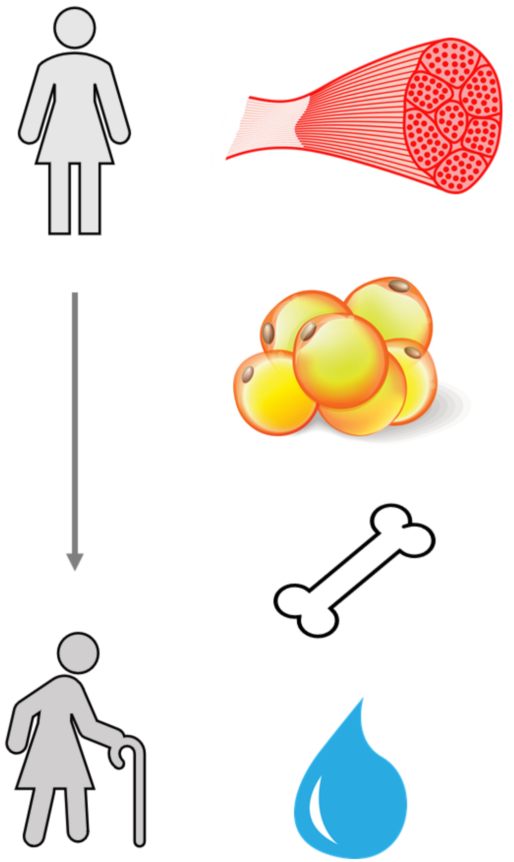
Association of body composition, physical performance and nutritional status in older adults

Sandra Unterberger, Rudolf Aschauer, Patrick A. Zöhrer, Agnes Draxler, Bernhard Franzke, Eva-Maria Strasser, Karl-Heinz Wagner and Barbara Wessner

Body Composition & Age

Body composition: determinant of overall health, fitness and nutritional status

Aging process is characterized by changes in body composition that have important consequences on health and physical function



- ↓ muscle mass
- alterations in muscle architecture
- muscle metabolic changes
- fat accumulation within muscle

- ↑ body fat
- redistribution from subcutaneous to abdominal fat

- ↓ bone density

- ↓ total body water

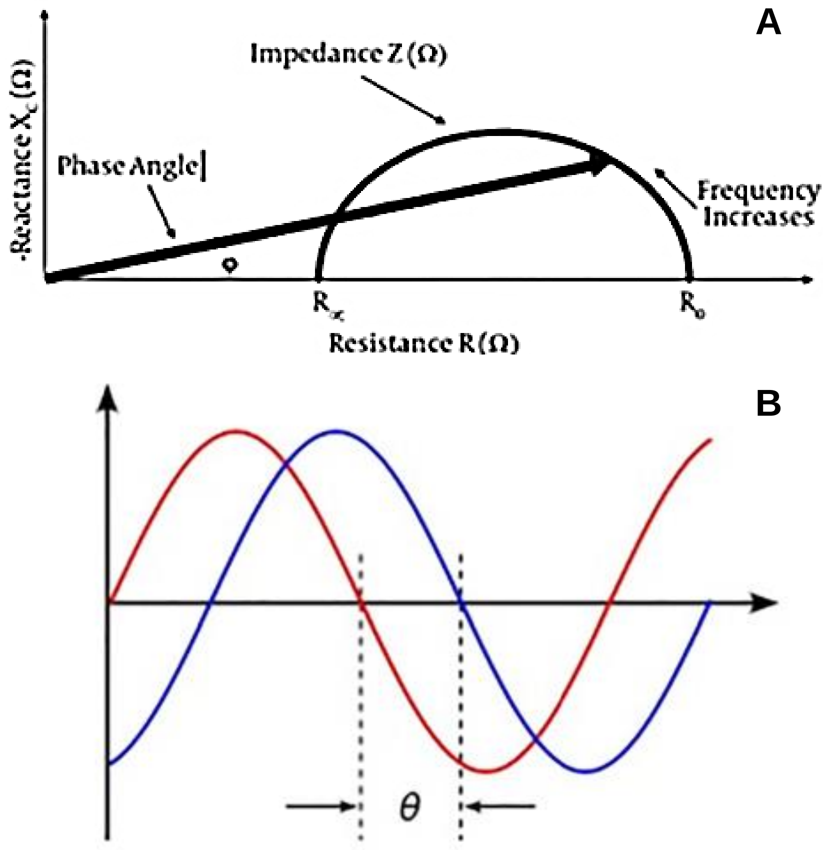
Assessment of Body Composition

- Several methods available to assess body composition
  ==> debate on "gold standard"

- Bioelectrical impedance analysis (BIA)
  - widely accepted, validated, simple, non-invasive, and convenient method
  - Criticism:
    considered to be less valid than dual-energy X-ray absorptiometry (DXA) in determining muscle and fat mass.
  - ==> use raw BIA parameters, like resistance, reactance and especially phase angle (PhA)

Phase angle

- Impedance is compounded of two parts, resistance, and reactance.
- Phase angle (PhA) is calculated from arctangent of reactance to resistance ratio (Figure A)
- Description of the angular shift (phase difference) between the sinusoidal waveforms of voltage and current (Figure B)
- ↓ PhA ==> indicate a decreased cell integrity or cell death
- ↑ PhA ==> attributed to greater cellularity (higher body cell mass relative to FFM), cellular integrity and cellular function

