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Body Composition In Clinical Practice

ACCESSIBLE METHODS

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a n d

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Nutrition and Body Composition
No conflict of interest
Relevance of assessing body composition

- **Quantification:**
  Assessment of nutritional and physical status

- **Risk assessment:**
  Cardiovascular and metabolic disease

- **Monitoring:**
  Changes in growth or aging / due to medical and nutritional treatments

- **Metabolic load:**
  Impaired outcome before/during treatment

- **Metabolic capacity:**
  Impaired physical function

- **Body Composition:**
  - ECW
  - ICW
  - FM
  - FFM, lean mass
  - BCM
  - Muscle mass

- **Adipose tissue distribution**
Assessing body composition

ECW

FM

FFM, lean mass

ICW

BCM

Muscle mass

Wang 1992
## Body composition analysis methods

<table>
<thead>
<tr>
<th>Clinical / bedside methods</th>
<th>Imaging methods</th>
<th>Research methods</th>
</tr>
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<tbody>
<tr>
<td>Anthropometry</td>
<td>Magnetic resonance imaging</td>
<td>Total body potassium counting</td>
</tr>
<tr>
<td>Bioimpedance analysis</td>
<td>Computer tomography</td>
<td>In-vivo-neutron activation analysis</td>
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<tr>
<td>Ultrasound</td>
<td>Dual X-ray absorptiometry</td>
<td>Isotope dilution technique</td>
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<tr>
<td></td>
<td></td>
<td>Air displacement plethysmography</td>
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</tbody>
</table>

### The choice of method depends on

- purpose (research or clinical use)
- availability
- costs
- feasibility
- safety (strain/exposure)
- evidence
- experience
Body composition measurement in disease is a challenge
Body composition: challenges in vivo
Bioelectrical impedance analysis

- Noninvasive
- Inexpensive
- (Portable)
- Repeatable
- High reliability under standardized conditions
- (Bed side method)
Impedance ($Z$) $= Z^2 = R^2 + Xc^2$

Resist ance ($R$) = pure opposition of a biological conductor to alternating electric current [350 – 650 Ω]

React ance ($Xc$) = capacitive effect produced by the tissue interfaces and cell membranes [40 – 80 Ω]

Calculation of compartments with regression equations:

- Validation against a reference method in an adequate study cohort
- Assuming a constant or known hydration (* 73% in FFM)

<table>
<thead>
<tr>
<th>Impedance</th>
<th>height</th>
<th>weight</th>
<th>sex</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z^2 = R^2 + Xc^2$</td>
<td>(body weight - FFM)</td>
<td></td>
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</tbody>
</table>

FFM* (kg) Fat mass
BIA: calculation of body compartments

- determination of total body water
- calculation of fat free mass
- estimation of body cell mass, muscle mass and fat mass

in subjects without significant fluid and electrolyte abnormalities when using appropriate regression equations (age, sex, ethnicity)

BIA for body composition cannot be recommended in abnormal hydration, in subjects at extremes of BMI ranges (<16 or >34 kg/m²) or in old patients

ESPEN – GUIDELINES: Bioelectrical impedance analysis:
Fat mass and fat free mass
Relation between low FFMI (fat free mass/m²) assessed by BIA and all cause mortality in patients >65yrs – at a group level

n= 3181
Measurement at hospital admission, 20 y follow up
Used equation for FFM: Kyle et al. Nutrition 2001

Calculating skeletal muscle mass with BIA – differing results according to equations

**Janssen et al:**
Skeletal muscle mass (kg) =
5.102 + [(height²/R * 0.401) + (sex * 3.825) + (age * -0.071)]
men=1, women=0

**Tengvall et al:**
Skeletal muscle mass (kg) =
-24.021 + (0.33 * height) + (-0.031 * R) + (0.083 * Xc) + (-1.58 * sex) + (0.046 * weight)
men=0, women=1

**Scafoglieri et al:**
Appendicular lean mass (kg) =
4.957 + (0.196 * height²/R) + (0.060 * weight) – (2.554 * sex)
men=0, women=1

\[ R = \text{resistance} \]
\[ Xc = \text{reactance} \]

Impact of sarcopenia derived by BIA on mortality in old patients with cancer

439 old patients with cancer (60 - 95 yrs; 43.5% women, 27.1% had sarcopenia (low muscle mass and low grip strength)
Equation for muscle mass by Janssen et al. (J Appl Physiol 2000)

Higher mortality
OR 1.53* [95% CI: 1.034; 2.250] P=.0033

*Adjusted for sex, age, number comorbidities and drugs per day, Karnofsky Index, weight loss ≥ 5% within previous 6 months, tumor stage and tumor category
Risk assessment: Phase angle (α) reflects muscle quality and predicts mortality

Grip strength

<table>
<thead>
<tr>
<th>5th reference percentile:</th>
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</thead>
<tbody>
<tr>
<td>Women</td>
</tr>
<tr>
<td>Bosy-Westphal 2002</td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td><strong>BMI 18.5–25</strong></td>
</tr>
<tr>
<td>18–19 y</td>
</tr>
<tr>
<td>20–29 y</td>
</tr>
<tr>
<td>30–39 y</td>
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<tr>
<td>40–49 y</td>
</tr>
<tr>
<td>50–59 y</td>
</tr>
<tr>
<td>60–69 y</td>
</tr>
<tr>
<td>≥70 y</td>
</tr>
<tr>
<td><strong>BMI &gt;25–30</strong></td>
</tr>
<tr>
<td>18–19 y</td>
</tr>
<tr>
<td>20–29 y</td>
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<td>≥70 y</td>
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</table>

