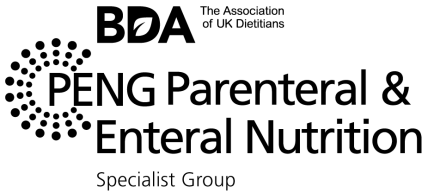

A Pocket Guide To **Clinical Nutrition**

Fifth Edition

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Estimating nutritional requirements for adults

Objectives

- To provide guidelines for estimating the nutritional requirements of adults receiving nutritional support, whether by the oral, enteral or parenteral route.

These guidelines have **not** been developed for use in therapeutic diets or for weight modification.

Introduction

The recommended method for estimating energy requirements for adults has been changed from a factorial method to one where requirements are based on energy values per kg body weight or per kg fat free mass (FFM), with the addition of a combined factor for diet-induced thermogenesis (DIT) and physical activity (PA) if appropriate.

The previous factorial method was based on using an equation to predict basal metabolic rate (BMR) (Henry, 2005), with additional factors for metabolic stress, diet-induced thermogenesis (DIT) and physical activity (PA) (Weekes and Soulsby, 2011).

The new recommendations have been made after completion of a formal guideline development process, including the conduct of five systematic reviews, and are now based on clinical studies where resting energy expenditure (REE) was measured in patients with acute or chronic illness rather than using a method that relies on data generated for use in healthy populations (i.e. Henry BMR prediction equations). As such, clinicians are advised that the estimations derived using the new method will not be directly comparable to estimations derived using the factorial method.

Data included in **Table 3.1**, **Table 3.2** and the online resources were obtained only from clinical studies that met defined criteria for the accurate measurement of resting energy expenditure (REE), total energy expenditure (TEE) and/or physical activity including DIT. See **Appendix 3.2** for details.

Cautions

- Clinicians should understand:
  - how they arrived at the estimated figures.
  - potential sources of error and extent of inaccuracy.
  - the evidence behind the method they used.
  - the risks or side effects of under or over feeding.
- It is an individual clinician's responsibility to ensure that their practice is supported by evidence.
- Clinicians must never blindly follow guidelines and should critically appraise all evidence (see **Appendix 3.1**).
- While prediction methods may provide adequate estimates of requirements for groups of patients they have a poor predictive value for individuals.
- When estimating nutritional requirements it may be appropriate to estimate a range and use clinical judgement to make a decision where to start.

N.B. This section does **not** include recommendations for the estimation of nutritional requirements in mechanically ventilated patients. See **Section 16.**

Estimated requirements are a starting point only therefore the application of clinical judgement and monitoring are essential.

Clinicians are advised to use the flow chart and the tables in this section only after reading the full section.

Step 1

Assess patient's nutritional status, including the measurement of actual body weight or fat free mass (FFM) in kg (see **Section 2, Tables 2.28, 2.29, 2.30** and **2.31**), and collect other relevant data including age, diagnosis, degree of metabolic stress and current intake (see **Table 3.4**).

Step 2

Determine body mass index (BMI) and refer to **Table 3.1** or **Table 3.2**.
In patients at the extremes of BMI (i.e. < 18.5 or >30kg/m^2), refer to **Table 3.6** for guidance on estimating energy requirements.

Step 3

Use **Table 3.1** or **Table 3.2** to estimate resting energy expenditure (REE), according to clinical condition, age and BMI. The data in these tables were obtained from a systematic review which included clinical studies that met defined criteria for measuring REE (see **Appendix 3.2**, **Table 3.18**).

REE (kcal/day) = BW x kcal/kg BW
or
REE (kcal/day) = FFM x kcal/kg FFM

N.B. if there is clinical evidence of metabolic stress (see **Table 3.5** for guidance), and no risk of re-feeding, it may be necessary to use REE figures towards the top of the range.
In the absence of data relating to a specific clinical condition, and the patient is not at risk of refeeding syndrome, clinicians are advised:

- to estimate REE using 20-25kcal/kg BW/day (or refer to the online resources), if the patient has a BMI between 18.5 and 30kg/m^2
- to estimate REE using **Table 3.6** if the patient's BMI is below 18.5 or above 30kg/m^2

(PENG Requirements Guideline Group Consensus Opinion 2018).

Step 4

TEE (kcal/day) = REE (kcal/day) x PAL

Use **Table 3.3** to assign a combined factor for physical activity and diet-induced thermogenesis (PAL) according to likely activity level.

N.B. Patients who are metabolically stressed (**Table 3.5**) are likely to be less physically active than thse who are less sick or who are in the recovery phase (PENG Requirements Guideline Group Consensus Opinion 2018).

All of the factors in **Table 3.4** should be considered prior to the initiation of nutritional support and clinicians should not base their estimate of energy requirements on a patient's weight alone.

Figure 3.1. Flow chart to aid the estimation of energy requirements in adults.

When estimating energy requirements using the data from **Table 3.2** clinicians are advised to measure rather than estimate FFM. Note that the studies included in **Table 3.2** may have used different methods to quantify FFM e.g. bio-electrical impedance analysis (BIA), dual energy X-Ray absorptiometry (DEXA) scanning, air displacement plethysmography or the sum of four skinfold thickness measurements.

When estimating energy requirements using the data from **Table 3.2** clinicians are advised to refer to the relevant studies to ensure they measure FFM using the same method wherever possible.

It should be noted however that in the clinical setting, BIA will be the most practical, accessible, cost effective method to use since it doesn't expose people to radiation. All methods, including BIA, should be used with an awareness of their limitations. Refer to **Section 2** for more information on BIA.

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day.

- *REE kcal/kg BW uses actual body weight.*
- *Data are presented as weighted means (range of reported means); if no range reported, data has come from 1 study only.*
- *In all studies there was considerable variation around the reported mean.*
- *Letters in superscript (^{A,B,C,D}) indicate methods used in the studies (see **Appendix 3.2 Table 3.18**).*
- **BMI was not reported; BMI assumed to be ≤ 18.5kg/m^2.*
- *†BMI was not reported; BMI assumed to be in the range 18.5 - 30kg/m^2.*
- *The number of patients with the relevant condition may be considerably less than the total number of subjects in the study.*
- *See online resources at http: www.peng.org.uk.*

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day.

