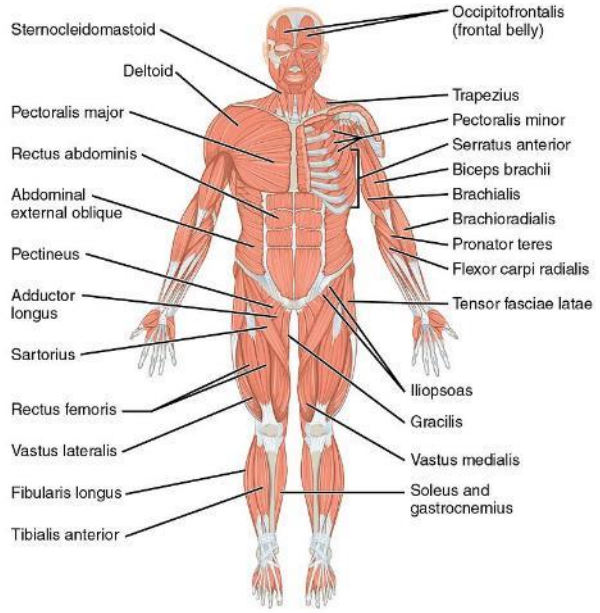
Muscle mass accuracy compared to full-body MRI

Ultrasound	CT	DXA	MRI
			
One muscle RF 2D Sagital CSA	**Some muscles** L3 2D Axial CSA	**Lean soft tissue** 2D Coronal area	**All muscles** Volume (3D)