* Confounders: age, sex, weight loss (</> 5%/6 months), BMI, tumor entity, disease severity (UICC), duration of disease, and type of treatment (chemotherapy, radiation, no treatment and other treatment)

β = -4.684* [95% CI: -6.164; -3.208] P<.0001

β = -4.548* [95% CI: -8.576; -0.572] P<.035

* [95% CI: 2.4, 6.8] P< 0.001

**Phase angle (α)** reflects muscle quality and predicts mortality

Bosy-Westphal 2002

**OR: 2.2** [95% CI: 1.4, 3.1] P< 0.001

• BIA provides good estimates of body composition in healthy adults
• Low FFM and low muscle mass determined with BIA are predictive of impaired prognosis (on group level)
• Estimation of muscle mass relies substantially on the type of equations used, leading to significantly different results
• Alterations of hydration affects reliability of results
• BIA derived phase angle (directly measured parameter) is highly associated with muscle strength and predictive of mortality and prognosis
Use of ultrasound

- Inexpensive, safe, bedside method
- Regional assessment of muscle quantity (size/mass) and quality (echo intensity)
- 5 main parameters: muscle thickness; muscle cross-sectional area; fascicle length, pennation angle; echo-intensity
- Several sites should be combined
- Standardized protocol necessary

Use of ultrasound: parameters reflecting skeletal muscle characteristics in older adults

Cohort grouped according to AWGS and EWGSOP classifications

- RF, rectus femoris; VI, vastus intermedius

→ Most US muscle quantity indicators lower in sarcopenia
→ Most US muscle quality indicators altered in dynapenia

Yamada et al. JAMDA 2017

n=100 men (81 yrs old)
n=247 women (79.7 yrs old)
Ultrasound: status quo (with regard to muscle)

- Many open issues regarding standardization:
  - measurement site, state of muscle, type and position of probe, frequency
- Some validation studies, but mainly in healthy (partly old) adults
- Relation of site specific loss of muscle and loss of whole body muscle mass is not clear
- Higher prevalence of sarcopenia in lower extremities than other regional sites

Use of computer tomography

Diagnosis of low muscle mass in the cancer content (secondary sarcopenia)
L3 skeletal muscle index (SMI)= skeletal muscle/height in m²
<52.4 cm²/m² (m)  <38.5 cm²/m² (f)

Impact of low lean/muscle mass on the mortality in obese cancer patients

→ n= 250 (63.9 ± 10.4 yrs; BMI ø 34.3 ± 4.4 kg/m² (30.0–55.0))
→ 15% sarcopenic obesity

→ Higher mortality:
HR = 2.4 [95% CI:1.5, 3.9]
(stratified according to age, sex, tumor entity and –stage as well as weight loss)

→ Dose limiting toxicity
→ Lower chemotherapy – clearance
→ Lower progression free survival
→ Higher postoperative complication rate

CT linear measures for screening of patients at risk

height and width of the psoas and paraspinal muscles are assessed with digital ruler and their combined ‘linear area’ in cm²

Cespedes Feliciano et al. Journal of Cachexia, Sarcopenia and Muscle 2018
Use of computer tomography

• Secondary analysis of body composition using available CT scans provides valuable information on prognosis
• Available only for patients with indication for CT scans as part of medical care
• not prescribable for measuring muscle mass in clinical routine
• Most studies (predicting mortality eg) use L3 lumbar muscle area which reflects a group of diverse muscles not single muscle
• Linear measures method might be a practical screening tool to identify patients at risk
Low calf circumference as prognostic factor for 30 day readmission rate in hospitalized patients

Table 4. Multivariable Analysis\(^a\) of Potential Risk Factors for 30-Day Hospital Readmission.

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>CI 95%</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td>4.52</td>
<td>1.11;18.42</td>
<td>0.03</td>
</tr>
<tr>
<td>CCI &gt; 2</td>
<td>3.29</td>
<td>1.21;8.97</td>
<td>0.01</td>
</tr>
<tr>
<td>Nutrition risk(^b)</td>
<td>9.53</td>
<td>1.16;77.9</td>
<td>0.02</td>
</tr>
<tr>
<td>Low CC(^c)</td>
<td>3.89</td>
<td>1.34;11.31</td>
<td>0.008</td>
</tr>
</tbody>
</table>

CC, calf circumference; CCI, Charlson’s comorbidity index; CI, confidence interval; OR, odds ratio.
\(^a\)Logistic regression adjusted for sex and age.
\(^b\)Nutrition risk: Patient-generated Subjective Global Assessment score ≥ 9.
\(^c\)Low CC: ≤ 34 cm for men and ≤ 33 cm for women.

Real et al. JPEN J Parenter Enteral Nutr. 2018

n= 194
Age: 59.2±17.8yrs

Conclusions:

- Variety of body composition methods available even as bedside methods
- Choice for clinical practice depends largely on availability
- BCA in disease is challenging – knowing possibilities and limitations of methods is relevant!