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Burns								
Burns (spontaneously breathing)							See text and online resources	
Cardiac								
Chronic heart failure			25[A] (21-28)			18[A]	See online resources	Riley *et al*. 1991 (n=28); Aquilani *et al*. 1994 (n=112); Aquilani *et al*. 1995 (n=36); Lommi *et al*. 1998 (n=14); Aquilani *et al*. 2003 (n=106); Savage *et al*. 2007 (n=109)
Gastrointestinal (GI) disease								
Crohn's disease	28[A]		25[A] (24-26)				In patients with low BMI, REE was 29 kcal/kg BW in active disease and 26 kcal/kg BW in remission (Gong *et al*. 2015)	Chan *et al*. 1986† (n=54); Stokes & Hill 1993† (n=13); Al-Jaouni *et al*. 2000 (n=40); Sasaki *et al*. 2010a (n=24); Gong *et al*. 2015 (n=75); Takaoka *et al*. 2015 (n=40)
Ulcerative colitis			26[A,B] (24-26)				REE decreased to ~ 23.5 kcal/kg BW following treatment. CRP, TNF- α and IL-6 were higher in patients with active disease (Inoue *et al*. 2015)	Sasaki *et al*. 2010b (n=23); Inoue *et al*. 2015 (n=13); Takaoka *et al*. 2015 (n=40)
Non-neoplastic GI disease							See **Table 3.2**	
HIV								
Outpatients			27[A] (25-33)				Patients who are gaining weight are likely to have higher REE ~ 30 kcal/kg BW (Macallan *et al*. 1995)	Macallan *et al*. 1995 (n=41); Süttmann *et al*. 2000 (n=11); Luzi *et al*. 2003 (n=24)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Cancer								
Acute leukaemia			26[B]				REE was 28 kcal/kg BW before chemotherapy and 24 kcal/kg BW after first cycle. N.B. moderate fast	Galati *et al*. 2016 (n=44)
Bone marrow transplant			24[A] (23-25)					Chamouard Cogoluenhes *et al*. 1998 (n=11)
Brain							See **Table 3.2**	
Gastro-intestinal			20[A] (19-23)	21[A] (17-21)				Hansell *et al*. 1986 (n=24); Merrick *et al*. 1988 (n=21); Nixon *et al*. 1988 (n=202); Fredrix *et al*. 1991a (n=104); Fredrix *et al*. 1991b (n=191); Lugli *et al*. 2011 (n=16)
Head and neck			22[A,D] (22-25)				REE decreased from 24 to 22 kcal/kg BW during chemo-radiation and rose to 25 kcal/kg BW by 2 weeks after treatment (García-Peris *et al*. 2005). Fasting status unclear (Langius *et al*. 2012)	Ng *et al*. 2004 (n=38); García-Peris *et al*. 2005 (n=18); Langius *et al*. 2012 (n=71)
Liver			23[A] (22-25)	22[A]			Subjects with larger tumours had increased REE. Presence or absence of ascites or cirrhosis did not affect REE in kcal/kg BW (Chen and Chung, 1994)	Chen & Chung 1994 (n=117); Merli *et al*. 1992 (n=24); Omagari *et al*. 2012 (n=74)
Lung			23[A] (20-25)	23[A]			REE in patients with stage 4 disease is likely to be at the higher end of the range (Takemura *et al*. 2016)	Nixon *et al*. 1988 (n=202); Fredrix *et al*. 1991c (n=134); Jebb *et al*. 1994 (n=28); Staal-van den Brekel *et al*. 1994 (n=100); van der Meij *et al*. 2010 (n=40); Takemura *et al*. 2016 (n=46)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Cancer								
Non-Hodgkin's lymphoma			20[A]				REE (kcal/kg) higher in stage IV patients and those with bulky tumours	Delarue *et al*. 1990 (n=10)
Oesophagus	29[A]		26[A] (23-29)				For the BMI <18.5kg/m² data, all subjects were black males (Thomson *et al*. 1990)	Okamoto *et al*. 2011 (n=16); Thomson *et al*. 1990 (n=31)
Pancreas	25[A] (24-26)		24[A]	24[A] (22-27)			Patients with evidence of an acute phase response were likely to have a higher resting energy expenditure (Falconer, 1994; Wigmore, 1997) See online resources	Falconer *et al*. 1994* (n=37); Wigmore *et al*. 1995* (n=33), Wigmore *et al*. 1997†(n=35); Barber *et al*. 2000* (n=22); DeJong *et al*. 2005 (n=26); Sasaki *et al*. 2011 (n=12); Omagari *et al*. 2012 (n=74)
Urological							See **Table 3.2**	
Various cancers (weight losing or cachectic)	24[A]			23[A]				Hyltander *et al*. 1991* (n=202); Bosaeus *et al*. 2001 (n=702); Lundholm *et al*. 2004† (n=297)
Various cancers (weight stable non cachectic)			23[A] (22-25)	25[A,B] (18-26)				Hyltander *et al*. 1991 (n=202); Hardin *et al*. 1993 (n=7); Lauvin *et al*. 1996 (n=229); Cereda *et al*. 2007 (n=10); Trutschnigg *et al*. 2013 (n=20)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Liver								
Acute hepatitis			27[A] (26-27)					Fan *et al*. 2008† (n=100); Meng *et al*. 2011 (n=315)
Alcoholic liver cirrhosis			28[A] (27-29)					Muller *et al*. 1991 (n=20); Addolorato *et al*. 1998b (n=57)
Chronic alcohol dependency			27[A] (26-27)					Addolorato *et al*. 1998b (n=57); Addolorato *et al*.1999 (n=90); Levine, Harris and Morgan, 2000 (n=72)
Chronic hepatitis			21[A] (19-22)					Fan *et al*. 2008† (n=100); Meng *et al*. 2011 (n=315); Hou *et al*. 2013 (n=70)
Cirrhosis			22[A] (19-27)				All studies varied regarding inclusion or exclusion of patients with ascites, and disease severity	Shanbhogue *et al*. 1987 (n=41); Merli *et al*. 1990 (n=35); Green, Bramley and Losowsky, 1991 (n=21); Nielsen *et al*. 1995 (n=15); Madden and Morgan, 1999 (n=16), Madden and Morgan, 2003 (n=142); Hou *et al*. 2013 (n=70); Teramoto *et al*. 2014 (n=488)
Liver transplantation (pre-op)			23[A] (23-27)				Post-operative changes in REE varied between studies; REE gradually decreased over several months to ~ 20 kcal/kg BW post-op (Green, Bramley and Losowsky, 1991; Perseghin *et al*. 2002)	Green, Bramley and Losowsky, 1991 (n=21); Perseghin *et al*. 2002 (n=38); Chen*et al*. 2016 (n=33)
Non alcoholic fatty liver disease					18[D]			Paniagua *et al*. 2014 (n=45)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Neurological disease								
Amyotrophic lateral sclerosis (ALS) (Motor neurone disease)			22[A]	24[A]			See **Table 3.2** and online resources	Desport *et al*. 2001 (n=93); Vaisman *et al*. 2009 (n=66)
Cerebral palsy							See online resources	
Dementia				20[A] (18-21)			Also see **Table 3.8** and online resources	Niskanen *et al*. 1993 (n=30); Reyes-Ortega *et al*. 1997 (n=12)
Muscular dystrophy			24[A]				See online resources	Deisenhammer *et al*. 1997† (n=28)
Multiple sclerosis	28[C,D] (24-30)						REE in kcal/kg may be higher for Duchene muscular dystrophy than for limb-girdle type (Okada *et al*. 1992). Fasting status unclear (Okada *et al*. 1992) See online resources	Okada *et al*. 1992* (n=338); Shimizu-Fujiwara *et al*. 2012 (n=77)
Head injury (acute spontaneously breathing)			29[A] (27-31)				Patients on paralysing agents, sedatives and barbiturates likely to have lower REE (Foley *et al*. 2008). Metabolic stress may last up to 30 days post injury (Krakau *et al*. 2006). Data not reported as kcal/kg BW in either systematic review. See online resources	Young *et al*. 1985 (n=16); Chioléro *et al*. 1989 (n=12); Weekes and Elia, 1996 (n=6); Krakau *et al*. 2006 (Syst review n=20 studies); Foley *et al*. 2008 (Syst review n=24 studies)
Head injury (rehabilitation)			24[A]				Mean 60 days post injury; >10% recent weight loss (Fugazza *et al*. 1998)	Fugazza *et al*. 1998 (n=11)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Neurological disease								
Haemorrhagic stroke			24[A]				See online resources	Nagano *et al*. 2016 (n=12)
Ischaemic stroke (acute)				21[A]			REE remained stable up to 90 days post stroke (Finestone *et al*. 2003)	Finestone *et al*. 2003 (n=91); Nagano *et al*. 2015 (n=30)
Ischaemic stroke (rehabilitation)			19[A]	19[C]			See **Table 3.2** and online resources	Aquilani *et al*. 1999 (n=150); Leone and Pencharz, 2010 (n=67)
Post polio syndrome			20[A]				All subjects were male See online resources	Bargieri *et al*. 2008 (n=34)
Spinal cord injury (acute)			23[A,D] (23-28)				REE likely to be higher in paraplegics than in quadriplegics (Cox *et al*. 1985). Fasting status unclear (Kearns *et al*. 1992)	Cox *et al*. 1985† (n=22); Kearns *et al*. 1992 (n=10)
Spinal cord injury (chronic)			25[A] (17-28)				More than one year post injury. See also systematic review by Nevin *et al*. 2016 (n=18 studies)	Lee *et al*. 1985 (n=17); Sedlock and Laventure, 1990 (n=4); Aquilani *et al*. 2001 (n=10); Yilmaz *et al*. 2007a (n=30); Yilmaz *et al*. 2007b (n=20); Bauman *et al*. 2015 (n=24)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Pancreatitis								
Acute			26[A]					Dickerson *et al*. 1991 (n=48)
Chronic (alcohol related)			25[A]					Dickerson *et al*. 1991 (n=48)
Septic			26[A]					Dickerson *et al*. 1991 (n=48)
Mixed populations or polymorbid								
Acutely ill hospitalised	30[D]		25[A,D] (24-27)	20[A] (19-22)			Fasting status unclear (Weijs *et al*. 2008). Fasting status and age not reported (Winter *et al*. 2005).	Campillo *et al*. 1992 (n=39); Lauvin *et al*. 1996 (n=229); Barak, Wall-Alonso and Sitrin, 2002 (n=567); Winter *et al*. 2005 (n=42); Alix *et al*. 2007 (n=90); Weijs *et al*. 2008 (n=93)
Mixed in and outpatients	29[B]		25[B] (21-27)		18.5[B]		Fasted for 2 - 8 hours; REE for whole population 25 kcal/kg BW	Kruizenga *et al.* 2016 (n=593)
Nursing home or long term care facility				21[A,B] (20-23)			REE measured after 8 hour fast (Lammes and Akner, 2006)	Lammes and Akner, 2006 (n=74); Silver *et al*. 2013 (n=45)
Outpatient			23[D]				Fasting status unclear	Weijs *et al*. 2008 (n=93)
Rehabilitation				19[A]				Gaillard *et al*. 2008 (n=36)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Renal								
Acute kidney injury			28[D]				Patients measured during mechanical ventilation and while receiving enteral or parenteral nutrition	Goes *et al*. 2017 (n=114)
Pre-dialysis			23[A] (19-26)				REE kcal/kg BW may rise as kidney function deteriorates (Kuhlmann *et al*. 2001)	Avesani *et al*. 2001 (n=48), Avesani *et al*. 2004 (n=90); Kuhlmann *et al*. 2001† (n=51); Passey *et al*. 2003 (n=7)
Peritoneal dialysis			23[A] (21-24)					Bazanelli *et al*., 2010 (n=40)
Haemodialysis			24[A,C] (19-25)				Short fast (Kogirima *et al*. 2006)	Kogirima *et al*. 2006 (n=54); Suneja *et al*. 2011 (n=18); Shah *et al*. 2016 (n=13)
Respiratory disease								
COPD - acute exacerbation							See online resources	
COPD - rehabilitation		27[A]	25[A]				Weight losing patients more likely to have higher REE kcal/kg BW (Schols *et al*. 1991)	Schols *et al*. 1991† (n=80); Burdet *et al*. 1997a (n=16)
COPD - outpatients	31[A] (29-33)		24[A] (21-26)	25[A]	24[A]		Increased REE associated with higher TNF- levels (Nguyen *et al*. 1999)	Green and Muers, 1991 (n=30); Doré *et al*. 1997 (n=26); Congleton and Muers, 1998 (n=20); Mannix *et al*. 1999 (n=10); Sergi *et al*. 2006 (n=86); Brúsik *et al*. 2012 (n=44)
Interstitial lung disease			27[A]					Hugli *et al*. 1995 (n=12)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Surgery								
Cardiac							See online resources	
Fixation of fractured neck of femur				23[A,C] (19-24)			Short fast (Jallut *et al*. 1990)	Jallut *et al*. 1990 (n=20); Miller *et al*. 2005 (n=6)
Gastro-intestinal surgery			24[A,D] (22-28)				Fasting status unclear (Novick *et al*. 1988)	Novick *et al*. 1988 (n=7); Copland, 2010 (n=56)
Gastric restriction surgery - pre-surgery					16[D]		Systematic review of REE at baseline and up to 12 months post surgery. Fasting status unclear	Browning *et al*. 2016 (Syst. Review n=8 studies)
General				26[A]			1 month post surgery	Campillo *et al*. 1992 (n=39)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Other								
Amputations							See online resources	
Cystic fibrosis			29[A] (24-34)				See online resources	Elborn *et al*. 1993 (n=30); Ward *et al*. 1999 (n=37); Richards *et al*. 2001 (n=31)
Graft-versus-host disease			22[A]					Zauner *et al*. 2001 (n=26)
Hereditary neuromuscular disease							See online resources	
Hip fractures							See **Table 3.2**	
Huntington's disease							See **Table 3.2** and online resources	
Infections			25[A]					Schneeweiss *et al*. 1992 (n=6)
Parkinson's disease				24[A]			See online resources	Levi *et al*. 1990 (n=30)
Pheochromo-cytoma			22[A]				REE 23 kcal/kg BW before adrenalectomy and 21 kcal/kg BW one year after surgery; associated with significant post-surgical weight gain and increase in fat mass	Petrák *et al*. 2013 (n=17)
Pressure ulcers				24[D] (21-26)			Systematic review + meta-analysis. Fasting status unclear	Cereda *et al*. 2011 (Systematic review n=5 studies)

