Estimating energy and protein requirements in clinical practice: 
The new PENG guidelines

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Structure

• Definitions

• Current practice and criticisms

• Updating the PENG guidelines

• How are we going to take this forward?
DEFINITIONS
Total Energy Expenditure

Physical activity
• Most variable component of TEE
• 25-50 % TEE (rarely > 75%)

Basal Metabolic Rate (BMR)
• 60 – 70 % TEE
• Highly reproducible in individuals
• 5 – 10 % variation observed between individuals mainly due to:
  • variability in the relation between height, weight and body composition
  • differences in the proportions of metabolically active organs and tissues
  • variations in thyroid function
  • circadian rhythms

Diet induced thermogenesis
~ 10 % mixed meal
Effect of protein > fat or CHO
Measured Energy Expenditure \neq \text{Requirements}
Measured Energy Expenditure (MEE)

Health

BMR

DIT

Activity

Disease

REE

BMR + Stress

DIT

Activity
Methods of measuring energy expenditure

• Indirect calorimetry (BMR or REE)
  • Short-term measurements (up to 24 hours)
  • Hood/ventilator modes
  • Establishing steady state

• Doubly-labelled water technique (TEE)
  • Long-term measurements (several weeks)
  • Cost and technical considerations

• Accelerometers, multi-sensor monitors (physical activity)
CURRENT PRACTICE
Methods for estimating energy requirements in disease

- Indirect calorimetry
- Factorial method e.g. PENG (2011)
- Regression equations e.g. Ireton-Jones (2002)
- Rule-of-thumb e.g. kcal/kg body weight or kcal/kg fat free mass
Factors that affect energy requirements in disease

- Age
- Gender
- Weight
- Type of illness (acute/chronic)
- Severity and phase of illness (acute/recovery)
- Metabolic state (catabolic, normal, anabolic)
- Nutritional status
- Interventions (medical, surgical, pharmacological)
- Physical activity (including effect of any disabilities)
- Psychological state
- Aims and likely duration of nutritional support

PENG guidelines (2011)

Underlying principle: use BMR equations derived for healthy populations and *adjust for illness in individuals*

1. Estimate BMR using Henry (2005)
2. Adjust for metabolic stress
3. Adjust for activity and DIT
4. Add/subtract for weight change?
Criticisms of the PENG recommendations - BMR equations

• BMR equations derived for healthy populations and not sick individuals

• Majority of clinical studies compare MEE with Harris-Benedict equations

• More recently MEE compared with other equations e.g. Schofield (1985) or Mifflin St Joer (1990)
Harris Benedict (HB) Equations (1919)

• 239 healthy subjects (data from 1909-1917)
  – 136 men; mean age $27 \pm 9$ yrs, mean BMI $21.4 \pm 2.8$ kg/m$^2$
  – 103 women; mean age $31 \pm 14$ yrs, mean BMI $21.5 \pm 4.1$ kg/m$^2$

• Considerations
  – Accuracy +10-15% in healthy individuals (Daly 1985)
  – Conditions reflect REE rather than BMR
  – May not be applicable to modern populations
Schofield equations (1985)

• Developed in the 1980s

• Database of 114 studies (7,173 subjects)
  – Studies carried out from 1914 to 1980 (including HB data)
  – Men (67%) women (33%)
  – 87% North European and American (47% Italian)
  – Few subjects from other ethnic groups (13%)

• Body weight/composition different, not valid for precise prediction of BMR worldwide

• Used in COMA 1991 and FAO/WHO/UNU (FAO 2004) reports
Henry equations (2005)

• Database of 10,552 BMR values (1914 – 2005)
  – more rigorous examination of methodology

• Inclusions:
  – measurement conditions met criteria for BMR
  – 55% men, 45% women
  – ↑ proportion of ethnic minorities (38%)
  – ↑ proportion of elderly (8%)

• Exclusions:
  – Italian/military (higher BMR)
  – malnourished/sick
  – outliers e.g. Burmese hill dwellers

• Recommended by SACN (2011) for healthy populations
Criticisms of the PENG recommendations

• Inappropriate use of stress factors:
  – Wide range of stress factors reported for some conditions (PENG have always recommended to start at the lower end, monitor and adjust if necessary)
  – Changes in medications, treatments medical and nursing practice e.g. oral steroids in COPD, HIV medication, burns management

• Use of static variables (weight)
  – weight often inaccurate
  – does not reflect changes in body’s physiology such as respiratory rate or temperature
What are the energy requirements of this patient?