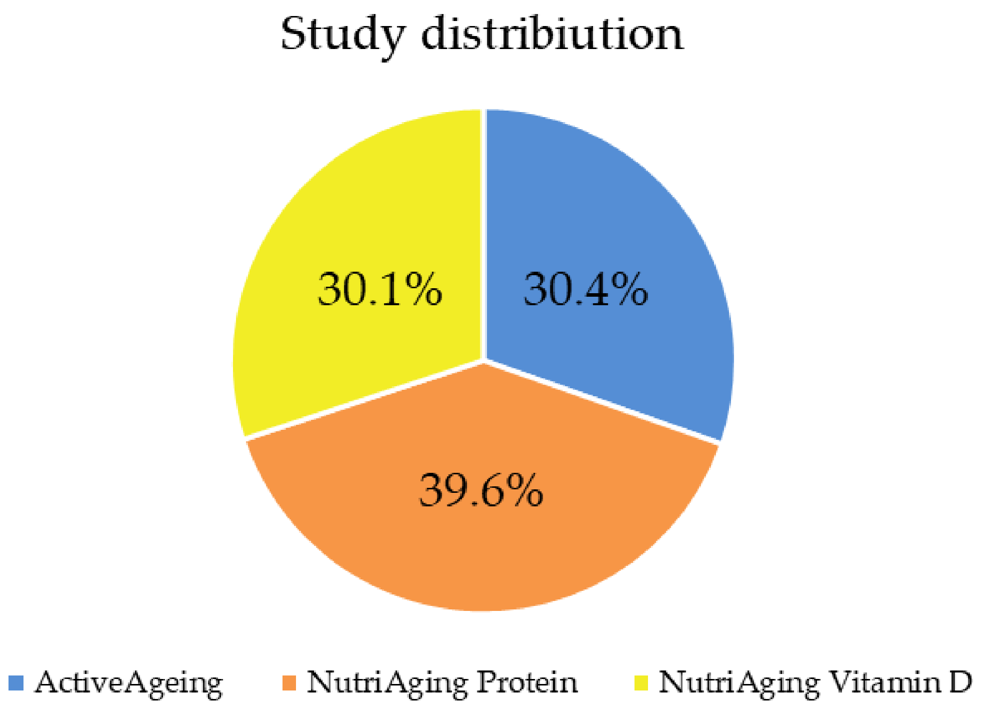


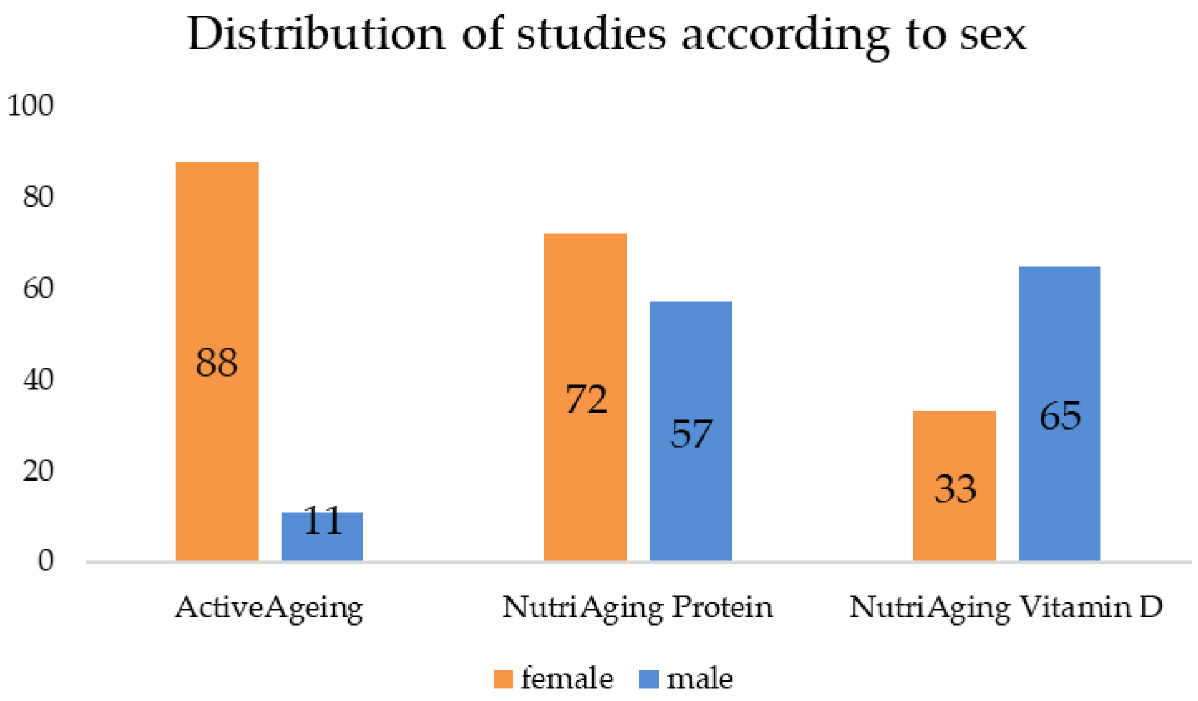
Bartoletti et al. 2021

Aim of the study

1) Description and Validation of sex-specific raw BIA values in an older population with DXA parameters
2) Determination of the association between PhA, physical performance and nutritional status