Table 3.1 Estimating resting energy expenditure (REE) using kcal/kg BW/day (continued).

Disease State	REE kcal/kg actual body weight (BW)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Other								
Rheumatoid arthritis							See online resources	
Sepsis			30[A] (30-31)	26[A]			See online resources	Nordenstrom *et al*. 1983 (n=18); Arnold *et al*. 1992 (n=6)
Sickle cell disease and thalassaemia			27.5[A]				See **Table 3.2** and online resources	Badaloo *et al*. 1989 (n=12)
Tuberculosis							See **Table 3.2** and online resources	

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day.

- *Fat free mass (FFM) should be measured by a validated method (**see Section 2**) and not estimated.*
- *Whenever possible, clinicians should ensure they measure FFM in the same way as reported in the studies e.g. BIA or DEXA.*
- *Data are presented as weighted means (range); if no range reported, data has come from 1 study only.*
- *In all studies there was considerable variation around the reported mean.*
- *Letters in superscript (^{A,B,C,D}) indicate methods used in the studies (see **Appendix 3.2 Table 3.18**).*
- **BMI was not reported; subjects are assumed to be ≤ 18.5kg/m^2.*
- *†BMI was not reported; BMI assumed to be in the range 18.5 - 30kg/m^2.*
- *The number of patients with the relevant condition may be considerably less than the total number of subjects in the study.*

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day.

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Burns								
Burns (spontaneously breathing)							See text and online resources	
Cardiac								
Chronic heart failure			35[A]	31[A]				Riley *et al*. 1991 (n=28); Tacke *et al*. 2013 (n=166)
GI disease								
Crohn's disease	34[A]		33[A] (31-35)				REE (kcal/kg FFM) likely to be higher in untreated patients or those with active disease (not in remission) (Gong *et al*. 2015; Sammarco *et al*. 2017)	Capristo *et al*. 1998a (n=103); Capristo *et al*. 1998b (n=54); Capristo *et al*. 1999 (n=104), Capristo *et al*. 2000 (n=40); Al-Jaouni *et al*. 2000 (n=40); Gong *et al* 2015 (n=75); Sammarco *et al*. 2017 (n=36)
Ulcerative colitis			32[A]					Capristo *et al*. 1999 (n=104)
Non-neoplastic GI disease	29[A]							Carbonnel *et al*. 1995 (n=23); Carbonnel *et al*. 1997 (n=11)
HIV								
Outpatients			32[A] (32-33)		31[A]		The study in obese subjects included all females (Lane and Provost-Craig, 2000). See also systematic review (Batterham, 2005 n=58 studies)	Lane and Provost-Craig, 2000 (n=26); Batterham *et al*. 2003 (n=86); Luzi *et al*. 2003 (n=24)

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Cancer								
Acute leukaemia			36[B]				REE was 39 kcal/kg FFM before chemotherapy and 33 kcal/kg FFM after first cycle. N.B. moderate fast	Galati *et al*. 2016 (n=46)
Bone marrow transplant			28[A] (28-31)					Chamouard Cogoluenhes *et al*. 1998 (n=11)
Brain			27[A]					Little *et al*. 2016† (n=21)
Gastro-intestinal			27[A]	30[A]				Nixon *et al*. 1988 (n=202); Fredrix *et al*. 1991b (n=191)
Head and neck			30[A,B,D] (23-33)				8 hour fast (Silver *et al*. 2007) Fasting status unclear (Langius *et al*. 2012; De Carvalho *et al*. 2015)	García-Peris *et al*., 2005 (n=18); Silver *et al*. 2007 (n=17); Langius *et al*. 2012 (n=111); De Carvalho *et al*. 2015 (n=32)
Liver			34[A]					Merli *et al*. 1992 (n=24)
Lung			30[A] (24-33)	33[A] (33-34)			REE decreased from ~ 33 to 28 kcal/kg FFM in patients who responded to treatment; REE remained at ~ 31 kcal/kg FFM in those who did not respond (Jebb *et al*. 1994)	Nixon *et al*. 1988 (n=83); Fredrix *et al*. 1991b* (n=191); Jebb *et al*. 1994 (n=48); Fredrix, *et al*. 1997* (n=39); Simons *et al*. 1997 (n=21)

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Cancer								
Non-Hodgkin's lymphoma							See **Table 3.1**	
Oesophagus	33[A]							Thomson *et al*. 1990 (n=31)
Pancreas	33[A] (32-35)		29[A]				Those with evidence of an acute phase response may have higher REE (Falconer *et al*. 1994)	Falconer *et al*. 1994* (n=37); Wigmore *et al*. 1995* (n=33); Bauer *et al*. 2004 (n=8)
Urological			28[C]				REE undertaken "at least 3 hours post prandially"	Xu *et al*. 2012 (n=253)
Various cancers (weight losing or cachectic)							See **Table 3.1**	
Various cancers (weight losing or cachectic)				38[A,B] (31-42)				Lauvin *et al*. 1996 (n=229); Trutschnigg *et al*. 2013 (n=20)

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Liver								
Acute hepatitis							See **Table 3.1**	
Alcoholic liver cirrhosis			48[A]					Muller *et al*. 1991 (n=20)
Chronic alcohol dependency			34[A] (33-35)					Addolorato *et al*. 1998a (n=70); Levine *et al*. 2000 (n=72)
Chronic hepatitis			31[A]				REE significantly decreased to ~29 kcal/kg FFM in patients who responded to interferon α-2a therapy	Piche *et al*. 2000† (n=67)
Cirrhosis			27[A] (24-33)					Merli *et al*. 1990 (n=35); Guglielmi *et al*. 2005 (n=374); Prieto-Frías *et al*. 2015 (n=57)
Liver transplantation			30[A] (21-39)					Ferreira *et al*. 2013 (n=17); Ferreira *et al*. 2014 (n=81)
Non alcoholic fatty liver disease							See **Table 3.1**	

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Neurological disease								
Amyotrophic lateral sclerosis (ALS) (Motor neurone disease)			35[A] (34-40)				Patients with familial ALS likely to have higher REE than patients with sporadic ALS (Funalot *et al*. 2009). Subjects requiring non-invasive ventilation may require ~ 36 kcal/kg FFM (Ellis and Rosenfeld, 2011)	Bouteloup *et al*. 2009 (n=61); Funalot *et al*. 2009 (n=44); Vaisman *et al*. 2009 (n=66); Ellis and Rosenfeld, 2011 (n=56)
Cerebral palsy							See online resources	
Dementia							See **Table 3.1** and online resources	
Muscular dystrophy							See **Table 3.1** and online resources	
Multiple sclerosis							See **Table 3.1** and online resources	
Head injury (acute spontaneously breathing)			33[A]					Weekes and Elia, 1996 (n=6)
Head injury (rehabilitation)							See **Table 3.1** and online resources	

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Neurological disease								
Haemorrhagic stroke							See **Table 3.1** and online resources	
Ischaemic stroke (acute)				31[A] (31-33)			See online resources	Weekes and Elia, 1992 (n=15); Nagano *et al*. 2015 (n=30)
Ischaemic stroke (rehabilitation)							See online resources	
Post polio syndrome			26[A]				All subjects were male	Bargieri *et al*. 2008 (n=34)
Spinal cord injury (acute)							See **Table 3.1**	
Spinal cord injury (chronic)			28					Jeon *et al*. 2003 (n=14)