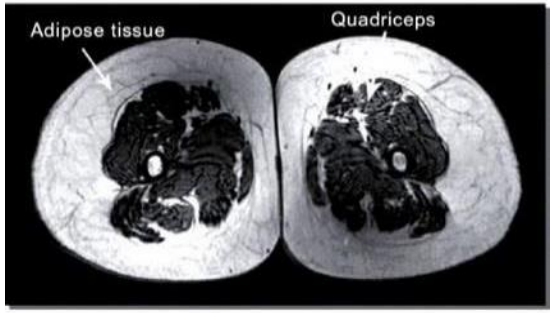
accuracy of measurement

Methodology

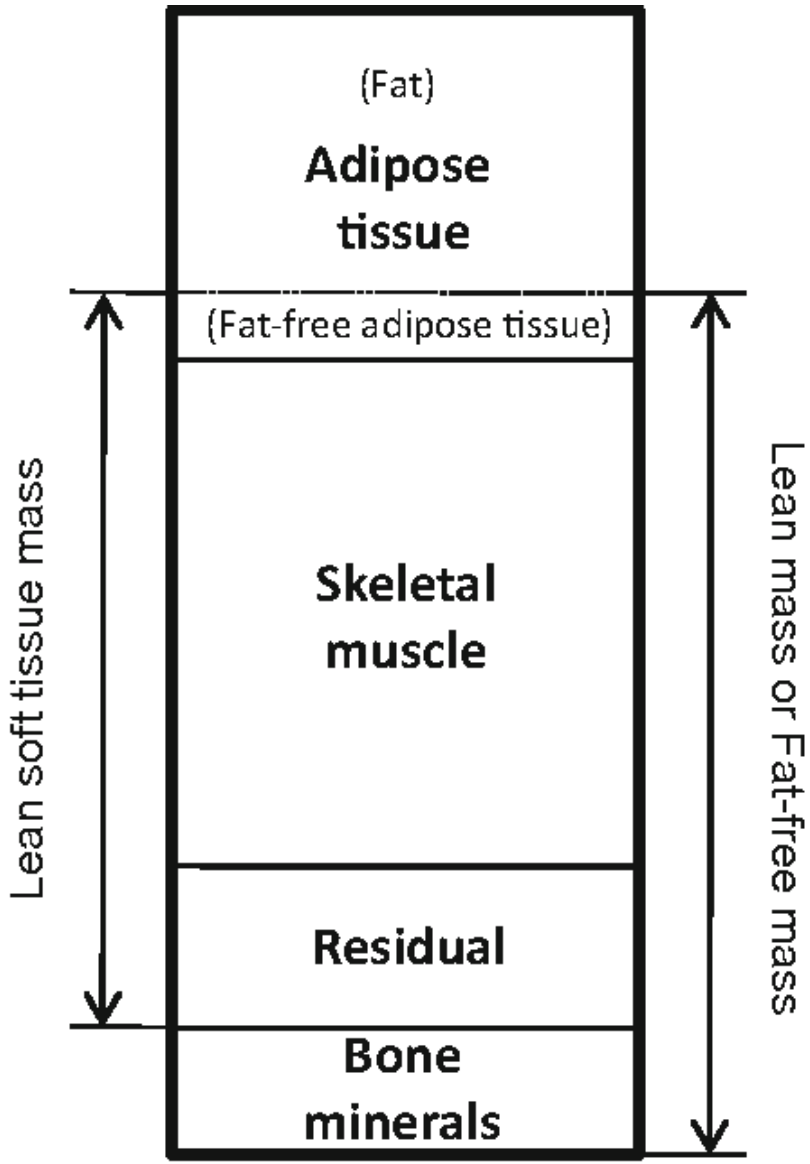
Whole body MRI



Whole body muscle mass

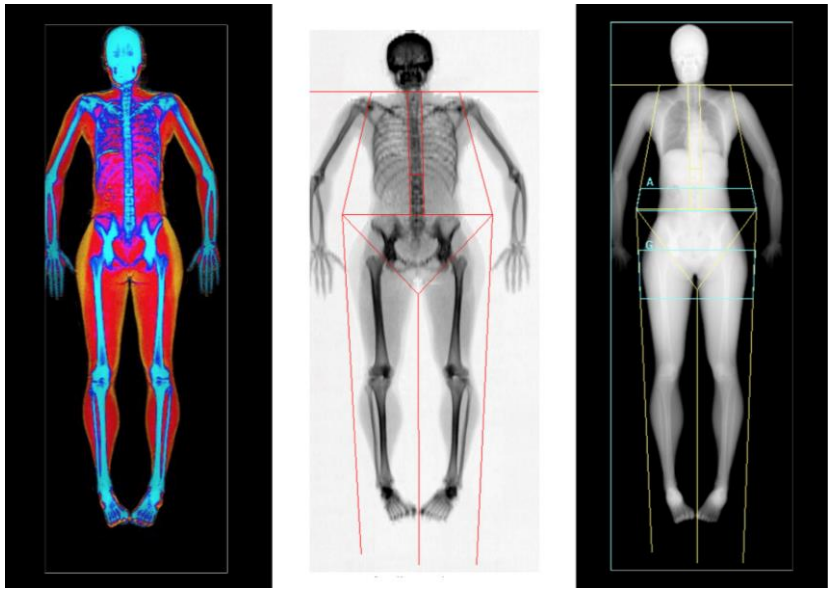


Methodology



Methodology

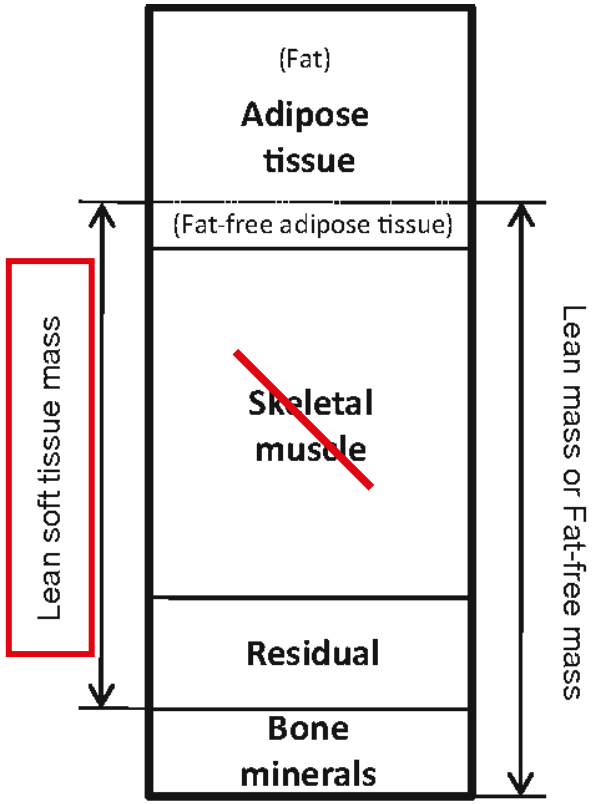
DXA