Distribution of studies/participants





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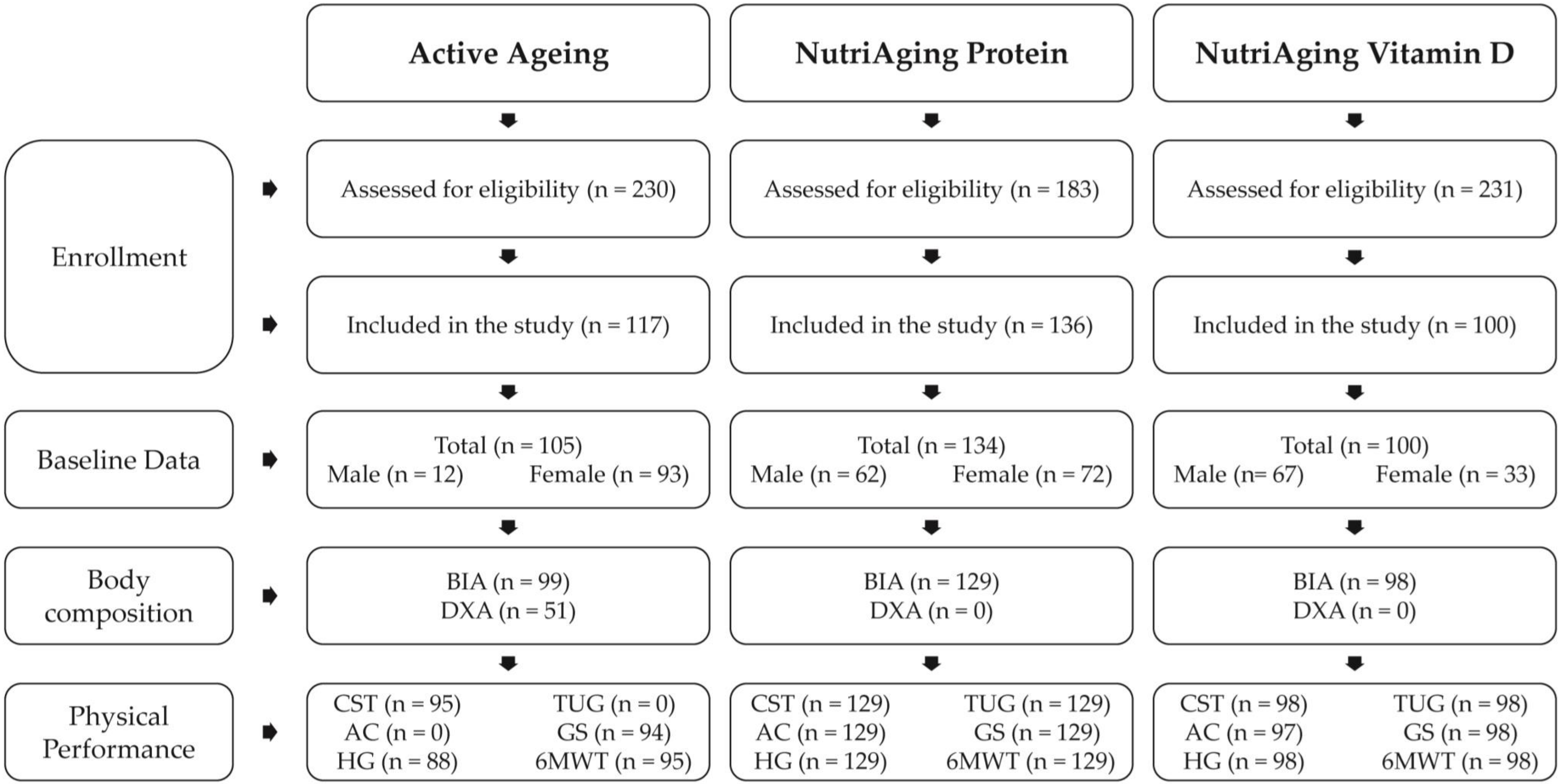
NutriAging



n = 326

Participants' flow.: RT = resistance training, CST = 30-s chair stand, AC = 30-s arm curl, HG = handgrip strength, TUG = timed up and go test, GS = gait speed, 6MWT = 6-min walk test

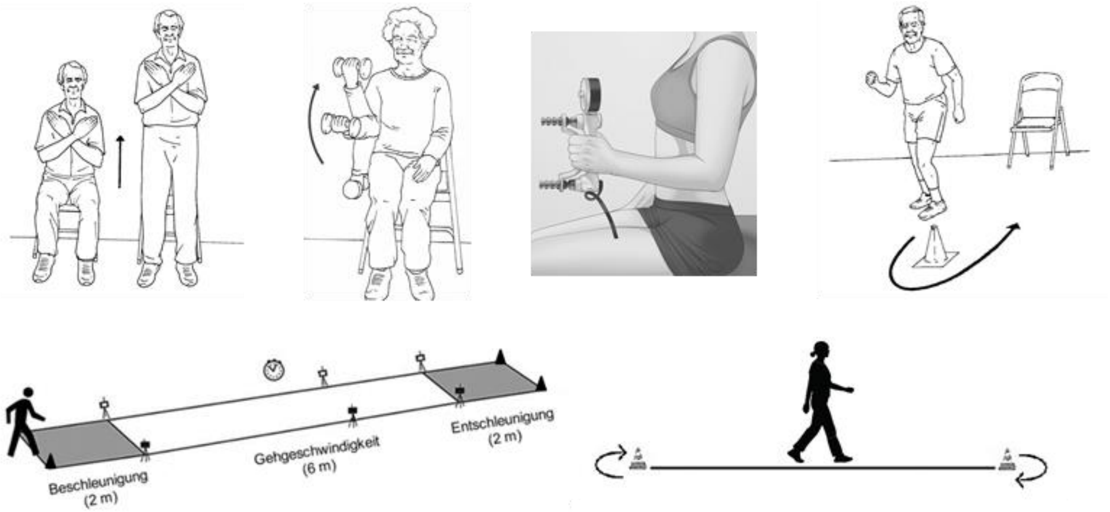
Outcomes

Body compositon

- BIA
  - PhA, reactance, resistance
  - Lean body mass (extracellular + body cell mass), body fat, total body water,
  - Skeletal Muscle Mass (Janssen et a. 2000)