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Pancreatitis								
Acute							See **Table 3.1**	
Chronic (alcohol related)	35[A]		30[A]					Hebuterne *et al*. 1996 (n=43)
Septic							See **Table 3.1**	
Mixed populations or polymorbid								
Acutely ill hospitalised		39[A] (35-45)	33[A] (32-34)	36[A] (33-39)			REE was higher in physically able underweight subjects (Katz score < 2) than in normal weight subjects (Sergi *et al*. 2002)	Al-Jaouni *et al*. 2002 (n=24); Schneider *et al*. 2002 (n=97); Sergi *et al*. 2002 (n=102)
Mixed in and outpatients							See **Table 3.1**	
Nursing home or long term care facility				29[B] (27-29)			REE measured after 8 hours fast	Lammes and Akner, 2006 (n=74)
Outpatient							See **Table 3.1**	
Rehabilitation							See **Table 3.1**	

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Renal								
Acute kidney injury							See **Table 3.1**	
Pre-dialysis			28[A]					Neyra *et al*. 2003† (n=40)
Peritoneal dialysis			40[A] (35-43)					Neyra *et al*. 2003† (n=40); Wang *et al*. 2004 (n=251)
Haemodialysis			35[A]	27[A]				Arkouche *et al*. 1997 (n=10); Neyra *et al*. 2003† (n=40)
Respiratory disease								
COPD - acute exacerbation							See online resources	
COPD - rehabilitation			31[A] (28-35)				Patients with raised CRP were more likely to have higher REE kcal/kg FFM (Broekhuizen *et al*. 2006). Patients who were weight losing were more likely to have higher REE kcal/kg FFM (Schols *et al*. 1991)	Schols *et al*. 1991 (n=80); Broekhuizen *et al*. 2006 (n=122)
COPD - outpatients			35[A] (34-38)	31[A] (25-34)				Burdet *et al*. 1997b (n=13); Doré *et al*. 1997 (n=26); Congleton and Muers, 1998 (n=20); Pouw *et al*. 1998 (n=20); Kao *et al*. 2011 (n=21)
Interstitial lung disease							See online resources	

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Surgery								
Cardiac							See online resources	
Fixation of fractured neck of femur							See **Table 3.1**	
Gastro-intestinal surgery							See **Table 3.1**	
Gastric restriction surgery - pre-surgery					36[A] (34-40)			Del Genio *et al*. 2007 (n=40), Del Genio *et al*. 2009 (n=28); Hasani *et al*. 2015 (n=42)
General				37[A]			1 month post surgery	Campillo *et al*. 1992 (n=39)

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Other								
Amputations							See **Table 3.1**	
Cystic fibrosis			35[A] (32-39)					Elborn *et al*. 1993 (n=30); Bell *et al*. 1996 (n=20); Ward *et al*. 1999 (n=37); Richards *et al*. 2001 (n=31)
Graft-versus-host disease							See **Table 3.1**	
Hereditary neuromuscular disease							See online resources	
Hip fractures				33[A]			Patients discharged by 30 days had lower REE at baseline than those with prolonged hospital stays	Paillaud *et al*. 2000 (n=40)
Huntington's disease			31[A]				See online resources	Gil Polo *et al*. 2015 (n=40)
Infections							See **Table 3.1**	
Parkinson's disease							See **Table 3.1** and online resources	
Pheochromo-cytoma							See **Table 3.1**	
Pressure ulcers							See **Table 3.1**	

Table 3.2 Estimating Resting Energy Expenditure using kcal/kg FFM/day (continued).

Disease State	REE kcal/kg fat free mass (FFM)						Comments	Studies (total number of subjects in each study)
	BMI < 18.5kg/m²		BMI 18.5 -30.0kg/m²		BMI > 30.0kg/m²			
	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years	Age ≤ 65 years	Age > 65 years		
Other								
Rheumatoid arthritis							See online resources	
Sepsis			41[A]					Carlson *et al*. 1997 (n=12)
Sickle cell disease and thalassaemia			34[A] (31-36)				Adults only (Buchowski *et al*. 2000) See **Table 3.1** and online resources	Borel *et al*. 1998 (n=14); Buchowski *et al*. 2000 (n=74)
Tuberculosis			32[D] (30-33)				Fasting status unclear	Schwenk *et al*. 2003 (n=32)

Estimation of energy requirements for adults

Components of energy expenditure.
For definition see **Figure 3.2.**

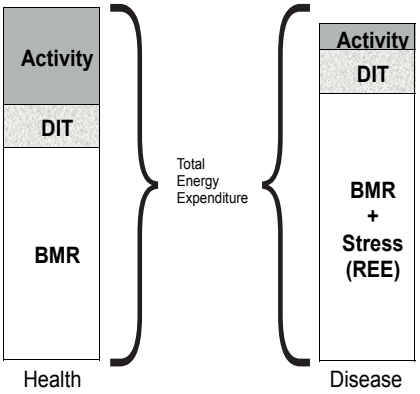

Figure 3.2 Theoretical model explaining the different components of energy expenditure.
BMR = basal metabolic rate; REE = resting energy expenditure; DIT = dietary-induced thermogenesis.

- TEE is the sum of BMR or REE, DIT and the energy expended in PA. The gold standard for measuring TEE is the doubly-labelled water method (Westerterp, 2017) although there are other methods available e.g. bicarbonate method (Elia *et al*. 1995).

- The terms BMR and REE are often used interchangeably however this is not scientifically correct. BMR is a theoretical concept which cannot be easily measured, especially in the clinical setting, so the term REE is most often used in clinical studies.

- REE is the energy expended lying still, at physical and mental rest after an overnight fast (at least 10 hours), with no stimulants such as coffee, alcohol or vigorous activity in the previous 24 hours. **The REE data presented in Tables 3.1 and 3.2 are therefore likely to represent the minimum energy requirement for a patient since they do not include DIT or PA**. REE is usually measured

in clinical studies by indirect calorimetry (Branson and Johannigman, 2004).

- A combined factor for PA and DIT (PAL) may be estimated from TEE and REE measurements i.e. TEE/REE = PA + DIT (PAL).

- Increasingly, physical activity is being measured directly using objective methods such as multi-sensor monitors, pedometers or accelerometers. The number of clinical studies using these methods remains small however, and there is a lack of data on the physical activity of sick or injured patients.

Points to consider when estimating energy requirements

The Scientific Advisory Committee on Nutrition report 'Dietary recommendations for energy' (Scientific Advisory Committee on Nutrition (SACN), 2011) made no formal recommendations regarding estimating energy requirements in illness however the following observations regarding energy requirements in illness were made.

- In the majority of chronic conditions BMR is usually normal or slightly increased (representing REE). Any increase in BMR is, however, often accompanied by a decrease in PA. Total energy expenditure (TEE) is therefore usually normal or decreased.

- Acute illness increases BMR above that predicted for healthy individuals of the same age and weight by up to 100%, although usually only by 0 – 40% (SACN, 2011). Both the magnitude and duration of the increase are dependent on the severity of illness.

- TEE does not necessarily indicate the requirements of the undernourished patient who may be in need of repletion, or the requirements of the over-nourished patient, who might benefit from restriction of energy intake.

Energy requirements in sick or injured individuals are influenced by many factors (**Table 3.4**) and as a result may be lower, similar to or, in rare cases, higher than requirements in healthy populations (**Figure 3.2**).

Table 3.4. Factors affecting energy requirements in illness and injury.

- Age.
- Sex.
- Body weight and body composition.
- Type of illness (e.g. acute or chronic).
- Severity and phase of illness (e.g. severe acute injury or recovery from surgery).
- Metabolic state (e.g. metabolically stressed, not stressed or anabolic).
- Nutritional status.
- Medical, surgical or pharmacological interventions.
- Absorptive capacity of the gastro-intestinal tract.
- Physical disabilities.
- Psychological state.
- Physical activity.
- Goals of nutritional support (see **Section 2**).
- Likely duration of nutritional support.

All of the factors in Table 3.4 should be considered prior to the initiation of nutritional support and clinicians should not base their estimate of energy requirements on a patient's weight alone.

The patient's clinical condition and response to treatment should be monitored regularly while nutritional support is being provided, and nutritional requirements should be reviewed and re-estimated regularly, taking into account any changes in the above factors. Refer to **Section 6**.

Metabolic stress, recovery and the anabolic phase

- Clinicians are advised to use **Table 3.5** to help determine the metabolic status of their patients. Please note this decision will be essentially based on clinical judgement, after review of laboratory data and clinical indicators, and in discussion with other health care professionals where required.
- Regular monitoring will assist the clinician in determining when their patient moves from one phase to another e.g. from being metabolically stressed to recovery.
- Once a patient has recovered from acute illness, they will enter the anabolic phase and at this stage, they will be more able to utilize additional energy and other nutrients for weight gain and repletion of body stores.

Table 3.5. Determining metabolic status.

Metabolically stressed	Recovery
Laboratory data	
↑ temperature	Temperature within normal range (without medication)
↑ white cell count	White cell count within normal range
↑ C-reactive protein (CRP)	CRP within normal range
↑ serum urea	Serum urea within normal range
↓ haemoglobin	Haemoglobin within normal range
↓ serum albumin	Serum albumin within normal range (although may continue to be affected by hydration status and other factors)
Hyperglycaemia	Blood glucose within normal range
Clinical indicators	
Anorexia Fatigue ↓ physical activity	↑ appetite ↑ vigour ↑ physical activity

Physical activity and diet-induced thermogenesis (PAL)

PAL comprises physical activity and diet-induced thermogenesis.

Physical activity

Acute and chronic illnesses are usually accompanied by a decrease in physical activity. PA is unlikely to exceed 20 % above REE (i.e. PAL 1.20) in most hospitalised patients or those who are acutely unwell at home (SACN, 2011) however, an individual assessment is necessary. The combined factors for PA and DIT (PAL) in **Table 3.3** take account of this likely lower activity.

