Body Composition –
Measures, physiologic and functional impact, health disparities

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Life course perspective -
Changes in body composition with age

- Middle age – gain in fat more than lean
- Older age –
  - Loss of height, mainly in spine
  - Loss of muscle mass
  - Increase in fat mass
  - Increase in central, abdominal fat and muscle fat
  - Bone loss
- Later on - loss of fat, muscle and bone

"Involution"

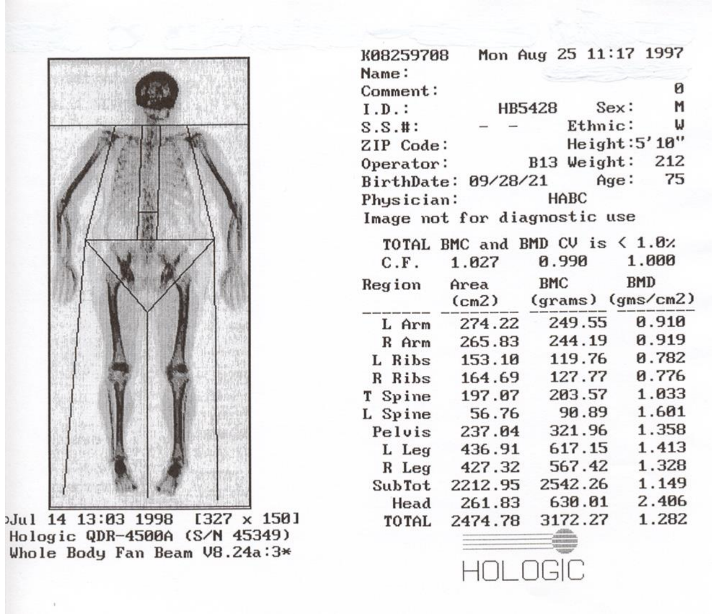
Measuring Body Composition

Body composition methods for quantification of fat-free (lean) (muscle) mass, fat mass, fat distribution

- Total body potassium
- Bioelectric impedance (BIA)
- Dual Energy X-ray Absorptiometry (DXA)
- Magnetic resonance or computerized tomography scan(MR/CT)
- Ultrasound
- D3 Creatine dilution

DXA - Evidence

- Most studies in older adults use DXA lean mass
- Associations found with disability, mobility, mortality
  - depending on indexing (ht^2, BMI, total mass, fat mass)
- Results not always consistent



K08259708 Mon Aug 25 11:17 1997
Name:
Comment: 0
I.D.: HB5428 Sex: M
S.S.#: - - Ethnic: W
ZIP Code: Height:5'10"
Operator: B13 Weight: 212
BirthDate: 09/28/21 Age: 75
Physician: HABC
Image not for diagnostic use

TOTAL BMC and BMD CV is < 1.0%
C.F. 1.027 0.990 1.000

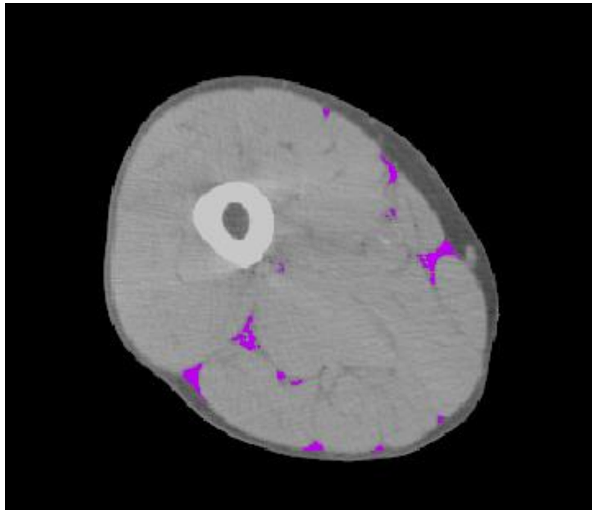
Region	Area (cm2)	BMC (grams)	BMD (gms/cm2)
L Arm	274.22	249.55	0.910
R Arm	265.83	244.19	0.919
L Ribs	153.10	119.76	0.782
R Ribs	164.69	127.77	0.776
T Spine	197.07	203.57	1.033
L Spine	56.76	90.89	1.601
Pelvis	237.04	321.96	1.358
L Leg	436.91	617.15	1.413
R Leg	427.32	567.42	1.328
SubTot	2212.95	2542.26	1.149
Head	261.83	630.01	2.406
TOTAL	2474.78	3172.27	1.282