- 70 year old male
- Weight: 65 kg
- BMI: 20 kg/m²
- Hospitalised with acute exacerbation of COPD
- Day 5; to be discharged today
## Harris-Benedict vs Schofield vs Henry

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Basal metabolic rate (BMR)</td>
<td>1388</td>
<td>1443</td>
<td>1509</td>
</tr>
<tr>
<td>110% BMR (Stress factor)</td>
<td>139</td>
<td>144</td>
<td>151</td>
</tr>
<tr>
<td>120% physical activity + DIT</td>
<td>278</td>
<td>288</td>
<td>302</td>
</tr>
<tr>
<td>Total</td>
<td>1805</td>
<td>1876</td>
<td>1962</td>
</tr>
</tbody>
</table>
Disease-specific regression equations

• Use a combination of static measurements and physiological parameters such as body surface area, age, temperature, respiratory rate and tidal volume

• Derived from, and validated in, specific clinical populations, most often intensive care

• Regression equations derived for other populations e.g. rheumatoid arthritis (Metsios et al, 2008)

Model 1: \[ \text{REE} = 127.74 \times \text{FFM}^{0.62} \times \text{CRP}^{0.068} \]
Model 2: \[ \text{REE} = 421.57 \times \text{weight}^{0.51} \times \text{age}^{0.25} \times \text{CRP}^{0.075} \]
Criticisms of disease-specific regression equations

• No guidelines on how frequently requirements should be reviewed and amended in the light of physiological changes

• No evidence that amending feeding regimens in response to changes in these variables results in better outcomes (yet)

• Open to similar criticisms regarding validity and applicability to individuals
Rule-of-thumb formulae

- Based on energy value per kg body weight, fat free mass or lean body mass
  e.g. 25 - 35 kcal/kg body weight/day (NICE, 2006)
  20 - 35 kcal/kg body weight/day (ASPEN, 2002)

- Originally derived for ICU patients yet no references to original work explaining how values were derived

- No defined criteria for when to use 20, 25, 30 or 35 kcal/kg/day

- Lack of validation studies
Criticisms of rule-of-thumb formulae

• REE (or TEE) not always clearly stated

• Unclear for people who are obese or underweight whether requirements should be calculated using actual or ideal body weight

• Do not account for changes in energy expenditure with age, gender or metabolic state
## Estimation of energy requirements

<table>
<thead>
<tr>
<th>Method</th>
<th>70 years; 65 kg; hospitalised with acute exacerbation of COPD (Day 3; to be discharged today)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMR + stress + activity/DIT(^1) (kcal/day)</td>
<td>1,960 kcal/day</td>
</tr>
<tr>
<td>25 - 35 kcal/kg/day(^2)</td>
<td>1,625 – 2,275 kcal/day</td>
</tr>
<tr>
<td>20 - 35 kcal/kg/day(^3)</td>
<td>1,300 – 2,276 kcal/day</td>
</tr>
<tr>
<td>Males = 11.5 x wt [kg] + 952(^4)</td>
<td>1,700 kcal/day</td>
</tr>
</tbody>
</table>

\(^1\) PENG guidelines (2011)

\(^2\) NICE guidelines (2006) for patients who are not severely ill or injured, nor at risk of re-feeding syndrome

\(^3\) ASPEN guidelines (2002) for unstressed adult patients with adequate organ function

\(^4\) Moore & Angelilo (1988) regression equation for moderate to severe COPD
All prediction methods

• May over or under-estimate compared with measured energy expenditure (MEE)

• Inadequately validated

• Poor predictive value for individuals

• Open to misinterpretation with the potential for clinical consequences (over or under-feeding)
UPDATING THE PENG GUIDELINES
What is a guideline?