Table 3.3 Combined factor for physical activity and DIT (PAL).

PAL	Description	Examples
1.00 - 1.10	In bed and immobile	Acute illness or injury or post-surgery
1.10 - 1.20	In bed and/ or sitting out	Hospital ward, care home or at home
1.20 - 1.25	Limited mobility	Hospital ward or at home with full time care
1.25 - 1.40	Sedentary	Care home or at home

(PENG Requirements Guideline Group Consensus Opinion, 2018).

For patients who are physically active i.e. not sedentary, a PAL greater than 1.4 may be required.

In some hospitalised patients however, PA may be increased due to:

- Abnormal neuro-muscular function (e.g. brain injury, Parkinson's disease, cerebral palsy, motor neurone disease).
- Prolonged and active physical therapy (e.g. patients with cystic fibrosis who require intensive physiotherapy).
- The increased effort involved in moving injured or painful limbs (e.g. patients in rehabilitation post trauma).

Currently there is a lack of evidence to guide the estimation of PAL in such patients. Clinicians are advised to use their clinical judgement and monitor patients regularly.

- In free-living healthy individuals a PAL value of 1.38 is the likely lower limit for those who are sedentary (SACN, 2011).
- Free living individuals in the community are likely to be more physically active than hospital patients although this may not always be the case.
- Some patients on home enteral or parenteral nutrition may have similar activity levels to healthy individuals whereas house bound or nursing home patients are likely to be similar to hospital patients.
- For patients considered to have activity levels nearer to healthy individuals clinicians are advised to use the recommendations by the SACN, 2011. Clinicians are advised to use their clinical judgement since these recommendations were designed to be applied to healthy populations where 60% of the population is overweight or obese.

- Energy expended in physical activity is affected by not only the intensity, frequency and duration of the activity but also the BMI and physical fitness of the individual.

Diet-induced thermogenesis

- Continuous infusion of nutrients does not significantly increase REE over fasting level whereas when feed is given as a bolus, an increase in total energy expenditure of 8-10% occurs (McClave and Snider, 1992).
- The combined factor for PA and DIT for hospital patients (**Table 3.3**) assumes continuous infusion and allows 5% of energy for DIT, whereas if feed is given as a bolus, or the patient is eating, energy expenditure may increase by an additional 5%. While it is important to be aware of this potential inaccuracy, practically it is rarely necessary to add an additional 5%.

Further considerations in specific conditions

Patients at the extremes of BMI (< 18.5kg/m^2 or > 30kg/m^2)

During the guideline development process it became evident that there is a severe lack of clinical studies investigating the nutritional requirements of patients requiring nutritional support at the extremes of BMI, in particular in populations with BMI > 30kg/m^2 (with the exception of ICU).

- An individual's REE is largely dictated by FFM, specifically the proportion of metabolically active tissue. In underweight individuals internal organs are relatively preserved while fat and skeletal muscle are lost, thus there may be a relative increase in REE per kg body weight (see **Figure 3.3**). While in patients of normal BMI requirements for energy increase in a linear relationship with body weight, this is probably not the case in obesity. In obese individuals (BMI > 30kg/m^2) the excess weight is likely to be approximately 25% FFM and 75% fat mass (FM) (Webster, Hesp and Garrow, *et al*. 1984).

- In obese individuals the use of actual body weight may over-estimate requirements while in underweight individuals this may result in under-estimation of requirements. Regular clinical monitoring is therefore essential in these patients.

- Currently there is no good quality evidence to support the use of adjusted body weight or specific cut offs at the extremes of BMI, therefore clinical judgement must be used to avoid over- or under-estimation of energy requirements (**Table 3.6**).

Table 3.6. Guidance for estimating energy requirements at the extremes of BMI.

BMI	Recommendation	Evidence
< 18.5kg/m^2	Once any re-feeding issues have been fully addressed, REE may be estimated using the formula 25 – 30kcal/kg actual body weight/day	PENG Requirements Guideline Group Consensus Opinion, 2018
> 30kg/m^2	If indirect calorimetry is not available, resting energy requirements may be estimated using the Mifflin-St Jeor (MSJ) equation (see below) using actual body weight, gender, height and age. **Men: 10 x weight (kg) + 6.25 x height (cm) – 5 x (age) + 5** **Women:10 x weight (kg) + 6.25 x height (cm) – 5 x (age) -161** In metabolically stressed obese patients clinicians are advised to feed to REE and regularly monitor the response to treatment. Currently it is unclear how energy requirements should be estimated for patients who are obese, in the recovery phase. Clinicians are advised to take a conservative approach i.e. estimate REE using the MSJ equation and consider adding a combined factor for DIT and PA (see **Table 3.3**), and regularly monitor the response to treatment.	Choban *et al*. 2013 Madden *et al.* 2016 Mifflin *et al*. 1990 PENG Requirements Guideline Group Consensus Opinion, 2018 PENG Requirements Guideline Group Consensus Opinion, 2018

N.B. Acutely unwell patients with anorexia nervosa should be fed in accordance with the MARSIPAN Guidelines (Royal College of Psychiatrists and Royal College of Physician, 2014).

Amputees

When estimating energy requirements for amputees, clinicians should note that while legs constitute approximately 37% of total body weight, their contribution to REE is unlikely to exceed 10 – 12% (see **Table 3.7**).

Table 3.7. Metabolically active tissues (Elia, 1992).

Organs/Tissues	% Body weight	% Basal Metabolic Rate
Liver + brain + heart + kidney	6	60 – 70
Skeletal muscle	40	18

Please refer to **Section 2, Table 2.3** for adjustment factors for estimating body weight in amputees.
Clinicians should be aware that there is a significant energy cost associated with walking following leg amputation (Starholm *et al*. 2016) with above-knee amputations likely to have the greatest effect (Waters *et al*. 1976). Clinicians should take this into account when considering adding the combined factor for physical activity and DIT.

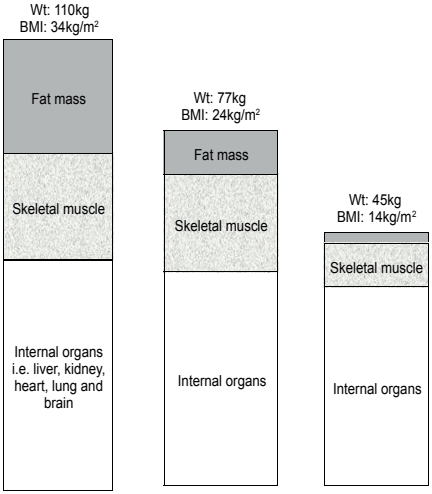

Figure 3.3. Body composition at different BMI (adapted from Horgan & Stubbs 2003).

Patients with fluid over-load

Oedema and ascites increase body weight without significantly increasing metabolically active tissue. Therefore, dry weight should be estimated and used to estimate requirements (see **Section 2, Table 2.2**).

Estimated dry weight = actual body weight – (estimated weight of ascites + estimated weight of oedema).

Also consider:

- Patient's weight before developing ascites or oedema.
- Patient's weight after paracentesis, drainage of ascites or pre and post dialysis.
- Estimating BMI from mid upper arm circumference (MUAC, see **Section 2**) and then weight from BMI (as a pre-requisite they would need to have no visible upper arm oedema and the patient's height). However, due to the potential for inaccuracy, this should only be used when no other method is practical.

Burns

Patients with severe burns exhibit a prolonged hypermetabolic response (Giantin *et al*. 1995; Monk *et al*. 1996), more or less proportional to the severity of the injury i.e. surface area and depth of burn (Matsuda *et al*. 1987). Over the past three decades advances in burn care have reduced the magnitude of the hypermetabolic response e.g. REE is lower when patients are nursed in a thermo-neutral environment (Aulick *et al*. 1979) and REE significantly decreases after surgical burn excision (Chai *et al*. 2000). As a result, feeding targets during the acute phase have been reduced in recent years.

While a number of studies were identified where REE was measured in mechanically ventilated patients there is a relative lack of data on REE in spontaneously breathing patients with burn injury. All of the studies identified during the searches included some patients who were mechanically ventilated and since results were not reported separately, it was not possible to determine REE in ventilated compared with spontaneously breathing patients.

The metabolic response to burn injury can vary considerably between individuals therefore ESPEN recommends (Rousseau *et al*. 2013) the use of indirect calorimetry or the Toronto predictive equation (Allard *et al*. 1990). It should be noted however that the Toronto equation was derived and validated in mechanically ventilated patients and its applicability to spontaneously breathing patients has yet to be established.

In spontaneously breathing patients with burn injury clinicians are advised to consult the online resources for further guidance and to monitor the patient's response to nutritional intervention regularly.

Long term enteral nutrition in patients with neuro-developmental disabilities or neuro-muscular dysfunction

Estimating the energy needs of non-ambulatory adult patients with severe neuro-developmental disabilities or neuro-muscular dysfunction is particularly challenging. Conventional methods for estimating energy requirements e.g. the factorial method, are likely to be inaccurate because they are intended for use in healthy subjects of normal body size and body composition, and with normal neuro-muscular function.

There is a lack of data on the energy requirements of these patients however, **Table 3.8** summarises the relevant studies identified during the guideline development process. Some studies included adolescents as well as adults. It should be noted that in some studies energy expenditure was measured during feeding therefore reported data may not represent REE (some DIT may be included).