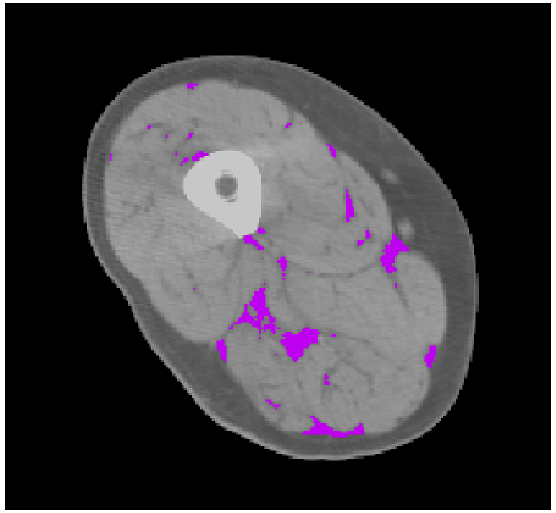
Jul 14 13:03 1998 [327 x 150]
Hologic QDR-4500A (S/N 45349)
Whole Body Fan Beam V8.24a:3*

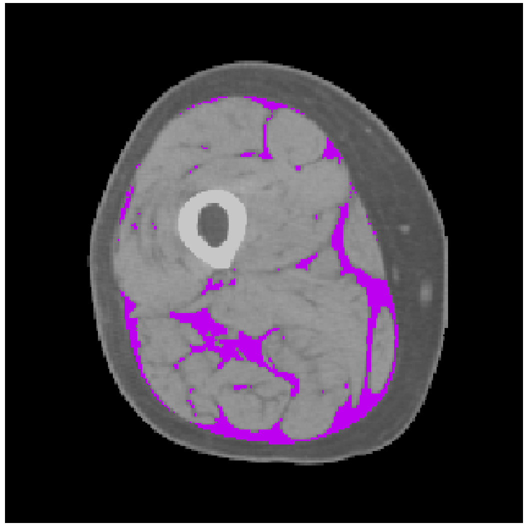
HOLOGIC

Sarcopenia and Skeletal Muscle fat

Less | More | Most



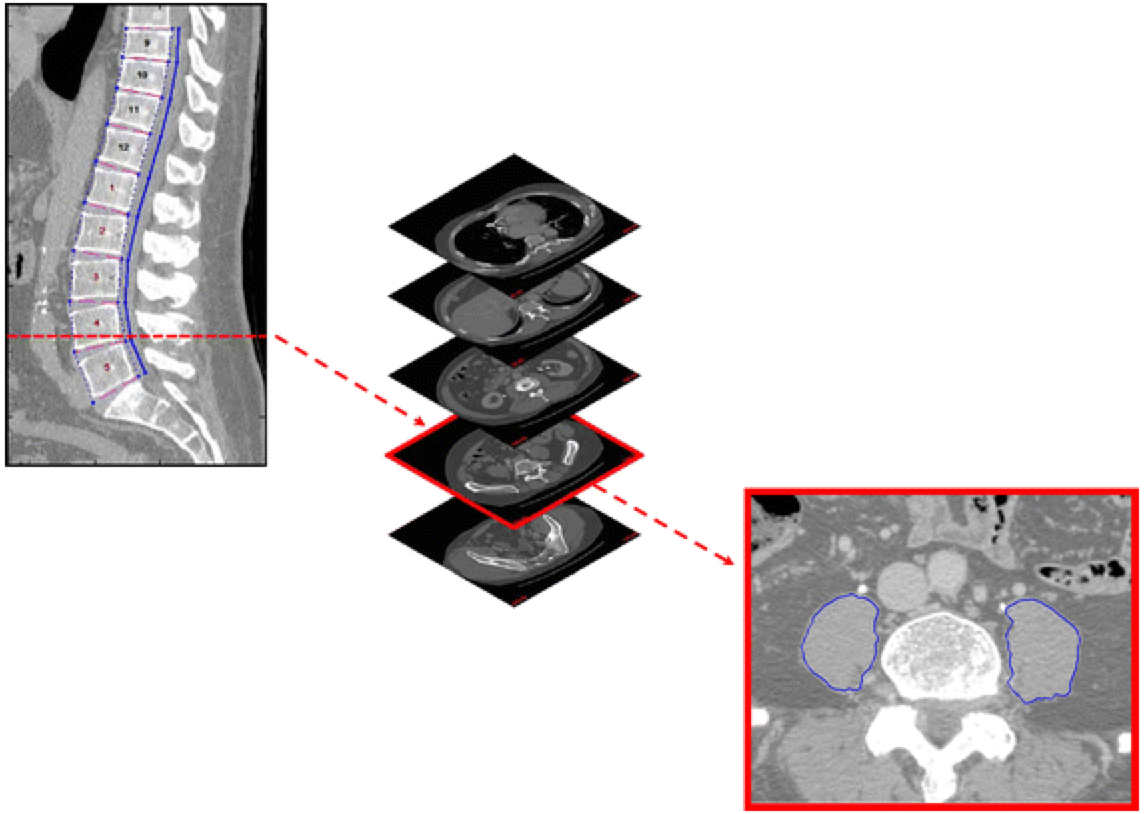




CT Scans of the mid thigh from actual Health ABC participants showing muscle