- DXA
  - FFM total, arms, trunk, legs, head
  - FM total, arms, trunk, legs, head

Physical Performance



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NutriAging

Characteristics of study population	total	female	male	p-value	effect size
Sex [f/m], (%)	326 (100%)	193 (59.2%)	133 (40.8%)	**0.001**	
Study Origin [Study 1/ Study 2/ Study 3], (%)	99 (30.4%)/ 119 (39.6%)/ 98 (30.1%)	88 (45.6%)/ 72 (37.3%)/ 33 (17.1%)	11 (8.3%)/ 57 (42.9%)/ 65 (48.9%)	**< 0.001**	0.440
Age [years]	75.2 ± 7.2	77.0 ± 7.2	72.7 ± 6.4	**< 0.001**	0.614
Body weight [kg]	76.2 ± 14.8	70.7 ±13.0	84.3 ± 13.4	**< 0.001**	-1.036
Height [m]	1.7 ± 0.1	1.6 ± 0.1	1.8 ± 0.1	**< 0.001**	-2.440
Body mass index [kg/m²]	27.5 ± 4.7	27.8 ± 5.0	27.1 ± 4.2	0.201	0.140
BMI categories (<25.0 kg/m², 25.0-29.9 kg/m², ≥ 30.0 kg/m²) [n, %]	89 (27.3%)/ 155 (47.5%)/ 82 (25.2%)	54 (28.0%)/ 80 (41.4%)/ 59 (30.6%)	35 (26.3%)/ 75 (56.4%)/ 23 (17.3%)	**< 0.010**	0.169
Waist circumference [cm], n = 315	94.7 ± 12.2	90.6 ± 11.3	100.4 ± 11.1	**< 0.001**	-0.876
Hip circumference [cm], n = 315	105.1 ± 9.6	106.0 ± 10.5	104.0 ± 8.1	**0.048**	0.218
Waist to Hip Ratio [-], n = 315	0.9 ± 0.1	0.9 ± 0.1	1.0 ± 0.1	**< 0.001**	-1.806
Arm circumference right [cm], n = 310	30.3 ± 3.4	29.8 ± 3.5	31.0 ± 3.2	**0.003**	-0.346
Calf circumference right [cm], n = 310	37.1 ± 3.2	36.5 ± 3.2	37.9 ± 3.0	**< 0.001**	-0.449

Note. Values are shown as mean ± standard deviation or as absolute and relative frequencies. p-values refer to differences between groups (independent-samples t-test, Chi Square Test). Effect size is given as Cohen's d for continuous variables (0.2 = small, 0.5 = moderate, 0.8 = large) and Cramer's V for categorical variables (0.1 = small, 0.3 = moderate, 0.5 = large).

Nutritional status	total	female	male	p-value	effect size
Energy intake [kcal]	1,748.9 ± 647.4	1,552.7 ± 503.1	2,032.9 ± 725.2	**< 0.001**	-0.795
Energy intake [kcal/kg BW]	23.4 ± 8.8	22.0 ± 8.6	24.5 ± 9.0	0.078	-0.206
Protein intake [g/day]	61.9 ± 25.8	55.6 ± 22.6	71.0 ± 27.4	**< 0.001**	-0.622
Protein intake [g/kg BW/day]	0.83 ± 0.36	0.81 ± 0.38	0.85 ± 0.33	0.272	-0.128
Carbohydrates [g/day]	183.6 ± 75.2	168.5 ± 63.8	205.5 ± 84.7	**< 0.001**	-0.506
Carbohydrates [g/kg BW/day]	2.48 ± 1.09	2.47 ± 1.08	2.49 ± 1.11	0.878	-0.018
Fat intake [g/day]	72.2 ± 36.1	62.5 ± 27.1	86.4 ± 42.5	**< 0.001**	-0.698
Fat intake [g/kg BW/day]	0.96 ± 0.46	0.91 ± 0.43	1.04 ± 0.51	**0.025**	-0.271

Note. Values are shown as mean ± standard deviation. p-values refer to differences between groups (independent-samples t-test). Effect size is given as Cohen's d for continuous variables (0.2 = small, 0.5 = moderate, 0.8 = large).