Although REE (kcal/day) tends to be low, in those studies where REE is expressed in kcal/kg actual body weight or kcal/kg FFM, a wide range has been reported, with considerable variation between individuals.

- Clinicians are advised to use clinical judgement when commencing nutritional support in these patients, to establish clear goals for nutritional treatment, and to monitor weight, clinical condition and other parameters regularly to determine whether or not goals are being met.
- During episodes of acute illness, well-established feeding regimens can provide a useful baseline for estimating energy requirements as part of overall assessment.

Currently there is a lack of data on the requirements for other macronutrients and micronutrients, in these patients.

Table 3.8. Measured energy expenditure in patients with neuro disabilities.

Study	Disease state (total number of subjects)	Age (years)	Weight (kg)	BMI (kg/m²)	REE (kcal/day)	REE (kcal/kg BW)	REE (kcal/kg FFM)	Comments
Severe neuro-developmental disabilities								
Bandini *et al*. 1995	Severe impairment of the central nervous system; gastrostomy feeding (n=20)	18.7 (± 6.2)	32.5 (± 6.4)	26.5 (± 4.2)	708 (± 231)	N/A	N/A	No control group. REE measured 2-4 hours after last feeding therefore not fully fasted. Regression equation derived and tested in similar patient group.
Brown *et al*. 1997	Severe developmental disorders receiving neuro rehabilitation; gastro- or jejunostomy feeding (n=21)	24.3 (± 11.5)	33.4 (± 10.2)	18.0 (Est.)	889 (± 170)	N/A	N/A	No control group. Fasting state unclear (not stated). Eleven patients described as depleted (i.e. < 15 % body fat using skinfold thickness measurements of triceps and calf).
Dickerson *et al*. 1999	Severe neuro-developmental disabilities; gastro- or jejunostomy feeding (n=20)	20.0 (± 11.3)	34.6 (± 10.4)	17.5 (Est.)	N/A	16 - 39 (range)	N/A	No control group. REE measured "at least 2 hours" after cessation of feeding therefore not fully fasted. N.B. Mean REE (kcal/kg BW) not reported.
Dickerson *et al*. 2002a	Cerebral palsy with fixed upper extremity (UE) contractures; gastro- or jejunostomy feeding (n=13)	31.9 (± 10.6)	37.7 (± 9.0)	16.1 (Est.)	893 (± 91)	24.7 (± 5.5)	30.5 (± 6.0)	No control group. REE measured during the infusion of "minimal enteral nutrition" i.e. <250 kcal, therefore not fully fasted. Some minor voluntary and involuntary movement was allowed during REE measurements.

Table 3.8. Measured energy expenditure in patients with neuro disabilities (continued).

Study	Disease state (total number of subjects)	Age (years)	Weight (kg)	BMI (kg/m^2)	REE (kcal/day)	REE (kcal/kg BW)	REE (kcal/kg FFM)	Comments
Severe neuro-developmental disabilities								
Dickerson *et al*. 2002a	Cerebral palsy with preserved UE movement; gastro- or jejunostomy feeding (n=11)	33.3 (± 8.1)	43.2 (± 11.5)	17.8 (Est.)	1144 (± 262)	27.0 (± 4.7)	32.9 (± 4.7)	
Dickerson *et al*. 2002b	Cerebral palsy; mixed group including patients with fixed UE contractures and patients with preserved UE movement; gastro- or jejunostomy feeding (n=15)	29.3 (± 12.0)	39.8 (± 10.1)	17.5 (Est.)	987 (± 273)	25.1 (± 5.2)	31.1 (± 5.6)	No control group. REE measured during the infusion of "minimal enteral nutrition" i.e. <250 kcal, therefore not fully fasted. Some minor voluntary and involuntary movement was allowed during REE measurements. Validation testing of the Arlington Developmental Centre (ADC) equation for estimating REE.
Dickerson *et al*. 2003	Cerebral palsy + chronic non-shivering hypothermia; gastro- or jejunostomy feeding (n=6)	38.0 (± 16.6)	48.6 (± 12.1)	23.1 (Est.)	890 (± 206)	N/A	N/A	Comments re control group and REE measurement conditions as above. REE was significantly higher when patients were normo-thermic compared with when they were hypo-thermic (783 ± 81 kcal/day vs. 606 ± 11 kcal/day respectively).

Table 3.8. Measured energy expenditure in patients with neuro disabilities (continued).

Study	Disease state (total number of subjects)	Age (years)	Weight (kg)	BMI (kg/m²)	REE (kcal/day)	REE (kcal/kg BW)	REE (kcal/kg FFM)	Comments
Persistent vegetative state								
Kudoh *et al*. 2000	Persistent vegetative state; long term gastrostomy feeding (n=8)	43 (20-64)	46.4 (40.1-60.2)	18.2 (14.7-23.1)	590 (478-688)	12.5	N/A	No control group. Fasting state unclear. No standard deviation or range reported for REE in kcal/kg BW.
Long term (> 6 months) enteral nutrition in severe dementia								
Wolf-Klein *et al*. 1995	Alzheimer's inpatients (n=4)	82.5 (78-87)	52.8 (46-62)	22.7 (16.5-26)	1035 (± 223)	29.7 (± 9.2)	N/A	REE also measured in outpatients with dementia (and compared with healthy controls) but not reported in kcal/day, kcal/kg BW or kcal/kg FFM.
	Multi-infarct dementia inpatients (n=5)	82 (74-95)	56.4 (48-65)	26.8 (23-28)	1031 (± 183)	28.7 (± 4.3)	N/A	
Long term (> 6 months) enteral nutrition post stroke								
Leone and Pencharz, 2010	Post stroke in neuro-rehabilitation or long-term care; permanent feeding tube in situ (n=10)	71 (± 9)	62.5 (± 8.9)	24.0 (± 3.8)	1200 (± 249)	19.4 (± 10.4)	N/A	Overnight fast. Historical control group (n=57).

REE kcal/kg BW uses actual body weight.
Est. = BMI estimated from weight and height or length data reported by study authors.

Estimation of protein requirements for adults

Protein requirements for injury and disease

- Maintenance of nitrogen balance depends on past and recent energy intake, metabolic state, physical activity and protein intake. Largest protein losses have been documented in sepsis, major trauma and burns. In these conditions nitrogen balance is almost impossible to achieve in the early catabolic phase post injury (Cerra *et al*. 1987).

- Guidance on the amount of protein that should be provided in nutritional support for patients with disease are based on a review of published guidelines and a summary of the recommendations can be found in **Table 3.9**.

- Where there is no protein requirement guideline available the PENG Requirements Guideline Group, 2018 recommends using **1.0-1.5g protein/kg actual body weight/day**.

- With the exception of Choban (2013) protein requirements for specific BMIs and weight ranges were not discussed in any of the guidelines.

When considering applying the recommendation of a guideline to clinical practice, both the rigour of the development process and the strength of the evidence should be considered. In general, for patients with a BMI 18.5-30kg/m^2, the majority of published guidelines recommend protein intakes between 1.0 to 1.5g/kg actual body weight/day during injury or disease. Therefore, for clinical conditions where there are no published guidelines, a protein intake of 1.0 to 1.5g/kg actual body weight/day should be used (PENG Requirements Guideline Group consensus opinion, 2018). Refer to **Section 2** for **guidance on nitrogen balance**.

Protein requirements in the post injury/ recovery phase

Aim to provide up to 1.9g protein per kg actual body weight/day (0.3g nitrogen/kg) in uncomplicated depletion or the anabolic phase post injury (Elia, 1994). It should be noted that experimentally starved, healthy individuals are able to consume (and utilise) up to 3.75g protein per kg

body weight/day (0.6 g nitrogen/kg) on re-feeding (Keys *et al*. 1950) although it is yet to be determined if this is applicable to patients recovering from acute illness or injury.

Protein requirements in kidney disease, liver disease and critical illness, can be found in **Sections 14**, **15** and **16 respectively.** For these clients, alongside this tool, you must refer to these chapters by purchasing a complete copy of the Pocket Guide To Clinical Nutrition: 5th Edition updated 2018.

Protein requirements at the extremes of body weight (BMI <18.5kg/m² and >30kg/m²)

A protein intake of 1.0 to 1.5g/kg actual body weight/day is likely to result in underfeeding in the underweight and overfeeding in the overweight but none of the published guidelines provide evidence-based recommendations on how to adjust intake other than the recent ASPEN guidelines (Choban *et al*. 2013). Choban *et al*. (2013) recommends high protein hypocaloric feeding but this recommendation is based on low level evidence so should only be used in experienced centres where FM and FFM can be monitored. Current practice in the UK is to reduce estimated protein requirements to 65-75% in obesity and in the absence of evidence-based guidelines this method should continue to be used (**Table 3.10**). Caution should be used when feeding patients with a BMI less than 18.5 kg/m² (**Table 3.10**).

Table 3.10. Estimation of protein requirements at the extremes of BMI.

BMI	Guide
BMI > 30kg/m²	Use approximately 75% of the value estimated from actual weight
BMI > 50kg/m²	Use approximately 65% of the value estimated from actual weight
BMI < 18.5kg/m²	Start at the upper end of the range (1.5g/kg/actual body weight/day) and monitor regularly, as 1.0 to 1.5g/kg actual body weight/day may result in underfeeding

PENG Requirements Guideline Group Consensus Opinion, 2018.