area, subcutaneous fat and intermuscular fat (highlighted in pink) variability in thighs of similar cross-sectional area

Health ABC

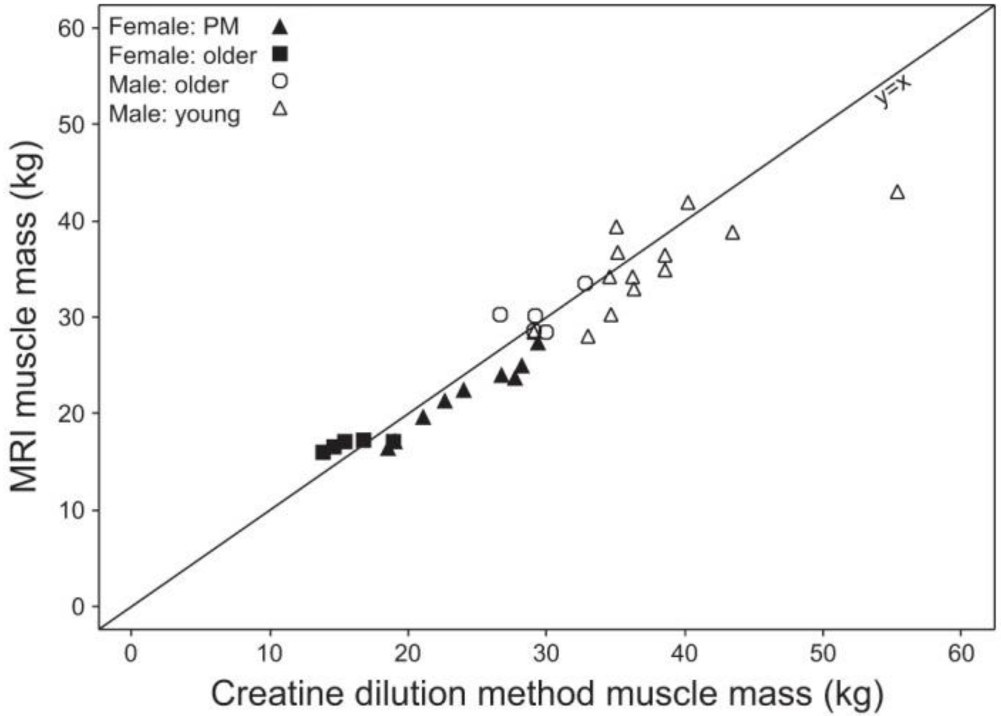
Sabel MS, Lee J, Cai S, Englesbe MJ, Holcombe S, Wang S. Sarcopenia as a prognostic factor among patients with stage III melanoma. Annals of surgical oncology. 2011 Dec 1;18(13):3579-85.