"Guidelines are recommendations intended to assist providers and recipients of health care and other stakeholders to make informed decisions. Recommendations may relate to clinical interventions, public health activities, or government policies."

*World Health Organisation 2003, 2007*

“Guidance is based on the best available evidence”

*NICE, 2014*
Hierarchy of evidence

- Systematic reviews
- Randomised controlled trials
- Cohort studies
- Case control studies
- Case studies and case reports
- Expert opinion and editorials
Guideline Development Process

- Establish guideline group and processes
- Define scope i.e. target audience, topic selection
- Consider consumer and stakeholder involvement
- Consider conflicts of interest
- Question generation (PICO)
- Define outcomes and consider values, preferences and utilities
- Design search strategy and conduct searches
- Decide what evidence to include
- Summarize the evidence (Data extraction and evidence tables)
- Judge the quality, strength and certainty of a body of evidence
- Develop recommendations and determine their strength
- Peer review, dissemination and implementation
- Evaluation and updating
Process

• Energy
  – Conduct systematic reviews of clinical studies
  – Meta-analyses (if possible)

• Protein, fluid, electrolytes and micronutrients
  – Conduct systematic reviews of published guidelines
  – Narrative review of findings
• Underlying principle: only use data where energy expenditure was measured in clinical settings

• Validated equipment and standard conditions for measuring REE, TEE and physical activity

• Comparison with healthy controls

• Review data on factors likely to impact requirements:
  – Gender, age, weight (BMI), body composition
  – potential indicators of hypermetabolism (acute or chronic) e.g. acute phase proteins, cytokines, body temperature
**Define process and questions**  
(No - Dec 2016)  

**Define selection criteria**  
Study type e.g. RCT  
Participants  
Interventions  
Comparisons  
Outcomes  
Study eligibility form  

**Define search terms and strategy**  

**Select databases**  
Cochrane Library  
Medline  
Embase  
Web of Science  
Cinahl  

**Conduct searches (DJ)**  
(January 2017)  

**Review titles**  
(Double)  

**Select abstracts**  
(Double)  

**Identify potential papers**  
(June 2017)  

**Data extraction**  
Double  
Data extraction pro forma  
(July 2017)  

**Quality review**  
GRADE criteria  
(August 2017)  

**Propose recommendations**  
Evidence tables  
Write supporting text  
(Sept - Nov 2017)  

**Peer review**  
(December 2017)  

**PUBLICATION**  
(March 2018)
Search questions

What are the energy requirements of:

- Hypermetabolic adult patients?
- Metabolically stable adult patients?
- Hypermetabolic adult patients at the extremes of BMI? i.e. < 18.5 or > 30 kg/m²
- Metabolically stable adult patients at the extremes of BMI? i.e. < 18.5 or > 30 kg/m²
- Adult patients receiving long term artificial nutritional support?
How do you define hypermetabolism?

• 10% (20% or 30%) above predicted BMR?

• Which BMR equation do you use?

• How long does hypermetabolism last in acute and chronic disease?

• How do you know a patient is hypermetabolic?
Metabolically stressed?