Protein requirements in parenteral nutrition

It has been recognised since the 1930's that the commonly used factor of 6.25 for conversion of nitrogen values to protein is just an approximation (Jones, 1931). It was based on the assumption that many food based proteins contain around 16% nitrogen. However, the actual nitrogen content

will vary according to the amino acid content (Fujihara *et al*. 2001). Parenteral nutrition amino acid solutions vary in their amino acid content and each would, in theory, have its own specific conversion factor which could be significantly different to 6.25. It is recommended that when estimating nitrogen requirements dietitians use the method for protein detailed in this section and convert to nitrogen using 6.25 but accept that this is just an approximation to give a starting point, after which monitoring and adjustment are crucial.

Table 3.9 Recommendations for estimating protein requirements in adults.

Clinical Condition	Protein Recommend-ations	Guideline Title	Summary of Types of Studies Included (e.g. 2 x Randomised Controlled Trail RCT)	Comments
Burns				
Adults with major burns	1.5-2.0g/kg/day	European Society for Clinical Nutrition and Metabolism (ESPEN) endorsed recommendations: nutritional therapy in major burns (Rousseau *et al*. 2013)	2 RCTs (1 in children) and 1 paediatric guideline	Includes some critically ill patients (major burns at beginning of treatment) also some adult and paediatric papers but only adult recommendations reported. Systematic review. Quality of the evidence assessed using the GRADE* process.
Burn injury	1.5– 2.0g/kg/day	International Society for Burn Injury (ISBI) Practice Guidelines for burn care (ISBI Practice Guidelines Committee, 2016)	1 RCT (reported twice); 2 cohort studies (1 in children); 3 observational studies (1 in children) and 4 review papers	Systematic review. No formal grading process used to assess the quality of the evidence.
Cancer				
Adult cancer patients and cancer survivors independent of severity of disease, stage of disease, or comorbidities	>1g/kg/day, if possible up to 1.5g/kg/day	ESPEN guidelines on nutrition in cancer patients (Arends *et al*. 2017)	1 letter; 6 reviews; 3 guidelines (1 in renal) and 2 observational studies	Systematic review. Quality of the evidence assessed using the GRADE* process.
Patients receiving radiation therapy	Minimum of 1.2g/kg/day	Workshop of expert dietitians (Australia). Evidence based practice guidelines for nutritional management of patients receiving radiation therapy (Isenring *et al*. 2008)	1 RCT	Non-English and case report studies were excluded. Systematic review. Quality of the evidence assessed using NHMRC** grading system.

*GRADE: Grading of Recommendations Assessment, Development and Evaluation ** National Health and Medical Research Council

Table 3.9 Recommendations for estimating protein requirements in adults (continued).

Clinical Condition	Protein Recommendations	Guideline Title	Summary of Types of Studies Included (e.g. 2 x RCT)	Comments
GI disease				
Inflammatory bowel disease (IBD)	1.2 to1.5g/kg/day (active IBD)	ESPEN guidelines on clinical nutrition in IBD (Forbes *et al*. 2017)	1 review and 2 observational studies (1 in children)	Systematic review. Quality of the evidence assessed using the SIGN*** grading system.
	1g/kg/day (remission)		1 systematic review; 1 observational study (in adolescents) and 1 RCT	
Patients with chronic intestinal failure (CIF) due to benign disease	Protein requirements based on individual patient characteristics (e.g. intestinal absorptive capacity/ anatomy / underlying disease)	ESPEN guidelines on chronic intestinal failure in adults (Pironi *et al*. 2016)	3 guidelines and 1 systematic review	Systematic review. Quality of the evidence assessed using the GRADE* process.
Home parenteral nutrition				
Home parenteral nutrition	0.8 - 1.4g/kg/day	Australasian Society of Parenteral and Enteral Nutrition (AuSPEN) Home Parenteral Nutrition Guidelines (Gillanders *et al*. 2008)	1 guideline	Systematic review. Guidelines appraised using AGREE**** instrument.
	0.8 – 1.0g/kg/day (unstressed patients) Up to 2.0g/kg/day in stressed or catabolic patients	ESPEN Guidelines on Parenteral Nutrition: home paremteral nutrition (HPN) in adult patients (Staun *et al*. 2009)	0 papers	Systematic review. Quality of the evidence assessed using SIGN*** grading system
	0.8 - 1.5g/kg/day	Development of quality of care interventions for adult patients on home parenteral nutrition (HPN) with a benign underlying disease using a two-round Delphi approach (Dreesen *et al*. 2013)	5 guidelines	Systematic review of guidelines. No formal grading of the guidelines and Delphi process to achieve consensus.

*** SIGN Scottish Intercollegiate Guidelines Network **** AGREE Appraisal of Guidelines Research and Evaluation

Table 3.9 Recommendations for estimating protein requirements in adult. (continued).

Clinical Condition	Protein Recommendations	Guideline Title	Summary of Types of Studies Included (e.g. 2 x RCT)	Comments
Liver				
Alcoholic steatohepatitis receiving enteral nutrition (EN)	1.2- 1.5g/kg/day	ESPEN Guidelines on Enteral Nutrition: Liver Disease (Plauth *et al.* 2006)	1 observational study, 1 cohort study and 3 RCT's	Systematic review Quality of the evidence assessed using SIGN*** grading system A number of the studies looked at safety of enteral nutrition or safety of enteral protein rather than actual protein intake
Cirrhosis receiving EN	1.2- 1.5g/kg/day		1 observational study, 7 RCT's, 1 literature review. 1 guideline	
Liver transplantation: postoperative	1.2- 1.5g/kg/day		3 RCT's	
Alcoholic steatohepatitis receiving parenteral nutrition (PN)	1.2g/kg/day without malnutrition or moderately malnourished	ESPEN Guidelines on Parenteral Nutrition: Hepatology (Plauth *et al.* 2009)	0 Studies	Systematic review. Quality of the evidence assessed using SIGN*** grading system
	1.5g/kg/day in the severely malnourished			
Cirrhosis receiving PN	1.2g/kg/day compensated cirrhosis without malnutrition		11 RCTs (1 analysed twice)	
	1.5g/kg/day decompensated cirrhosis with severe malnutrition			
	Encephalopathy: standard aa solution in grade ≤II, ↑Branch chain aminoacid (BCAA) and ↓aromatic aa in grade III to IV			
Acute or sub-acute liver failure receiving PN	0.8–1.2g/kg/day		1 controlled study; 1 case review paper (3 cases) and 1 paper.	
Obesity				
Hospitalised obese without severe renal or hepatic dysfunction	High protein hypocaloric feeding	American Society for Parenteral and Enteral Nutrition (ASPEN) Clinical guidelines: nutrition support of hospitalized adult patients with obesity (Choban *et al.* 2013)	2 RCTs; 2 comparative studies and 2 observational studies.	Patients were mainly surgical or intensive care unit (ICU). Systematic review. Quality of the evidence assessed using the GRADE* process.
	Protein: 1.2g/kg actual weight/day or 2-2.5g/kg ideal body weight/day			
	Energy: 50-70% estimated requirements or <14kcal/kg/day			

Table 3.9 Recommendations for estimating protein requirements in adults (continued).

Clinical Condition	Protein Recommendations	Guideline Title	Summary of Types of Studies Included (e.g. 2 x RCT)	Comments
Older adults				
Older adults (>65 years) with complicating medical conditions	1.2 to 1.5g/kg/day	Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group (Bauer *et al*. 2013)	2 observational studies (1 in healthy adults) and 1 systematic review	Not a systematic review; used a "Delphi-like" process to achieve consensus
	Up to 2.0g/kg/day in severe illness, injury, marked malnutrition		2 observational studies (1 in critical care); 1 book chapter and 3 guidelines (all critical care)	Unclear how studies were identified and selected for inclusion and unclear how the quality of the evidence was assessed and graded
Older adults (>65 years) with acute or chronic illness	1.2 to 1.5g/kg/day with even higher intake for individuals with severe illness or injury	ESPEN endorsed recommendations Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group (Deutz *et al*. 2014)	A number of papers in healthier older adults and 1 review paper in adults with illness	ESPEN Expert Group Not a systematic review Unclear how studies were identified and selected for inclusion and unclear how the quality of the evidence was assessed and grade.
Polymorbid				
Polymorbid inpatients i.e. at least 2 co-occurring chronic diseases	Minimum of 1.0g/kg/day	ESPEN Guidelines on nutritional support for polymorbid internal medicine patients (Gomes *et al*. 2017)	1 RCT and a subsequent secondary analysis of the same data and 3 guidelines	Systematic review Quality of the evidence assessed using SIGN grading system.
Adult hospitalised patient; unable to sustain volitional intake, expected to remain in hospital >3d and in ICU or general ward.	Protein should be determined independently of energy with ongoing assessment of protein provision	American College of Gastroenterology (ACG). ACG clinical guideline nutrition therapy in the adult hospitalized patient (McClave *et al*. 2016)	2 observational studies (in ICU) and 2 review papers (1 in ICU)	Systematic review Quality of the evidence assessed using the GRADE* process

Table 3.9 Recommendations for estimating protein requirements in adults (continued).