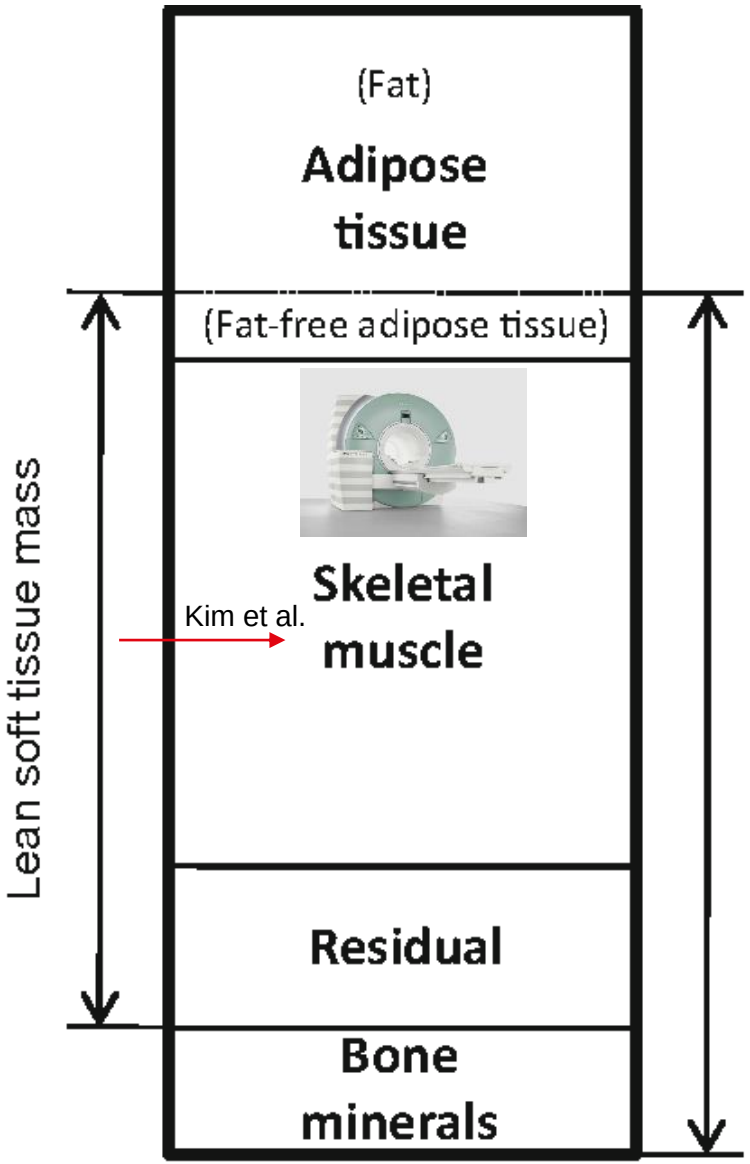
Fat-Free Mass
Appendicular Lean Soft Tissue
Appendicular Skeletal Mass Index

Methodology

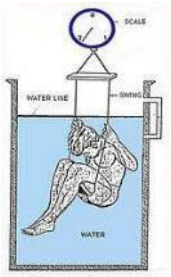
Appendicular *Skeletal Muscle* Index (ASMI) = $\frac{Appendicular\ Lean\ Soft\ Tissue\ [kg]}{Height^2[m^2]}$