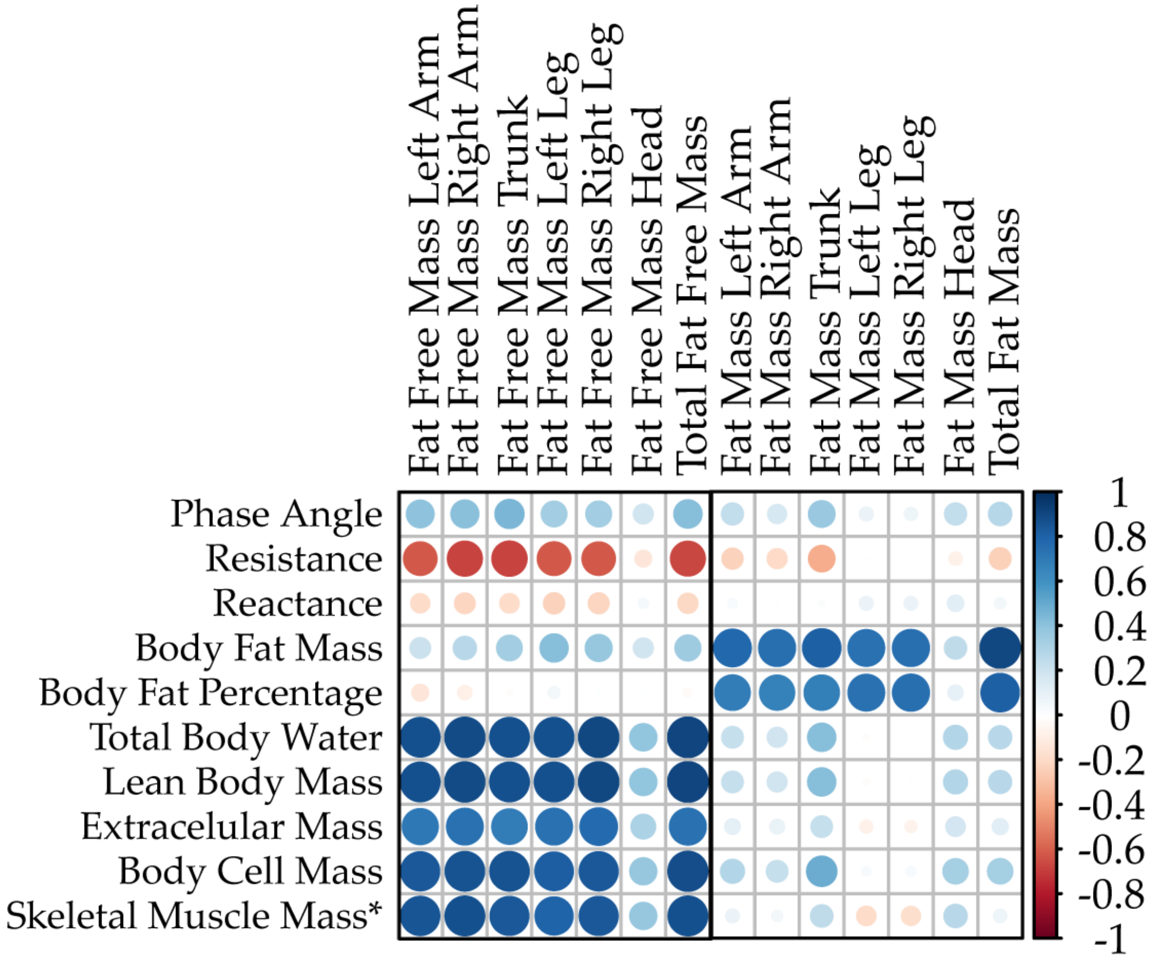
Bioelectrical impedance parameter (n = 326)	total	female	male	p-value
Phase angle [°]	5.0 ± 0.7	4.7 ± 0.7	5.3 ± 0.7	**< 0.001**
Resistance [ohm]	495 ± 79	534 ± 68	438 ± 57	**< 0.001**
Reactance [ohm]	43 ± 8	44 ± 7	40 ± 7	**< 0.001**
Resistance/height [ohm/m]	300 ± 59	335 ± 45	249 ± 33	**< 0.001**
Reactance/height [ohm/m]	26 ± 5	28 ± 5	23 ± 4	**< 0.001**
Total body water [l]	40.6 ± 8.9	34.6 ± 4.0	49.5 ± 6.3	**<0.001**
Lean body mass [kg]	55.6 ± 12.2	47.2 ± 5.5	67.7 ± 8.6	**<0.001**
Extracellular mass [kg]	29.7 ± 6.2	26.0 ± 3.3	35.2 ± 5.4	**<0.001**
Body Cell Mass [kg]	25.8 ± 6.8	21.2 ± 3.4	32.5 ± 4.8	**<0.001**
Body fat mass [kg]	20.6 ± 8.9	23.3 ± 9.1	16.6 ± 6.7	**<0.001**
Body fat percentage [%]	26.8 ± 9.2	32.0 ± 7.4	19.2 ± 5.4	**< 0.001**
Skeletal muscle mass [kg]	24.6 ± 7.6	19.1 ± 3.3	32.7 ± 4.2	**<0.001**
Physical performance parameter				
Physical Performance Score, n = 315	0.06 ± 2.44	0.08 ± 2.52	0.04 ± 2.33	0.859
30-s chair stand test [reps], n = 322	12.4 ± 3.6	11.9 ± 3.6	13.0 ± 3.5	**0.009**
Handgrip strength [kg], n = 315	30.7 ± 11.2	23.2 ± 6.3	41.2 ± 7.4	**<0.001**
30-s arm curl test [reps] n = 226	17.1 ± 4.0	15.9 ± 3.5	18.1 ± 4.2	**<0.001**
Timed up and go [s] n = 227	5.4 ± 1.1	5.8 ± 1.1	5.1 ± 1.1	**<0.001**
Gait speed [m/s], n = 321	2.0 ± 0.6	1.8 ± 0.5	2.4 ± 0.5	**<0.001**
6-minute walk test [m], n = 322	529.6 ± 141.4	471.2 ± 127.4	612.6 ± 117.0	**< 0.001**

Values are shown as mean ± standard deviation. p-Values refer to differences between groups (independent-samples t-test).