– Acute or chronic
– Surgery or injury within the previous week
– Infection or inflammation
– Post-operative complications
– Treatments and medications e.g. dialysis, chemotherapy, BMT or steroids

N.B. Stress response is characterised by at least one of the following:
– elevated temperature
– raised white cell count
– elevated C-RP
– raised urea and low serum albumin
– hyperglycaemia
## PICO questions

<table>
<thead>
<tr>
<th><strong>P (Population)</strong></th>
<th><strong>I (Intervention/Exposure)</strong></th>
<th><strong>C (Comparison)</strong></th>
<th><strong>O (Outcome)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence of hypermetabolic state measured using a validated method, rapid heart rate, MEWS score or early warning screening tool, Inflammatory markers (CRP, raised WBC, TNF, ILS, raised temperature, pre-albumin)</td>
<td>Having their energy expenditure measured using a validated technique (indirect calorimetry, DELTA trac, breath by breath method) only measured by machines that produce an RQ figure</td>
<td>Possible comparisons with healthy controls</td>
<td>Unlikely to find out outcome</td>
</tr>
<tr>
<td>Adult only over 18 and no upper age limit</td>
<td>Studies that have reported BMR</td>
<td>Possible comparisons with same disease different drugs</td>
<td></td>
</tr>
<tr>
<td>Body mass index &gt;18.5kg/m² and &lt;30kg/m²</td>
<td>REE patients will be included (including PN) if they have been fasted overnight, they need to have been fasted for at least 6 hours (Looking for a steady state i.e. 30minutes in a steady state, ideally an hour. Oxygen consumption has not varied by 10% to indicate they have been in a steady state)</td>
<td>Possible comparisons with same disease different stage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Doubly labelled water (which gives you TEE)</td>
<td>Possible comparisons with age and gender</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole body calorimetry (non fasted)</td>
<td>Possible comparisons with other clinical conditions including ICU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urea bicarbonate method (non fasted)</td>
<td></td>
<td></td>
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</tbody>
</table>
Energy requirements
Search strategy

• Five databases (including Cochrane)
• Search for relevant guidelines and systematic reviews
• Filtered to identify human studies
• No limits on date, language or types of study
• Hand-searching (reference lists of identified systematic reviews, trials and guidelines, grey literature)
• Quality of included studies assessed using GRADE criteria i.e. study design, inconsistency, indirectness, imprecision and publication bias
Inclusion and exclusion criteria

Inclusion
- REE measured by indirect calorimetry
- TEE measured by doubly-labelled water
- Physical activity
- Clinical settings
- Potential to require nutritional support

Exclusion
- Hand-held devices e.g. MedGem®
- Mechanically ventilated
- Anorexia nervosa
- Obesity syndromes e.g. Prader-Willi, Gaucher’s
- > 3 months post obesity surgery
- HIV (pre-HAART)
Search results

43,664 titles and abstracts

1,185 original papers reviewed

503 studies met inclusion criteria

36 systematic reviews and meta-analyses

190 studies with control groups

263 studies with no control groups

14 studies require translation

EE not measured

Studies in children

Excluded conditions e.g. mechanically ventilated

154 fasted

36 non-fasted

158 fasted

110 non-fasted
Study populations

• Majority (> 90%) reported REE

• More than 30 different disease states

• Hospital, outpatients, inpatient and outpatient rehabilitation units, and nursing homes

• Significant proportion did not report weight, BMI or nutritional status

• Very few reported clinical parameters indicating metabolic state

<table>
<thead>
<tr>
<th>Studies (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
</tr>
<tr>
<td>Liver disease</td>
</tr>
<tr>
<td>COPD</td>
</tr>
<tr>
<td>Renal disease</td>
</tr>
<tr>
<td>EN and PN</td>
</tr>
<tr>
<td>IBD</td>
</tr>
<tr>
<td>Heart failure</td>
</tr>
<tr>
<td>Elderly</td>
</tr>
<tr>
<td>HIV</td>
</tr>
<tr>
<td>Post-bariatric</td>
</tr>
<tr>
<td>Surgery</td>
</tr>
</tbody>
</table>
# How MEE data were reported

<table>
<thead>
<tr>
<th></th>
<th>Resting energy expenditure</th>
<th>Total energy expenditure</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>kcal/day</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>kcal/kg body weight</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>kcal/kg fat free mass*</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Predicted (kcal/day)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>% predicted e.g. Harris-Benedict or Schofield</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>TEE/REE</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>kcal</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>METs</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Units: kcal, kJ, MJ  
Time: per day, hour or minute  
* Measured by skinfold thickness, DEXA or BIA
Outpatients