Methodology

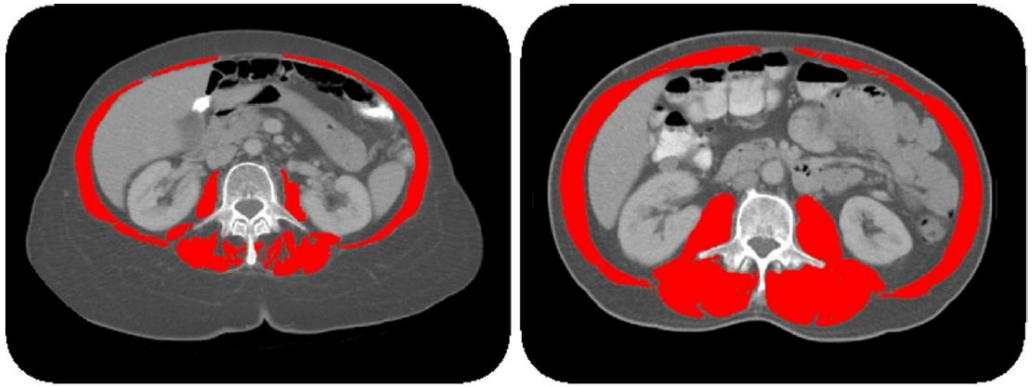


4C method



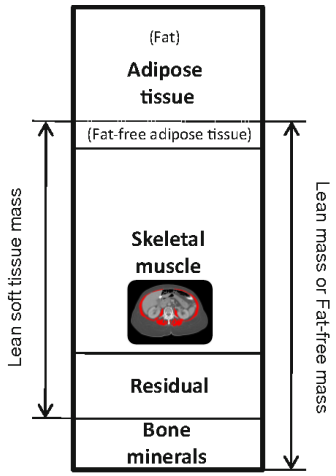
Methodology

CT



81M
BSA = 1.59 m²
SMI = 31.8 cm²/m²

65M
BSA = 1.59 m²
SMI = 54.4 cm²/m²

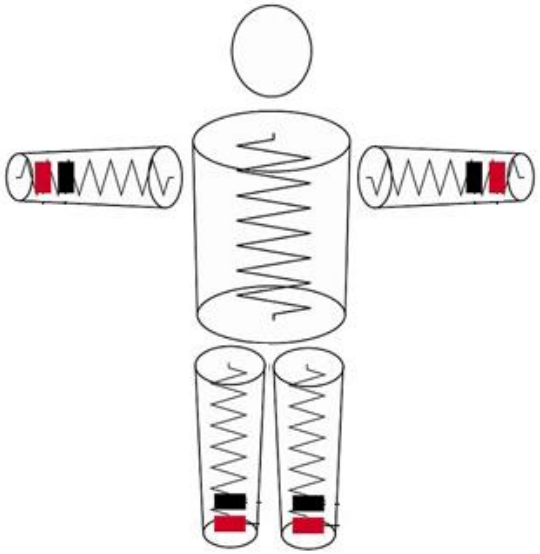


Muscle Mass Cross sectional area L3 (CSA)

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

Psoas thickness (CT), quadriceps thickness (US)

Methodology – Bioimpedance Analysis (BIA)