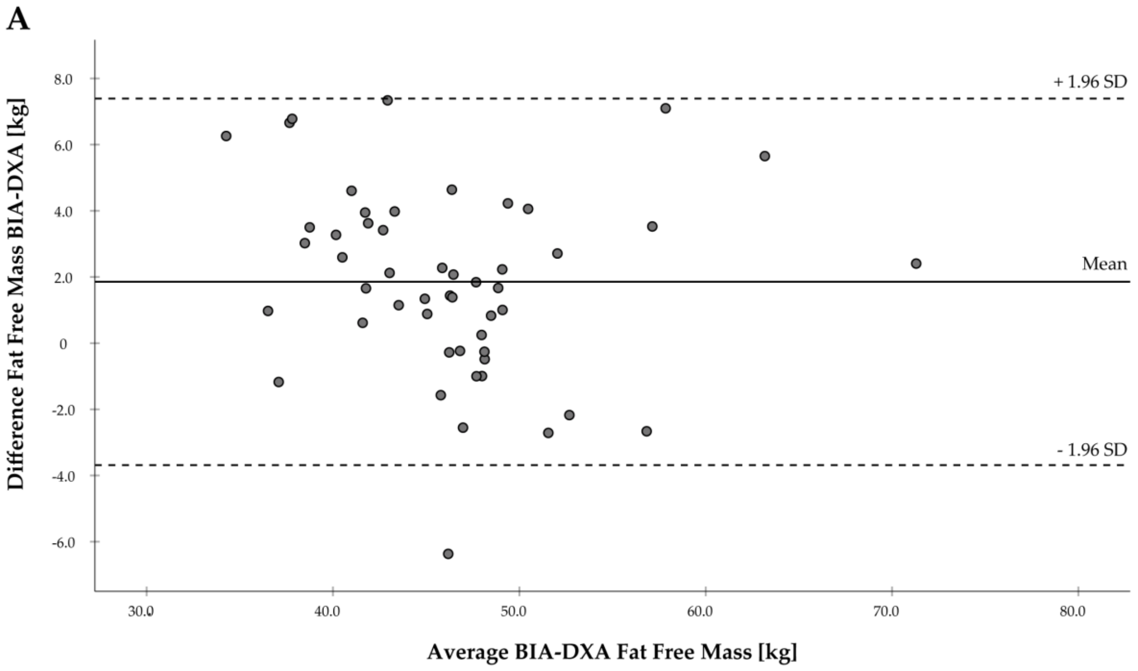
Agreement of body composition parameters by BIA and DXA I

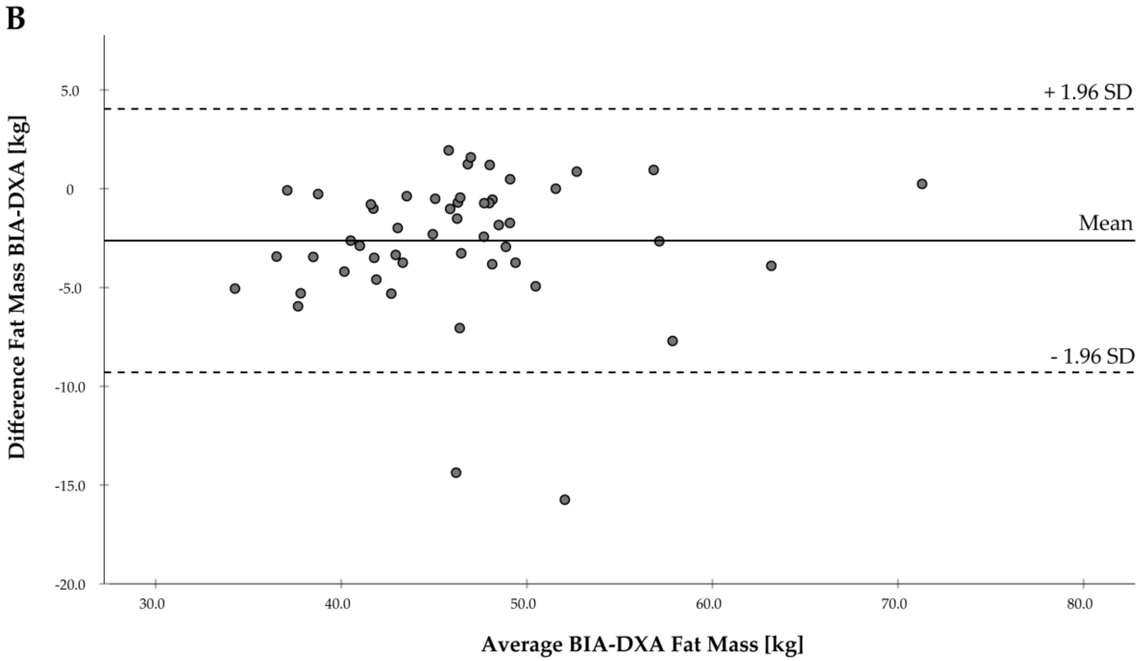
Strong
- FFM & Lean Body Mass
- FFM & device-derived BIA parameters
- FFM & population-specific parameters
- FFM & Resistance
- Body fat & FM