- 36 trials (1989 to 2015)
- Sample sizes: 6 to 105
- Age: 66 (± 5) years
- BMI: 22.7 (± 2.8) kg/m²
- FEV₁: 42.8 (± 10.1) % predicted

- 19 trials reported REE
  - Mean 1413 (± 200) kcal/day
- 11 trials reported REE % predicted (Harris-Benedict)
  - Mean 114 (± 8) %
- 9 trials reported TEE
  - 1906 (± 280) kcal/day
- 6 trials reported PAL
  - Mean PAL = 1.54 (± 0.08)
REE % predicted (Harris-Benedict)  
COPD vs. control

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>COPD</th>
<th>Control</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean [%predicted]</td>
<td>SD [%predicted]</td>
<td>Total</td>
</tr>
<tr>
<td>Creutzberg 1998</td>
<td>117</td>
<td>9</td>
<td>22</td>
</tr>
<tr>
<td>Donahoe 1989</td>
<td>113</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Fitting 1989</td>
<td>117</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Franssen 2002</td>
<td>105</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>Goldstein 1987</td>
<td>116</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Goldstein 1988</td>
<td>113</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Hugli 1991</td>
<td>120</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Hugli 1993</td>
<td>110</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Hugli 1996</td>
<td>120</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Schols 1991</td>
<td>114</td>
<td>15</td>
<td>68</td>
</tr>
<tr>
<td>Shin 2007</td>
<td>106</td>
<td>14</td>
<td>60</td>
</tr>
<tr>
<td>Yoneda 2001</td>
<td>126</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>302</td>
<td>121</td>
<td>213</td>
</tr>
</tbody>
</table>

Heterogeneity: Chi² = 213.93, df = 11 (P < 0.000001); I² = 95%
Test for overall effect: Z = 23.34 (P < 0.000001)

REE 15.7 % higher than predicted in COPD
### REE (kcal/day) and REE (kcal/kg FFM)

#### COPD vs. control

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>COPD</th>
<th>Control</th>
<th>Mean Difference IV, Fixed, 95% CI</th>
<th>Mean Difference IV, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baarents 1997</td>
<td>1,471 174</td>
<td>1,474 138</td>
<td>7.4%</td>
<td>-3.00 [-156.89, 150.89]</td>
</tr>
<tr>
<td>Crisafulli 2011</td>
<td>1,413 198</td>
<td>1,259 203</td>
<td>21.1%</td>
<td>154.00 [62.96, 245.04]</td>
</tr>
<tr>
<td>Fitting 1989</td>
<td>1,674 233</td>
<td>1,471 179</td>
<td>5.3%</td>
<td>203.00 [20.89, 385.11]</td>
</tr>
<tr>
<td>Hugli 1993</td>
<td>1,469 216</td>
<td>1,512 173</td>
<td>6.5%</td>
<td>-43.00 [-206.54, 120.54]</td>
</tr>
<tr>
<td>Schols 1991</td>
<td>1,480 194</td>
<td>1,460 217</td>
<td>23.5%</td>
<td>20.00 [-66.29, 106.29]</td>
</tr>
<tr>
<td>Schols 1992</td>
<td>1,436 245</td>
<td>1,535 231</td>
<td>5.2%</td>
<td>-99.00 [-283.00, 85.00]</td>
</tr>
<tr>
<td>Sergi 2006</td>
<td>1,774 334</td>
<td>1,570 272</td>
<td>10.3%</td>
<td>204.00 [74.03, 333.97]</td>
</tr>
<tr>
<td>Yoneda 2001</td>
<td>1,413 251</td>
<td>1,107 53</td>
<td>20.7%</td>
<td>306.00 [214.20, 397.80]</td>
</tr>
</tbody>
</table>