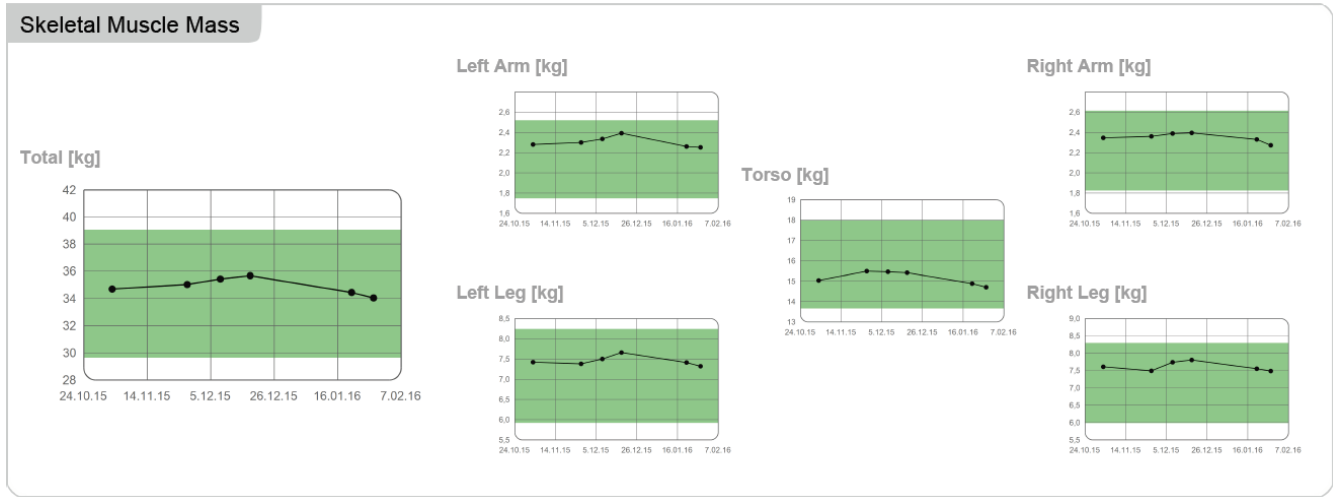


BIA

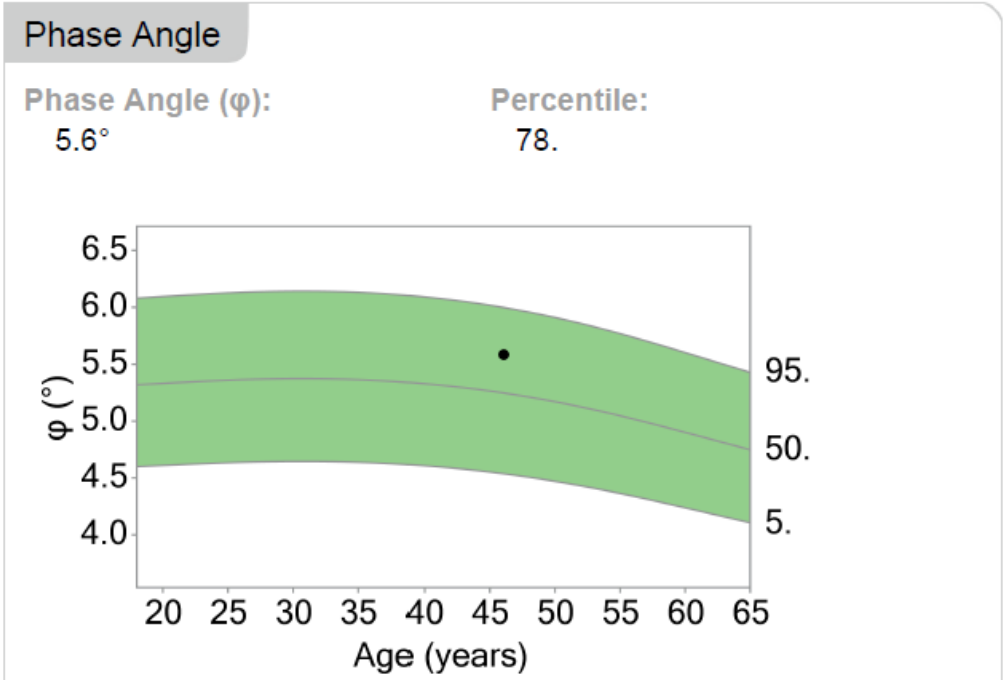
Formula Generation

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

Methodology – Bioimpedance Analysis (BIA)