Moderate
- PhA & FFM

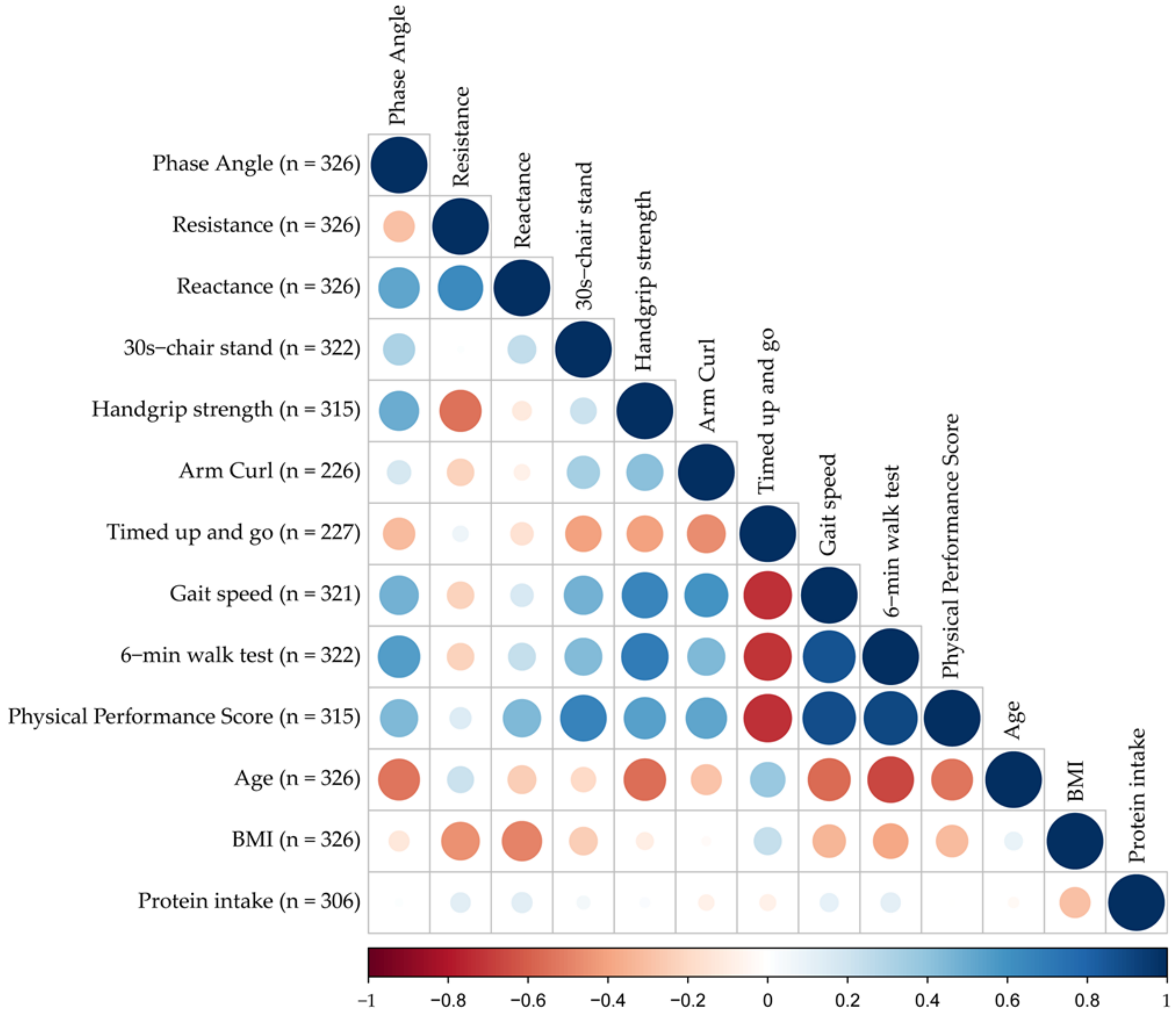


Agreement of body composition parameters by BIA and DXA II





Association between BIA raw parameters, physical performance, age, BMI and protein intake



PP tests	Model	R^2	F	Ind. Variables	B	β
CST	Model 1	0.108	12.313***	Constant	20.294***	
				Age	-0.055*	-0.138
				Sex	0.675*	0.118
				BMI	-0.141***	-0.235
	Model 2	0.142	12.607***	Constant	12.827***	
				Age	-0.016	-0.040
				Sex	0.351	0.061
				BMI	-0.132***	-0.221
				PhA	0.885**	0.226
HG	Model 1	0.774	351.328***	Constant	67.182***	
				Age	-0.571***	-0.369
				Sex	15.534***	0.704
				BMI	-0.013	-0.005
	Model 2	0.781	272.191***	Constant	79.156***	
				Age	-0.554***	-0.358
				Sex	13.849***	0.628
				BMI	-0.160	-0.066
				Resistance	-0.017**	-0.125
	Model 3	0.784	220.890***	Constant	69.060***	
				Age	-0.508***	-0.328
				Sex	13.702***	0.621
				BMI	-0.138	-0.057
				Resistance	-0.015*	-0.110
				PhA	1.031*	0.067
AC	Model 1	0.136	11.549***	Constant	30.298***	
				Age	-0.188***	-0.240
				Sex	1.977***	0.261
				BMI	-0.030	-0.034
	Model 2	0.155	10.110***	Constant	40.573***	
				Age	-0.200***	-0.255
				Sex	0.993	0.131
				BMI	-0.151*	-0.174
				Resistance	-0.012*	-0.241