**Total (95% CI)**

- **COPD**: 219
- **Control**: 188
- **Mean Difference**: 124.31 [82.50, 166.11]

**Heterogeneity**: $\chi^2 = 35.54, \text{df} = 7 (P < 0.00001); I^2 = 80\%$

**Test for overall effect**: $Z = 5.83 (P < 0.00001)$

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<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental</th>
<th>Control</th>
<th>Mean Difference IV, Fixed, 95% CI</th>
<th>Mean Difference IV, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitting 1989</td>
<td>32.8 4.4</td>
<td>26.3 1.7</td>
<td>2.8%</td>
<td>6.50 [3.58, 9.42]</td>
</tr>
<tr>
<td>Kao 2011</td>
<td>32.9 0.8</td>
<td>27.9 0.7</td>
<td>54.5%</td>
<td>5.00 [4.33, 5.67]</td>
</tr>
<tr>
<td>Pouw 1998</td>
<td>33.5 0.9</td>
<td>28.3 0.8</td>
<td>42.7%</td>
<td>5.20 [4.45, 5.95]</td>
</tr>
</tbody>
</table>

**Total (95% CI)**

- **Experimental**: 36
- **Control**: 25
- **Mean Difference**: 5.13 [4.64, 5.62]

**Heterogeneity**: $\chi^2 = 1.02, \text{df} = 2 (P = 0.60); I^2 = 0\%$

**Test for overall effect**: $Z = 20.43 (P < 0.00001)$
PROTEIN (NITROGEN)
Protein balance

RNI for nitrogen in healthy adults (DoH, 1991) = 0.75 g protein/kg (0.12g N/kg)

Not severely ill or injured (NICE 2006) = 0.8-1.5g protein/kg (0.13-0.24g N/kg)
Current PENG Guidelines

<table>
<thead>
<tr>
<th>Estimation of nitrogen requirements</th>
<th>Nitrogen g/kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.17</td>
</tr>
<tr>
<td>Hypermetabolic 5–25%</td>
<td>0.20</td>
</tr>
<tr>
<td>25–50%</td>
<td>0.25</td>
</tr>
<tr>
<td>&gt; 50%</td>
<td>0.30</td>
</tr>
<tr>
<td>Depleted</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
Protein searches

• 7 databases searched

• 203 clinical guidelines identified

• More than 20 clinical conditions including burns, cancer, dementia, IBD, pancreatitis and renal (some mixed populations)
Systematic review evidence – Hospitalised adults

- Systematic Review of RCTs (4 databases) comparing at least two different levels of protein intake
- 33 studies included (23 ‘high’ or ‘exceptional’ quality)
- Protein requirements varied according to clinical condition (1.0 - 2.3g/kg BW)
- Limited availability of high-level evidence
- No meta-analyses undertaken due to significant heterogeneity

Ferrie S et. al. (2013): Food and Nutrition Sciences 4, 201-214
# Nitrogen – the evidence

<table>
<thead>
<tr>
<th>Study</th>
<th>Group</th>
<th>g N/kg/d</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wolfe et al (1983)</td>
<td>Burns</td>
<td>0.35 vs 0.22</td>
<td>No benefit</td>
</tr>
<tr>
<td>Shaw et al (1987)</td>
<td>Sepsis</td>
<td>0.18, 0.24, 0.36</td>
<td>No change in N breakdown, optimum balance at 0.24</td>
</tr>
<tr>
<td>Larrson et al (1990)</td>
<td>Severe trauma</td>
<td>0.1, 0.15, 0.2, 0.25, 0.3</td>
<td>Improved N balance &lt; 0.2, then no benefit</td>
</tr>
<tr>
<td>Ishibashi et al (1998)</td>
<td>Trauma, sepsis</td>
<td>0.14, 0.19, 0.24</td>
<td>All – N balance 50% increase in N balance at 0.19, then no benefit</td>
</tr>
</tbody>
</table>