Cross-sectional CT images were used to measure the areas of the left and right psoas muscles at the level of the fourth lumbar vertebra. After identifying individual vertebral levels, we then selected the individual imaging slice at the inferior aspect of L4 and outlined the borders of the left and right psoas muscles. The area of the resulting enclosed regions was then computed to generate the cross-sectional area of the psoas muscles. Psoas muscle density was measured as the average radiodensity (HU) of the enclosed regions

MRI vs D3 Creatine

Fig. 6.



Total muscle mass from MRI vs. muscle mass from the D_3-creatine dilution method calculated using mean steady-state D_3-creatinine enrichment ($r = 0.868$, $P < 0.0001$). r, Pearson's partial correlation coefficient adjusted for sex.

Clark, Richard V., et al. "Total body skeletal muscle mass: estimation by creatine (methyl-d3) dilution in humans." American Journal of Physiology-Heart and Circulatory Physiology (2014).

DXA appendicular lean vs MRI and D3 Creatine

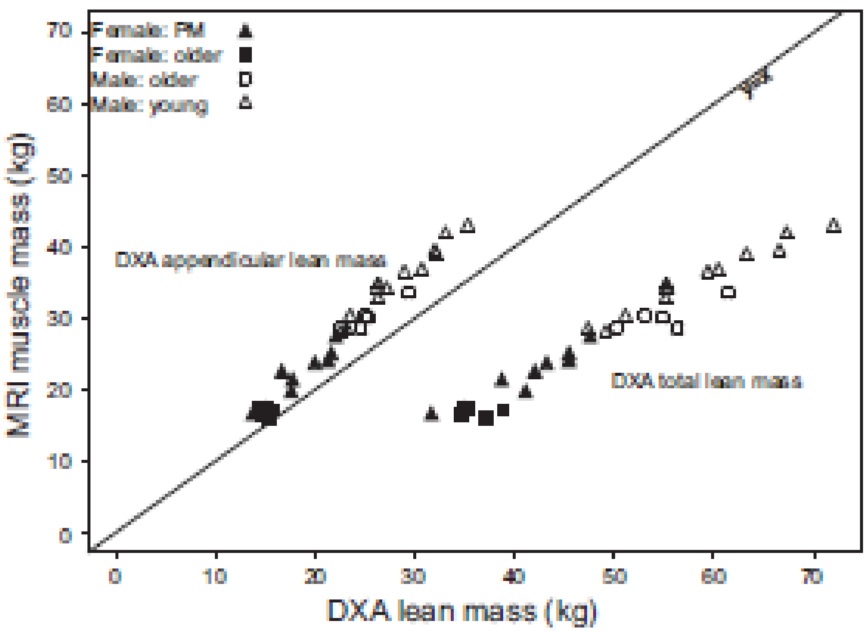


Fig. 7. Total muscle mass from MRI vs. dual-energy X-ray absorptiometry (DXA) appendicular lean mass (ALM) ($r = 0.957$, $P < 0.0001$) and DXA total lean body mass (LBM) ($r = 0.923$, $P < 0.0001$).