PP tests	Model	R2	F	Ind. Variables	B	β
TUG	Model 1	0.307	32.605***	Constant	-1.647	
				Age	0.078***	0.361
				Sex	-0.668***	-0.319
				BMI	0.067***	0.276
	Model 2	0.320	25.868***	Constant	-0.122	
				Age	0.071***	0.328
				Sex	-0.597***	-0.285
				BMI	0.065***	0.272
				PhA	-0.196*	-0.124
GS	Model 1	0.575	141.297***	Constant	5.625***	
				Age	-0.040***	-0.500
				Sex	0.390***	0.347
				BMI	-0.029***	-0.244
	Model 2	0.585	109.820***	Constant	44.851***	
				Age	-0.036***	-0.449
				Sex	0.358***	0.318
				BMI	-0.028***	-0.237
				PhA	0.091**	0.118
6MWT	Model 1	0.682	224.011***	Constant	1597.978***	
				Age	-11.329***	-0.592
				Sex	81.936***	0.296
				BMI	-8.965***	-0.309
	Model 2	0.701	183.220***	Constant	1322.378***	
				Age	-9.826***	-0.513
				Sex	71.023***	0.257
				BMI	-8.684***	-0.299
				PhA	32.042***	0.170
	Model 3	0.714	155.229***	Constant	1443.476***	
				Age	-9.849***	-0.514
				Sex	40.679**	0.147
				BMI	-11.397***	-0.392
				PhA	57.426***	0.305
				Resistance	-3.704***	-0.206

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				Resistance	-3.704***	-0.206

PP tests	Multiple Regression Models					
	Model	R^2	F	Ind. Variables	B	β
PP score	Model 1	0.471	92.123***	Constant	21.221***	
				Age	-0.219***	-0.630
				Sex	-1.003***	-0.204
				BMI	-0.159***	-0.295
	Model 2	0.500	77.334***	Constant	15.362***	
				Age	-0.187***	-0.539
				Sex	-1.245***	-0.254
				BMI	-0.156***	-0.290
				PhA	0.702***	0.206
	Model 3	0.509	63.850***	Constant	17.116***	
				Age	-0.187***	-0.539
				Sex	-1.687***	-0.344
				BMI	-0.196***	-0.363
				PhA	1.076***	0.316
				Reactance	-0.054*	-0.166

Note. PP = physical performance; R^2 = coefficient of determination; F = F statistic; ΔR^2 = adjusted R^2; ΔF = changes in F; B = unstandardized regression coefficient; β = standardized coefficient; BMI = body mass index; PhA = phase angle; CST = 30-s chair stand; HG = handgrip strength; AC = 30-s arm curl; TUG = timed up and go; GS = gait speed; 6MWT = 6-min walk test; PPscore = physical performance score;
*p < 0.050, **p < 0.010, ***p < 0.001.

Discussion I

Agreement between BIA and DXA parameters

- FFM and FM were strongly correlated
- BIA overestimated FFM and underestimated FM compared with DXA
  - Results are in line with current literature (Fonseca et al. 2018, Ling et al. 2011, Bosy-Westphal et al. 2008)
  - BIA has high potential as an accurate method for analysing body composition
  - if accuracy is sufficient must be assessed on an individual basis

Discussion II

Association between PhA, physical performance, age, BMI and dietary intake

- Major influencing factors of PhA are sex, age, BMI and nutritional status (Stobaus et al. 2012)
- Correlations were found between PhA, 6-min walk test, 30-s chair stand, 30-s arm curl, timed up and go, gait speed, handgrip strength and physical performance score
    - Similar results were found in studies including healthy and hospitalized adults (Tomeleri et al. 2012, Kyle et al. 2012)
    - Plausible explanation: physical function is directly related to muscle mass, so that a decrease in muscle mass is reflected in reduced physical performance as well as a lower PhA (Tieland et al. 2018)
- In contrast to physical function, no correlations were found between PhA & nutritional status
    - Possible explanation: study population was not undernourished, rather overnourished

Discussion III

Hierarchical Multiple Regression

- PhA was identified as a predictor of 6-min walk test, gait speed, timed up and go, 30-s chair stand, handgrip strength and physical performance score
- No impact on 30-s arm curl
  - Possible explanation: percentage of muscle mass is higher in lower than in upper body (Janssen et al. 2000)
    ==> whole body PhA not as representative for upper body
- Sex, age and BMI as most important factors influencing of physical performance
  - Exception: BMI in handgrip strength and 30-s arm curl test

Discussion IV

Hierarchical Multiple Regression

- High predictability in handgrip strength and 6-min walk test
  - ==> independent on the type of exercise (strength and endurance)
- Low predictability in 30-s chair stand and 30-s arm curl test
  - Possible explanation: both tests focus on strength endurance and coordination ability (Boukadida et al. 2015)
- Physical Performance Score can be used as a global indicator of physical function of upper and lower body

Conclusion

- Higher PhA values are related to better performance in physical function but not with macronutrient intake.

- PhA is an interesting parameter in the context of physical performance
  - ==> avoids the problem of searching for a suitable regression equation
  - ==> suitable for a diverse population.

- In addition, the aspect of cell integrity is particularly interesting in the context of physical fitness, as the muscle cell and its contractile properties play an essential role.

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