Paediatric specificities of nutritional assessment

Body composition measurement in children

N. Mehta (US)
Body Composition Measurement in Children

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I have no financial disclosures related to this presentation
Objectives

• To discuss the role of body composition measurement in children

• To review available methods of body composition assessment

• To review best practices for body composition assessment
Body Composition Measurement in Children

Body composition basics

Why should we measure body composition?

Currently available methods for BC assessment

Best practice
Body Composition Measurement in Children

Body composition basics

Why should we measure body composition?

Currently available methods for BC assessment

Best practice
Body Composition - compartments

- Absolute body mass
  - Fat
    - Fat free mass
      - 2-C model (underwater weighing)
  - Lean mass
    - Bone
      - 3-C model (DXA)
  - Fat
    - Protein
      - Bone
      - Water
      - 4-C model

Percent of body mass

0 50 100
Body Composition - compartments

Body Composition - compartments

Body Composition – regional variation

Body Composition Measurement in Children

Body composition basics

Why should we measure body composition?

Currently available methods for BC assessment

Best practice
Body composition in children – metabolically active portion

REE-FFM relationship

Five-Compartment Model

Body composition in children – why should we measure?

Variety of ages, developmental stage, pre-existing nutritional deficits and sizes.

Variability in:
Impact of disease
Effectiveness of interventions
Outcomes
NUTRITIONAL ASSESSMENT ON THE ICU

technical challenges

- challenging

- combination of anthropometrics
  - (weight/skin fold thickness)
  - and biochemical data

- Dry weight, Weight %ile / %Std wt.

- NCHS growth charts

- Waterlow criteria
  - (wt/ht; ht/age)

- anthropometric measurements
  - altered - capillary leak syndrome
  - edema and weight gain
240 MV critically ill adults.
CT scan abdomen (day 1-4)

L3 level skeletal muscle area

Low muscle area 63% pts. Mortality: 29%

Low-muscle area assoc with higher mortality
females (47.5% vs. 20%; \( P = 0.008 \)) and
males (32.3% versus 7.5%; \( P < 0.001 \))

Overall, muscle mass was the primary predictor of mortality

Kaplan-Meier survival plot for low- and normal-muscle area group (log rank test, \( P < 0.001 \)).

Muscle function testing in survivors of severe burn injury

Severely burned children (n=33) significantly lower lean body mass significantly lower peak torque as well total work performance using the extensors of the thigh.

Peak torque
Total work

Isokinetic Dynamometer

Body composition in children – why should we measure?

Arch Dis Child 2006;91:612–617

Body Composition Measurement in Children

Body composition basics

Why should we measure body composition?

Currently available methods for BC assessment

Best practice
Body composition in children – measurement methods

• **Anthropometrics**
  Skinfold thickness
  Mid-arm muscle circumference
  BMI

• **Hydrodensitometry** Underwater weighing

• **Isotope dilution** Deuterium

• **Bioelectrical impedance analysis**

• **Air-displacement plethysmography**

• **Dual-energy x-ray absorptiometry (DXA)**

• **CT scanning or MRI**

• **Neutron activation analysis**

• **Total body potassium**
Body Mass Index associated with outcomes in Mechanically Ventilated Children

N = 1622; 90 PICUs; 16 countries

Admission BMI Z scores:
- Normal weight (54.2%)
- Underweight (17.9%)
- Overweight (14.5%), Obese (13.4%)

After adjusting for severity of illness and site

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
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<tbody>
<tr>
<td>Mortalitya</td>
<td></td>
<td></td>
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<tr>
<td>Underweight</td>
<td>1.53</td>
<td>1.24–1.89</td>
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<tr>
<td>Overweight</td>
<td>1.44</td>
<td>0.94–2.19</td>
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<td>Obese</td>
<td>1.55</td>
<td>0.87–2.76</td>
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<tr>
<td>Infections</td>
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<td>Underweight</td>
<td>1.88</td>
<td>1.18–3.01</td>
<td>0.008</td>
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<tr>
<td>Overweight</td>
<td>1.42</td>
<td>0.99–2.05</td>
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<tr>
<td>Obese</td>
<td>1.64</td>
<td>1.33–2.03</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Body composition in children – measurement methods

Upper-Arm Area \( (\text{mm}^2) \) = \( (\pi/4) \times (\text{MAC}/\pi) \).

Upper-Arm Muscle Area \( (\text{mm}^2) \) = \( [(\text{MAC} - \pi(\text{TSF})]/4\pi) \).

Upper-Arm Fat Area = (Upper-Arm Area - Upper-Arm Muscle Area).