Muscle Quantity



Muscle Quality

Conclusion

Review

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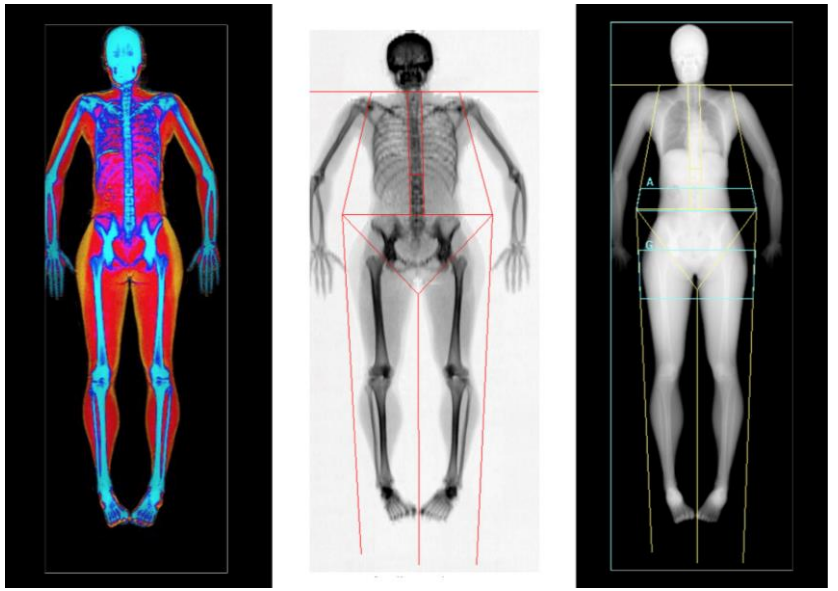
"In summary, published reference values for SM differ widely dependent on the outcome parameter and reference population. Results should consider the limitation of all proxies for total SM with respect to application in individual cases as well as for measurement of changes in SM.

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."

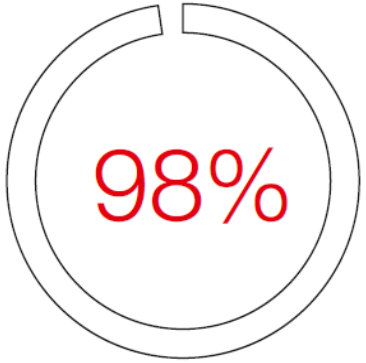
Bioimpedance Analysis and Fat Mass

Methodology

DXA



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



Fat mass accuracy compared to 4-compartment model

Fat-Free Mass
Fat Mass

Bosy-Westphal A, Mueller MJ. *Assessment of fat and lean by quantitative magnetic resonance: a future technology of body composition research*. Curr Opin Clin Nutr Metab Care 2015.

Santos DA, Silva AM, Matias CN, Fields DA, Heymsfield SB, Sardinha LB. *Accuracy of DXA in estimating body composition changes in elite athletes using a 4-compartment model as the reference method.* Nutr & Metab 2010 7:22.

Schoeller DA, Tylavsky FA, Baer DJ, Chumlea WC, Earthman CP, Fuerst T, Harris TB, Heymsfield SB, Horlick M, Lohman TG, Lukaski HC, Shepherd J, Siervogel RM, Borrud LG. *QDR 4500A dual-energy X-ray absorptiometer underestimates fat mass in comparison with criterion methods in adults.* Am J Clin Nutr 2005;81:1018 –25.

Tylavsky FA, Lohman TG , Blunt BA, Schoeller DA, Fuerst T, Cauley JA, Nevitt MC, Visser M, Harris TB. *QDR 4500A DXA overestimates fat-free mass compared with criterion methods*. J Appl Physiol 94: 959–965, 2003.