Clinical Condition	Protein Recommendations	Guideline Title	Summary of Types of Studies Included (e.g. 2 x RCT etc)	Comments
Pressure Ulcers				
Adults at risk of pressure ulcers	Mixed nutritional supplementation (energy and protein) may reduce pressure ulcer development	Nutritional interventions for preventing and treating pressure ulcers (Langer and Fink, 2014)	7 RCTs (pooled into meta-analysis)	Cochrane systematic review. Quality of the evidence assessed using the Cochrane Collaboration Toolkit
	1.25-1.5g/kg/day	Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline (National Pressure Ulcer Advisory Panel (NPUAP) & European Pressure Ulcer Advisory Panel (EPUAP), 2009)	2 guidelines and 1 meta-analysis	Systematic review. Quality of the evidence assessed using the GRADE* process.
Adults with pressure ulcers	No clear evidence that mixed nutritional supplements improve pressure ulcer healing	Nutritional interventions for preventing and treating pressure ulcers (Langer and Fink, 2014)	14 RCTs	Cochrane systematic review. Quality of the evidence assessed using the Cochrane Collaboration Toolkit
	1.25-1.5g/kg/day	Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline (NPUAP & EPUAP, 2009)	4 RCTs (1 in critical care)	Systematic review. Quality of the evidence assessed using the GRADE* process.
Surgery				
Enterocutaneous fistula (ECF) defined as an abnormal connection between the gastrointestinal tract and the skin	1.5 to 2.0g/kg/day Up to 2.5g/kg/day in high output entero-atmospheric fistula	American Society for Parenteral and Enteral Nutrition (ASPEN)-FELANPE Clinical Guidelines (Kumpf *et al*. 2017)	0 Studies	Systematic review. Quality of the evidence assessed using the GRADE* process.
Surgical patients at risk (substantial weight loss, low BMI (<18.5-22kg/m^2), inflammatory response)	1.5 g/kg ideal body weight/day (or 20% of total energy requirements) Protein: fat: glucose caloric ratio of 20:30:50%	ESPEN Guidelines on Parenteral Nutrition surgery (Braga *et al*. 2009)	1 cohort study; 2 RCT's (1 in ICU); 1 observational study (paediatrics); 1 conference abstract and 1 observational study (ICU)	Systematic review. Quality of the evidence assessed using the SIGN*** grading system. Unclear why ideal or adjusted body weight was recommended

Estimation of carbohydrate requirements for adults

(Wolfe, Allsop and Burke, 1979; Sauerwein and Romijn, 1994)

The primary goal of providing energy is the provision of substrates for oxidation.

- Glucose requirements for the chronically sick can be set at 4-5g/kg/day.
- For individuals who are critically ill or who have acute respiratory problems it is important to base estimations of requirements on the rate of glucose oxidation in order to prevent excess CO_2 production.
- **Glucose oxidation rate = 4 to 7mg/kg body weight/min/ day.**

For example: If a patient weighs 70kg, estimated glucose oxidation rate is:

{[(4 to 7mg x 70kg) x 60minutes] x 24hours} /1000 =

= 403-706g/day i.e. ≈400-700g glucose /day ≈ 1600-2800 calories from glucose

60 minutes refer to how many minutes are in 1 hour
24 hours refer to how many hours are in 1 day
The result is then divided by 1000 in order to convert mg to g

- Excess glucose is not oxidized but stored as glycogen.
- Glycogen storage capacity is about 15g/kg. Therefore, massive intakes of carbohydrates > 500g/day will, after a few days, result in lipogenesis.

Estimation of lipid requirements for adults

- Usually approximately 1.0 to 1.5g/kg actual body weight/ day.
- Prevention of deficiency of essential fatty acids (EFA):
  - o Diets should provide a minimum of 1 to 2% of total dietary energy as EFA or a minimum of 2 to 5 g/day of linoleic acid (COMA, 1991).
  - o linoleic acid should provide at least 1% of total energy and alpha linolenic acid at least 0.2% of total energy (COMA, 1991).

Estimation of fluid, electrolytes and micronutrient requirements for adults

The management of fluid and electrolytes can be complex in metabolically unstable patients and the NICE guideline on intravenous (IV) fluid management (NICE, 2013) is an essential resource to help clinicians avoid life threatening complications such as dehydration, fluid overload, electrolyte and acid base disturbances.

Improved surgical outcomes are demonstrated when attention to fluid balance is maintained and patients are not overloaded (Lobo *et al*. 2002) and enhanced recovery after surgery (ERAS) protocols are now established in many countries and supported by international guidelines (Lassen *et al*. 2012; Nygren *et al.* 2012; Gustafsson *et al*. 2013).

Decisions regarding the prescription of artificial nutrition support require a careful and thorough assessment of the individual patient. The NICE guideline (2013) contains algorithms covering assessment, fluid resuscitation, fluid maintenance and replacement and redistribution. Adult requirements for fluid and electrolytes can be seen in **Table 3.11**.

A review in 2012 investigating the derivation of equations for estimating fluid requirements reported limited evidence in a small number of subjects therefore highlighting the importance of ongoing monitoring (Vivanti, 2012).

When estimating fluid and electrolyte requirements an assessment of other sources needs to be taken into consideration including IV fluids (**Table 3.12**), IV medications, blood products, oral and enteral sources. When estimating sodium requirements, an assessment of the **sodium content of medications** should be considered (see **Section 13**). For example: paracetamol contains about 17mmol per 500mg. If prescribed 1g four times a day, this equates to 136mmol of sodium per day (White and Bradnam, 2015).

Table 3.11. Adult requirements for fluid and electrolytes.

	Daily baseline requirements		Other considerations
	Oral/enteral (Tyler 1989; Department of Health 1991)	**Parenteral** (Tyler, 1989; NICE, 2013)	
Fluid			
Maintenance requirements Replacement of losses: • Pyrexia • Loss of body fluids (urine, gastrointestinal losses, drains, etc.)	**18-60 years 35ml/kg/day** **> 60 years 30ml/kg/day** • In the unlikely event that pyrexia is untreated, clinicians may need to consider adding 2 – 2.5ml/kg for each °C rise in temperature above 37°C • must be assessed on an individual basis	**25-30ml/kg/day** (NICE, 2013)	Extra bicarbonate may be required in cases of biliary, pancreatic, small bowel and diarrhoea fluid losses. For patients who are obese, adjust the IV fluid prescription to their ideal body weight. Use lower range volumes per kg (patients rarely need more than a total of 3 litres of fluid per day) and seek expert help if their BMI is more than 40kg/m^2. Consider prescribing less fluid (20–25ml/kg/day) for patients who are older or frail, have renal impairment or cardiac failure, are malnourished and at risk of refeeding syndrome (NICE, 2013).
Electrolytes			
Sodium	25 – 70mmol* (1.0mmol/kg)	1mmol/kg (NICE, 2013)	Pyrexia – In the unlikely event that pyrexia is untreated, clinicians may need to consider adding 1.5mmol Na^+ to each 10ml additional fluid required as calculated above. Additional sodium may be required when hyponatraemic but check fluid balance first and consider other possible causes (ascites, over-hydration).
Potassium	50 – 90mmol* (1.0mmol/kg)	1mmol/kg (NICE, 2013)	Additional K^+ will be required if hypokalaemic (check magnesium in hypokalaemia refractory to treatment).
Calcium	10 – 17.5mmol*	0.1 – 0.15mmol/kg	Hypocalcaemia may be due to a decrease in the transport protein albumin because ~50% of calcium is bound to albumin. Most laboratories report both values (calcium and corrected calcium). To calculate corrected calcium Calcium (mmol/l) + (40-serum albumin (g/l)/40).
Magnesium	Men 7.8-12.3mmol* Women 6.2-10.9mmol*	0.1 – 0.2mmol/kg	Hypomagnesaemia may be due to a decrease in the transport protein albumin because magnesium is bound to albumin.
Phosphate	RNI for phosphate should be equal to the RNI for Ca^{++} in mmol*	0.5 – 0.7mmol/kg *or* 10mmol/1000kcal	Do not exceed 50mmol phosphate/day during enteral and parenteral nutrition.
Chloride	RNI for chloride should be equal to the RNI for Na^+ in mmol*	1mmol/kg	The concentration of chloride given is similar to that of sodium.

*ranges given are LRNI – RNI (Department of Health, 1991). The LRNI will meet the requirements of only a few people who have low needs. The RNI will meet the requirements of 97% of the population during health and thus should be the target intake. More may be required in patients with poor status, increased losses from diarrhoea, stoma/fistulae, nasogastric aspirates/vomiting or venting gastrostomies or altered requirements due to disease process.

Medications administered IV can contribute a significant amount of fluid and sodium if delivered in 0.9% sodium chloride which will need to be taken into account during estimations of requirements (**Table 3.13**). Please check with your pharmacist.

Table 3.13. Sodium content of medications if diluted with IV 0.9% sodium chloride.

Volume of 0.9% sodium chloride	Sodium (mmol)
100ml	15.4
250ml	38.5
500ml	77

An assessment of the composition of gastrointestinal losses (Lee, 1974) will also be required and the composition of body secretions is shown in **Table 3.14** and **Figure 3.4**. More detail can be found in the NICE guidelines (NICE, 2013). A systematic review investigating the sodium content of body fluids found a wide variation in different clinical populations therefore ongoing monitoring is essential (Kaptein *et al*. 2016). If in doubt seek senior advice. There is no evidence for the fluid and electrolyte requirements of patients at extremes of BMI and therefore ongoing monitoring is imperative to prevent complications.

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PENG Requirements Guidelines Group Consensus Opinion, 2018

Where data from clinical studies were absent or conflicting, the Guideline Development Group held a series of consensus development meetings (face-to-face or online) during which the relevant issues were discussed and voted on prior to circulation for peer review.

Decisions made in this way are indicated by the following term: PENG Requirements Guideline Group Consensus Opinion, 2018.

For references please refer to the PENG Pocket Guide print edition available here.