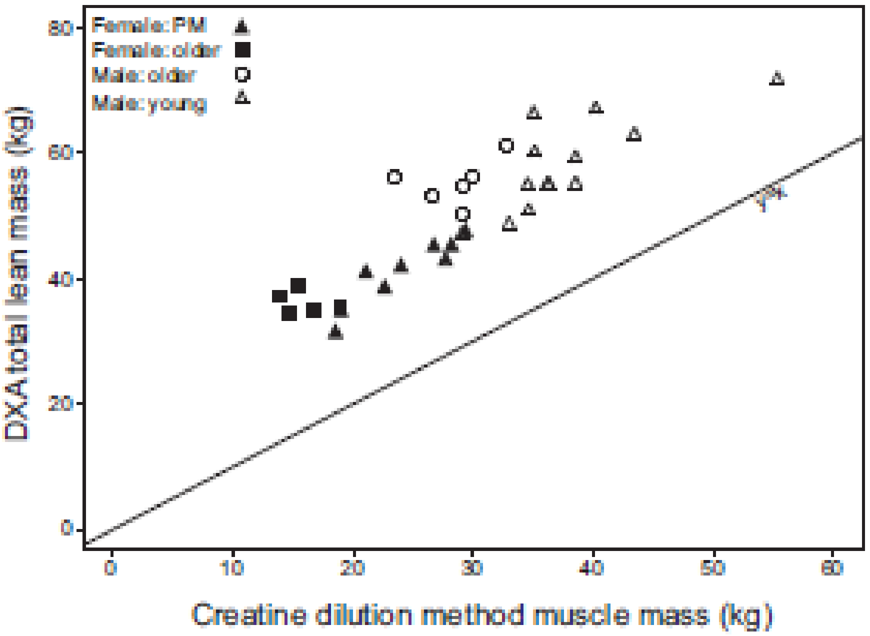


Fig. 9. DXA total lean mass vs. muscle mass from the D_3-creatine dilution method calculated using mean steady-state D_3-creatinine enrichment ($r = 0.745$, $P < 0.0001$).

Clark, Richard V., et al. "Total body skeletal muscle mass: estimation by creatine (methyl-d3) dilution in humans." American Journal of Physiology-Heart and Circulatory Physiology (2014).

Body composition – physiology and function

MUSCLE

- Muscle is major determinant of RMR and distribution of water soluble drugs
- Lean mass by DXA has weak if any association with physical function or mortality
- Lean mass by DXA is strongly related to muscle strength which predicts function and mortality

FAT

- Muscle fat increases with age, is correlated with visceral fat and is strongly related to outcomes
- In old age, subcutaneous fat is protective for mortality but impairs function
- Visceral fat associated with CVD risk, diabetes and inflammation

Mobility limitations & muscle area, density and strength

Health ABC

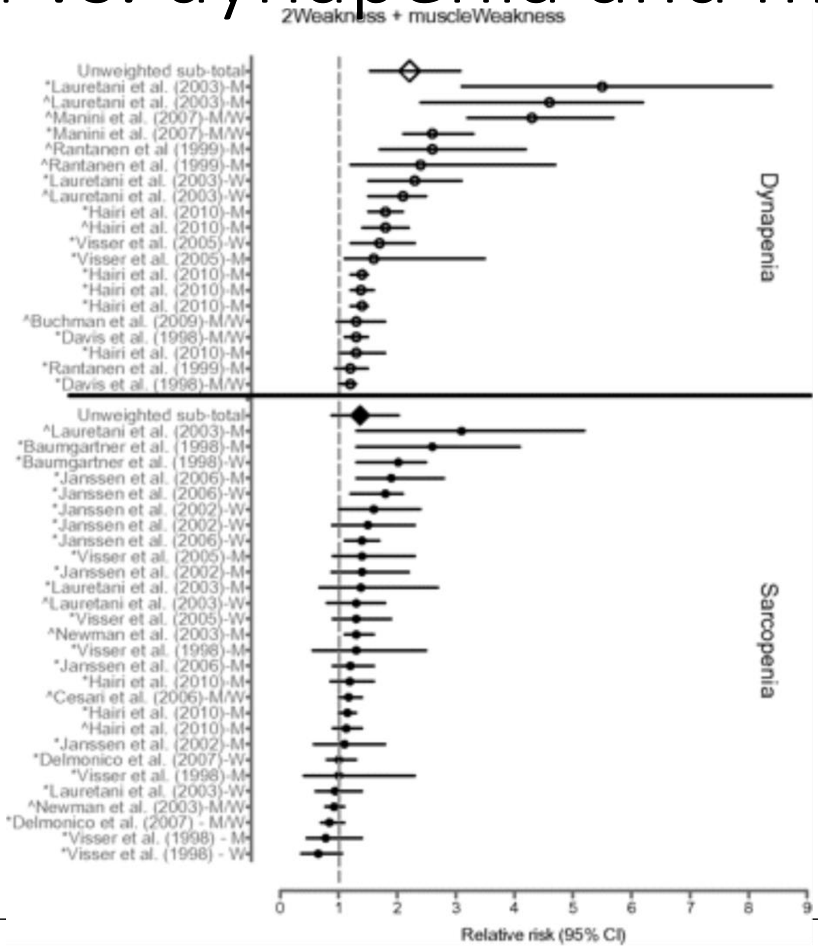
- Mobility limitation
  - any difficulty walking ¼ mile or climbing 10 steps
- Small muscle area, low muscle density and weak knee strength
  - increased risk of mobility limitation
- Only **muscle density, strength and fat** were independently associated with limitations