Arm Fat Index (\%) = \left( \frac{\text{Upper-Arm Fat Area}}{\text{Total Upper-Arm Area}} \right) \times 100.
Body composition in children – MUAC and outcomes

Tertiary PICU – Brazil

N=72
Median age 21 months

Malnutrition
41% Stunted
18% Wasted

Anthropometrics
WFAz
HFAz
UAMA

Impact of nutritional status on duration of MV

Body composition: Impact of nutrient adequacy on MUAC

Y. Moreno. Prelim data 2017
Body composition in children – measurement methods

Archimedes' principle
Body composition in children – measurement methods

Measurement of body density

Gold standard for BC measurement
2-compartment model

Archimedes’ principle

Difficult in young children due to need to submerge head while exhaling.
Unable to use in sick children
Body composition in children – measurement methods

Total body water and body composition assessment with Deuterium Dilution
Deuterium (99.8%) administered

Urine enrichment with $^2$H – Isotope Ratio MS

Total body water and body composition assessment with Deuterium Dilution
Deuterium (99.8%) administered

Enrichment with $^2$H – Isotope Ratio MS

Total body water and body composition assessment with Deuterium Dilution
Body composition in children – measurement methods

Deuterium (99.8%) administered

Enrichment with $^2$H – Isotope Ratio MS

TBW = dose/enrichment

FFM (kg) = TBW (kg)/0.732

Total body water and body composition assessment with Deuterium Dilution
Body composition in children with SBS

Children with Intestinal Failure

N = 15
Age: 7.2 (5.0, 10.1) years
Weight: 19.9 (15.7, 25.7) kg
BMI-z: 0.49 (-0.72, 0.81)

Methods:

Isotope dilution:
\( ^2 \text{H}_2 \text{O} \) (99.8%) 0.2 grams/kg

IRMS – isotope enrichment
Calcs: TBW, LBM, Fat mass

DXA scan: LBM, Fat mass,
BIA: TBW, LBM, Fat mass

<table>
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<tr>
<th>Methods</th>
<th>LBM (kg)</th>
<th>Fat Mass (kg)</th>
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<tbody>
<tr>
<td>Deuterium dilution</td>
<td>16.7 (11.7, 21.5)</td>
<td>4.3 (3.5, 6.3)</td>
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<tr>
<td>DXA scan</td>
<td>18.5 (12.0, 20.8)</td>
<td>5.3 (4.1, 6.5)</td>
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Body composition in children with SBS

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Bioelectric impedance analysis (BIA)
Bioelectric impedance analysis (BIA)
## BIA in children with chronic illness

### Comparison Variables

<table>
<thead>
<tr>
<th>Comparison Variables</th>
<th>Correlation</th>
<th>Agreement Analysis</th>
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<tbody>
<tr>
<td></td>
<td>R</td>
<td>95% Confidence Intervals</td>
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<tr>
<td><strong>Fat Mass (kg) measured by DXA vs estimated by Skinfold based equation</strong>-</td>
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<tr>
<td>Brook</td>
<td>0.93</td>
<td>0.89-0.95</td>
</tr>
<tr>
<td>Wendel 2SF</td>
<td>0.93</td>
<td>0.89-0.95</td>
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<tr>
<td>Wendel 4SF</td>
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<tr>
<td>Deurenberg</td>
<td>0.97</td>
<td>0.96-0.98</td>
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<tr>
<td>Houtkooper</td>
<td>0.95</td>
<td>0.93-0.97</td>
</tr>
<tr>
<td>Horlick</td>
<td>0.93</td>
<td>0.90-0.96</td>
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<tr>
<td>Schaefer</td>
<td>0.92</td>
<td>0.88-0.95</td>
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<tr>
<td>Rush</td>
<td>0.95</td>
<td>0.93-0.97</td>
</tr>
<tr>
<td>Kushner1</td>
<td>0.93</td>
<td>0.89-0.95</td>
</tr>
<tr>
<td>Kushner2</td>
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<td>Kushner 1</td>
<td>0.87</td>
<td>0.75-0.94</td>
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<tr>
<td>Kushner 2</td>
<td>0.90</td>
<td>0.80-0.95</td>
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</table>
BIS predicts outcomes after pediatric cardiac surgery

122 children with CHD following cardiac surgery

Serial BIS measurements peri-operative period

Low phase-angle (≤2.7°) on day 2 = longer PICU-LOS (OR 7.8; 2.7-22.45, p < 0.001)

Bioelectric Impedance Spectroscopy

Body composition in children – DXA

Attenuation phenomenon - through bone, lean tissue, and fat is different

- Uses ionizing radiation but the effective dose is low
- Needs patient to lie for several minutes (>4 yrs age)
- Lack of normal reference data

Bone density data have good accuracy
Body composition in children – DXA
Body composition in children – Air Displacement Plethysmography

Same principle as underwater weighing

Measures the volume of air displaced by the subject

Problem with the physiological accuracy of a common FFM density among individuals
Body Composition Measurement in Children

Body composition basics

Why should we measure body composition?

Currently available methods for BC assessment

Best practice
Body composition in children – Best practice

Prioritize assessment of body composition
Conceptual definition of pediatric malnutrition

Mehta NM et al. JPEN. 2013 Jul;37(4):460-81
Body composition in children – Best practice

Muscle function testing

Dynamometry

Hand grip strength
Relevant outcomes....?
Thank You

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ASCPEN 2018
Nutrition Science and Practice Conference

Cesar’s Palace
Las Vegas, Nevada
Jan 22^{nd} - 25^{th}