Deurenberg-Yap M, Deurenberg P. *Validity of deuterium oxide dilution for the measurement of body fat among Singaporeans*. Food and Nutrition Bulletin 23 (3): 34-37, 2002

Van der Ploeg GE, Withers RT, Laforgia J. *Percent body fat via DEXA: comparison with a four-compartment model.* J Appl Physiol 94: 499–506, 2003;

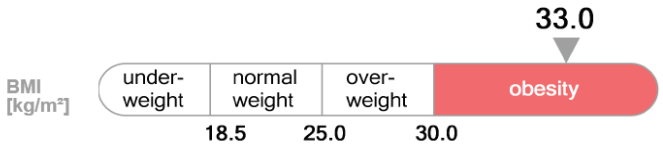
Bioimpedance Analysis Parameters

BMI

Weight: 81.75 kg

BMI: 32.96 kg/m²

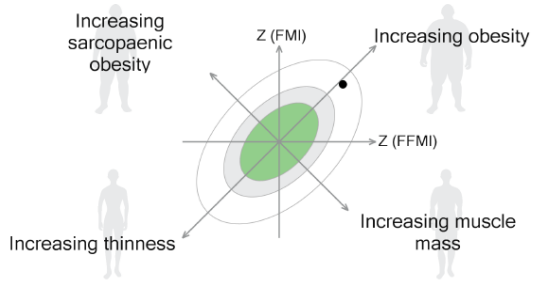
Height: 1.575 m



Body Composition Chart

Fat Mass Index (FMI): 13.9 kg/m²

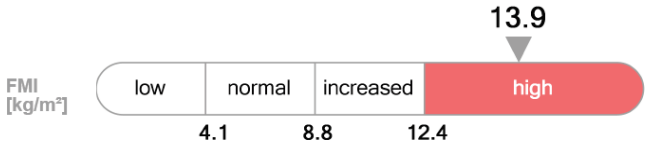
Fat-Free Mass Index (FFMI): 19.0 kg/m²



Fat Mass

Fat Mass (FM): 34.50 kg (42.2 %)*

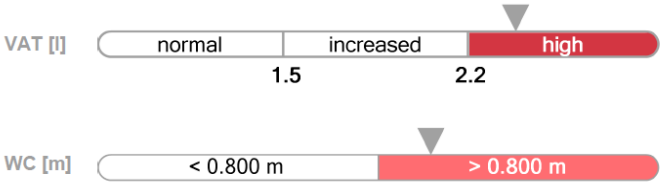
Fat Mass Index (FMI): 13.9 kg/m²



Visceral Fat & Waist Circumference

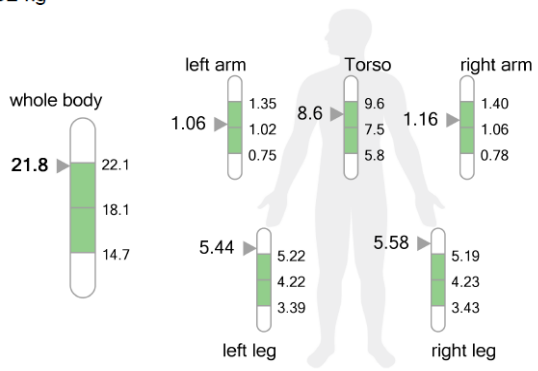
Visceral Adipose Tissue (VAT): 2.4 l