Hazard ratio for incident mobility limitation (95% CI)

Muscle Parameter	Women
Mid-thigh muscle area	
1 = low	1.34 (0.95–1.88)
2	1.01 (0.74–1.38)
3	1.00 (0.75–1.32)
4 = high	1.0
Mid-thigh muscle attenuation	
1 = low*	1.55 (1.10–2.17)
2	1.69 (1.23–2.34)
3	1.33 (0.96–1.85)
4 = high	1.0
Knee extensor strength	
1 = low	1.69 (1.22–2.35)
2	1.53 (1.11–2.10)
3	1.08 (0.78–1.49)
4 = high	1.0

Visser. Journal of Gerontology. 2005

Sarcopenia vs. dynapenia and mortality



Most studies – strength significantly associated with mortality

Most studies – sarcopenia not significantly associated with mortality

From: Dynapenia and Aging: An Update, Manini and Clark

J Gerontol A Biol Sci Med Sci. 2011;67A(1):28-40. doi:10.1093/gerona/glr010

Should muscle mass be indexed to body size?

- Scaling with height squared (approximately) removes correlation of appendicular lean with height. (BMI for muscle)
- Scaling can be complex (Heymsfeld 2011)
  - Leg length not considered in simple scaling
    - leg length lower in Asians, higher in African Americans compared to Caucasians.
  - Tremendous individual variation
- Scaling variables do not seem to influence associations.

Should muscle mass be indexed to body size?

Table 1. Characteristics of MrOS Men by Quartiles of Muscle Mass/Body Mass by D_3Cr Dilution

	Quartile 1, (lowest) <0.273 N = 350	Quartile 2 ≥0.273–<3.02 N = 350	Quartile 3 ≥0.302–<0.338 N = 350	Quartile 4 (highest) ≥0.338 N = 351	*p*-value
Anthropometrics and demographics					
Age	85.5 ± 4.3	84.7 ± 4.1	83.9 ± 4	82.6 ± 3.2	<.001
White race	326 (93.1)	324 (92.6)	323 (92.3)	289 (82.3)	<.001
Height (cm)	172.8 ± 6.9	172.3 ± 6.6	172.1 ± 6.6	171.7 ± 7	.166
Weight (kg)	86.6 ± 13.5	80.7 ± 11.9	78.0 ± 11.3	73.4 ± 9.1	<.001
BMI (kg/m^2)	29 ± 4.0	27.1 ± 3.3	26.3 ± 3.2	24.9 ± 2.7	<.001
Percent body fat	32.1 ± 5.3	29.1 ± 4.9	26.7 ± 4.7	23.3 ± 4.8	<.001
ALM (kg)	22.7 ± 3.4	22.2 ± 3.1	22.5 ± 3.0	22.4 ± 3.0	.200
ALM/ht^2 (kg/m^2)	7.6 ± 1.0	7.5 ± 0.8	7.6 ± 0.8	7.6 ± 0.8	.144

Cawthon, Peggy M., et al. "Strong Relation Between Muscle Mass Determined by D3-creatine Dilution, Physical Performance, and Incidence of Falls and Mobility Limitations in a Prospective Cohort of Older Men." The Journals of Gerontology: Series A (2018).

Change in weight, muscle, fat

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doi:10.1093/gerona/glw163
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OXFORD

Research Article

Body Composition Remodeling and Mortality: The Health Aging and Body Composition Study

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- Loss of lean mass (DXA) or muscle area (CT) was associated with mortality
  - Both men and women, both DXA and CT
  - Independent of starting lean mass/muscle area
  - Little effect of potential cofounders
  - Loss by CT area (not DXA) – Association with mortality remained significant after adjusting for weight loss

Subgroup differences in body composition

- Sex difference is profound
  - Differences between man and women in muscle and fat - virtually non-overlapping
- Ethnic differences are less clear
  - African-Americans - longer leg length (Gallagher D, JAP, 1997) and lower VAT (Carroll, JF Obesity, 2008).
  - Hispanics – varies (Cameron, N, International journal of obesity 2017.
  - Asians – BMI risk at lower BMI, e.g. BMI>23 (WHO, Lancet, 2004), lower cut-offs for sarcopenia (Chen, LK, JAMDA, 2014)