Ishibashi N et al. (1998): Critical Care Medicine 26, 1529-1535  
Larsson J et al. (1990): British Journal of Surgery 77, 413-416
Nitrogen guidelines – metabolic stress

• During metabolic stress there is little benefit in providing > 0.2g N/kg (Elia 1990)

• Excess intakes are unlikely to correct negative N balance/prevent skeletal muscle loss (Ishibashi 1998)

• Excess N provision could:
  – ↑ free circulating amino acids
  – Metabolised – oxidised to urea
  – ↑ urea production reduces capacity to excrete salt and water (often oedematous) (NICE 2006)

Elia M (1990): Medicine International 82, 3392-3396
Ishibashi N et. al. (1998): Critical Care Medicine 26, 1529-1535
Key PROT-AGE recommendations for dietary protein intake in sick older adults

• Most older adults who have an acute or chronic disease should consume more dietary protein (i.e. 1.2-1.5 g/kg BW/d)
• People with severe illness or injury or with marked malnutrition may need as much as 2.0 g/kg BW/d.
• Older people with severe kidney disease who are not on dialysis (i.e., estimated GFR < 30 mL/min/1.73m²) are an exception to the high-protein rule; these individuals need to limit protein intake.
• Protein quality, timing of intake, and amino acid supplementation may be considered but further studies are needed to make explicit recommendations.
• In combination with increased protein intake, exercise is recommended at individualized levels that are safe and tolerated.

Bauer J et. al. (2013): Journal of the American Medical Directors Association 14, 542-559
## Estimation of requirements

<table>
<thead>
<tr>
<th>Protein (g/kg/day)</th>
<th>♂; 70 years; 65 kg; hospitalised with acute exacerbation of COPD (Day 3; to be discharged today)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - 2.0&lt;sup&gt;1&lt;/sup&gt;</td>
<td>65 – 130 g protein/day (Day 3 ∴ no stress factor added)</td>
</tr>
<tr>
<td>0.8 - 1.5&lt;sup&gt;2&lt;/sup&gt;</td>
<td>52 – 97.5 g protein/day</td>
</tr>
<tr>
<td>0.8 - 2.0&lt;sup&gt;3&lt;/sup&gt;</td>
<td>52 – 130 g protein/day</td>
</tr>
<tr>
<td>1.2 – 1.5&lt;sup&gt;4&lt;/sup&gt;</td>
<td>78 – 97.5 g protein/day</td>
</tr>
</tbody>
</table>

<sup>1</sup> PENG guidelines (2011)
<sup>2</sup> NICE guidelines (2006) for patients who are not severely ill or injured, nor at risk of re-feeding syndrome
<sup>3</sup> ASPEN guidelines (2002) for unstressed adult patients with adequate organ function
<sup>4</sup> Bauer J et. al. (2013): Journal of the American Medical Directors Association 14, 542-559 (PROT-Age)
Guideline Development Process

- Establish guideline group and processes
- Define scope i.e. target audience, topic selection
- Consider consumer and stakeholder involvement
- Consider conflicts of interest
- Question generation (PICO)
- Define outcomes and consider values, preferences and utilities
- Design search strategy and conduct searches
- Decide what evidence to include
- Summarize the evidence (Data extraction and evidence tables)
- Judge the quality, strength and certainty of a body of evidence
- Develop recommendations and determine their strength
- Peer review, dissemination and implementation
- Evaluation and updating
The future

- Publication of the new Handbook chapters
- Peer-reviewed journals
- Nutritional requirements course
Conclusions

• Estimated requirements are a starting point only. Clinical judgement and monitoring are essential.

• Systematic approach used to identify, collate and review clinical studies and guidelines.

• A variety of methods will be presented for estimating requirements (including comments on the quality of the evidence and strength of recommendations).

• Individual responsibility to ensure practice is supported by evidence
  – Never blindly follow guidelines
  – Critically appraise all evidence you encounter.
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- Danielle Judges, Kent
- Jo Cope, Aintree
- Dr Christine Baldwin, London

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