Waist Circumference (WC): 0.95 m



Skeletal Muscle Mass

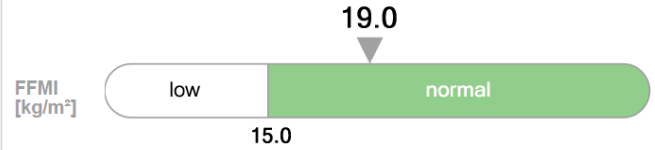
Skeletal Muscle Mass (SMM): 21.82 kg



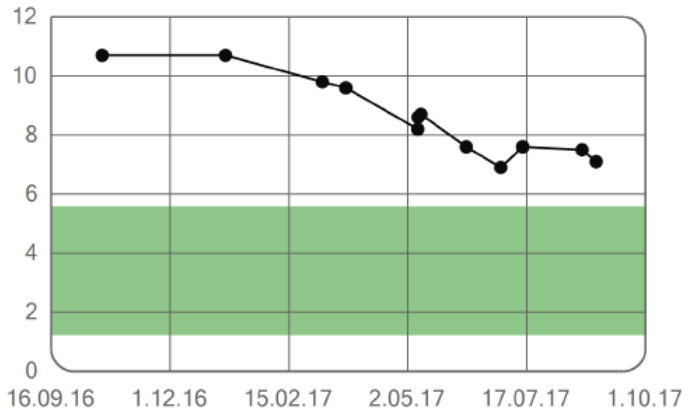
Fat-Free mass

Fat-Free Mass (FFM): 47.25 kg (57.8 %)*

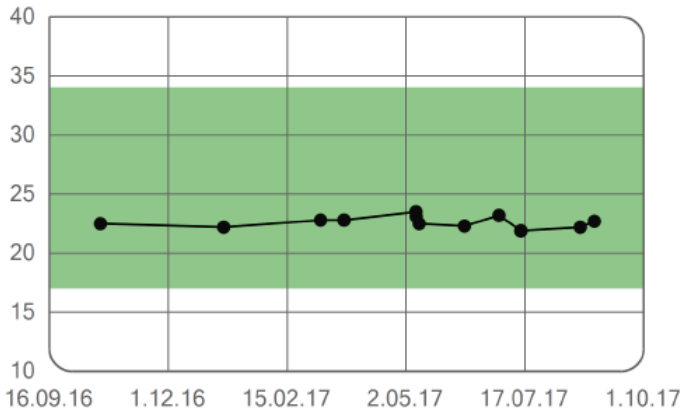
Fat-Free Mass Index (FFMI): 19.0 kg/m²



Fat Mass Index [kg/m²]

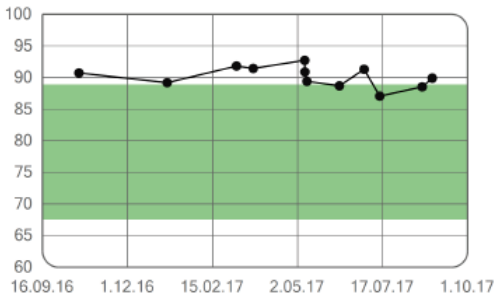


Fat-Free Mass Index [kg/m²]

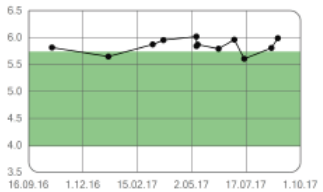


Skeletal Muscle Mass

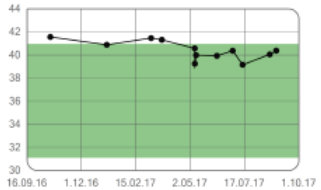
Total [lbs]



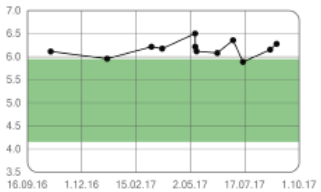
Left Arm [lbs]



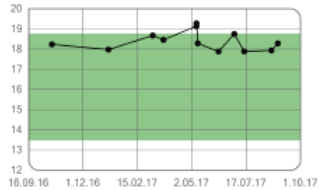
Torso [lbs]



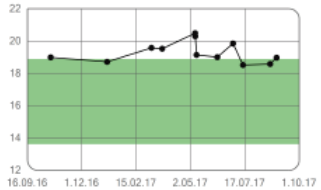
Right Arm [lbs]



Left Leg [lbs]



Right Leg [lbs]



Precision for health

Contact

Melvin NG
Regional Sales Manager

seca Asia Pacific SDN BHD
50470 Kuala Lumpur, Malaysia

melvin.ng@seca.com