Knowledge gaps

- Ideal body composition uncertain
  - More work on ethnic differences needed
  - Role of scaling to size uncertain
  - Need to look at fat and muscle together
  - Lack of agreement on definition of sarcopenia
- Muscle quality inadequately defined
  - Metabolic function – fat oxidation
  - Contractile protein function, strength per mass
  - Fiber innervation and recruitment
  - Muscle fat infiltration
- Interventions?
  - Increase is muscle mass does not translate to better function, while reducing fat mass does.
  - Weight management vs. body composition remodeling

Research opportunities

- Body composition assessment – assess newer methods for ability to predict morbidity and mortality
- Tissue biology - relationship to function – biopsy needed
- Consider bone, muscle and fat together – shared risk and protective factors
- Life course – better understanding of weight history and peak performance in youth in relation to declines

Thanks

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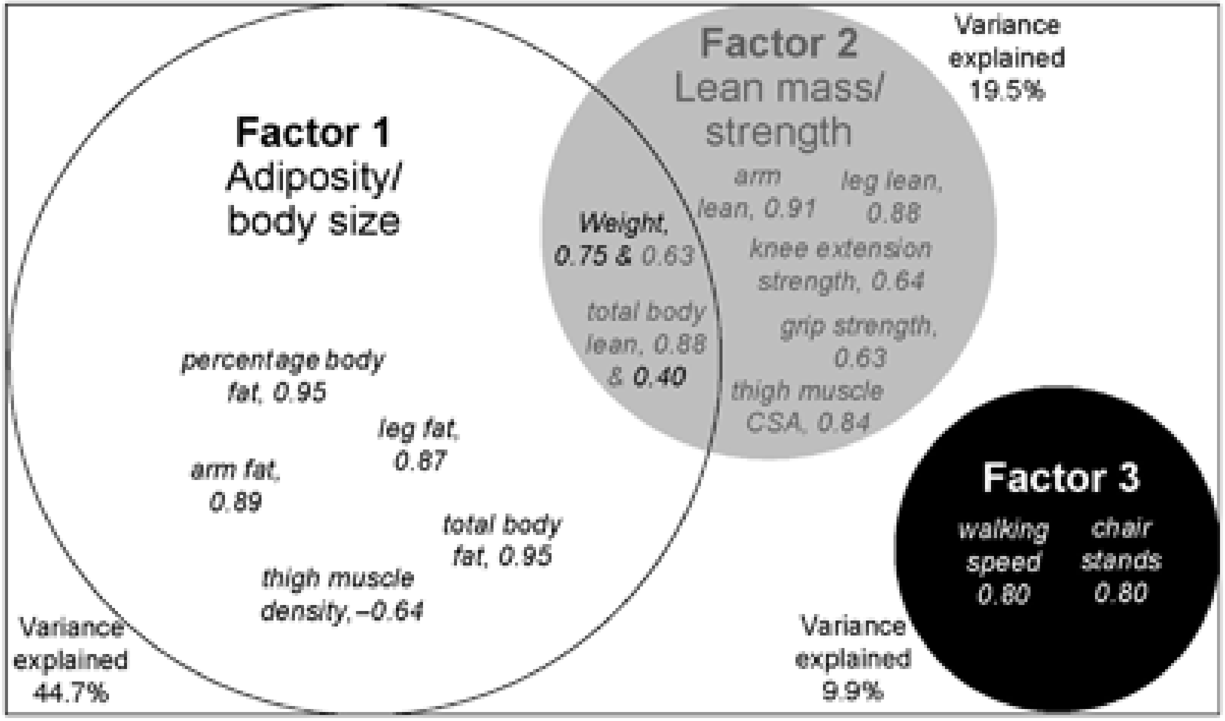
Clustering of Strength, Physical Function, Muscle, and Adiposity Characteristics and Risk of Disability in Older Adults, Cawthon, et al, 2011.



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Volume 59, Issue 5, pages 781-787, 13 MAY 2011 DOI: 10.1111/j.1532-5415.2011.03389.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1532-5415.2011.03389.x/full#f1