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Disease-specific regression equations

Clinical condition	Population	Regression equation	Validity testing	Comments	References
Burns					
Burn injury	N = 23 adult patients with burns; mean 39% total body surface area burns; twice weekly measurements during hospital stay. Subgroup of 16 patients measured in both fed and fasted states.	**REE (kcal/day)** -4343 + (10.5 x %TBSA) + (0.23 x CI) + (0.84 x EBEE) + (114 x temp) – (4.5 x PBD) TBSA = total body surface area; CI = energy intake; EBEE = expected basal energy expenditure calculated using the Harris-Benedict equation; Temp = Temperature (^{o}C); PBD = post burn days	Validity tested in 10 mechanically ventilated patients with burns, at different intervals during hospitalisation; mean age 34 ($\pm$ 3.7) years, 49% ($\pm$ 5.5%) total body area burns. Measured while feeding therefore not fasted.	Toronto equation as recommended for use by ESPEN (Rousseau *et al.* 2013).	Allard *et al.* 1988; Allard *et al.* 1990
Cancer					
Colorectal cancer	N = 18 adult patients with metastatic colorectal cancer; mean age 60 years.	**REE (kcal/day)** 343.52 x liver mass (kg) + 841.49	Regression equation not validity tested in a similar clinical population.	Liver mass (including metastases) measured using computed tomography.	Lieffers *et al.* 2009
Cardiac					
Chronic heart failure	N = 166 adult patients with chronic heart failure (left ventricular ejection fraction ≤ 40%); mean age 67 years, mean BMI 28.5kg/m^2.	**REE (kcal/day)** *Without muscle wasting* 26.1 x FFM + 297.0 *With muscle wasting* 26.9 x FFM + 184.1 FFM = fat free mass (kg)	Regression equation not validity tested in a similar clinical population. REE measurements compared with 27 healthy controls.	Fat free mass (FFM) measured using Dual X-Ray absorptiometry (DEXA) scanning. Patients with low skeletal muscle index (SMI) categorised as muscle wasting i.e. SMI < 7.26 kg/m^2 for men and < 5.45 kg/m^2 for women.	Tacke *et al.* 2013

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Clinical condition	Population	Regression equation	Validity testing	Comments	References
Mixed populations or polymorbid					
Medical and surgical inpatients	N = 200 adult patients with a variety of medical and surgical diagnoses including 33% with major burns; 33% ventilator-dependent; 8% obese; mean age 43 years; mean weight 68.9kg.	**Estimated energy expenditure (kcal/day)** *Ventilator-dependent* 1925 – (10 x age) + (5 x weight) + (281 x sex) + (292 x trauma) + (851 x burn) *Spontaneously breathing* 629 – (11 x age) + (25 x weight) – (609 x obesity) Age (years); Weight (kg); Sex (male=1; female=0); Trauma (present=1; absent=0); Burn (present=1; absent=0); Obesity i.e. weight >30% above ideal body weight according to Metropolitan Life Insurance tables (present =1; absent=0)	Validity tested in 100 patients with a variety of diagnoses including 33% with major burns; 36% ventilator-dependent; 7% obese; mean age 41 years; mean weight 66.4kg.	Energy expenditure was measured "2 hours after intake" for those on oral diet and "during the day" for those on continuous enteral or parenteral nutrition (not fully fasted).	Ireton-Jones *et al.* 1992
Inpatients and outpatients	N = 513 adult hospital patients (253 female); 237 inpatients and 276 outpatients. Mixed diagnoses, often complex with multi-morbidities; mean age 53 years; mean BMI 23.4 kg/m^2.	**REE (kcal/day)** *BMI < 25 kg/m^2* (11.355 x weight) + (7.224 × height) – (4.649 × age) + (135.265 × sex) - 137.475 *BMI > 25 kg/m^2* (14.038 × weight) + (4.498 × height) – (0.977 × age) + (137.566 × sex) - 221.631 Weight (kg); Height (cm); Age (years); Sex (female=0; male=1)	Regression equation not validity tested in a similar clinical population. Measured energy expenditure compared with 16 prediction equations.	Adjusting the weight in the equation in underweight and obese patients (i.e. for those with BMI < 18.5 kg/m^2 weight was adjusted to BMI = 18.5 kg/m^2 and for those with BMI > 30 kg/m^2 weight was adjusted to BMI = 30 kg/m^2) did not improve the percentage of patients with an accurate predicted REE.	Kruizenga *et al.* 2016

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Neurological					
Amyotrophic lateral sclerosis (ALS) also known as Motor neurone disease (MND)	N = 80 adult patients (35% female) with ALS; mean age 59 years; mean BMI 27.1 kg/m^2.	**TEE (kcal/day)** *Females* 655 + (9.6 x weight) + (1.8 x height) – (4.7 x age) + (55.96 x ALSFRS-6 score) – 168 *Males* 66 + (13.7 x weight) + (5 x height) – (6.76 x age) + (55.96 x ALSFRS-6 score) – 168 Weight (kg); height (cm); age (years); ALSFRS-6 score = ALS functional rating scale score	Regression equation not validity tested in a similar clinical population.	TEE measured using the doubly-labelled water technique for 10 days; REE measured using indirect calorimetry. Regression equation incorporates the Harris-benedict equation. The authors also provide other regression equations using the Mifflin St Joer equation.	Kasarskis *et al.* 2014
Cerebral palsy	N = 21 (9 female) adult patients with cerebral palsy; 10 with spasticity and 6 with athetosis; mean age 28 years; mean BMI 24.3kg/m^2.	**REE (kcal/day)** 616.2 + (72.2 x FFM) + (524.2 x athetosis) FFM (kg) measured using seven skinfold thickness sites; Athetosis (1=present; 0=absent)	Regression equation not validity tested in a similar clinical population. Energy expenditure measurements compared with 50 healthy control subjects.	Athetosis = a condition in which abnormal muscle contraction causes involuntary writhing movements.	Johnson *et al.* 1996
	N = 30 adults (60% male) with cerebral palsy. Mean age 37 years; mean BMI 23.6 kg/m^2 for males and 27.2 kg/m^2 for females.	**TEE (kcal/day)** *Equation 1* 1325.1 + (REE x 0.677) – (% body fat x 11.12) + (ambulation x 299.15) + (sex x 95.69) REE = resting energy expenditure; % body fat using DEXA; ambulation = 0 for non-	Regression equation not validity tested in a similar clinical population.	*Equation 1* REE measured using Indirect calorimetry (overnight fast). Body composition measured using DEXA scanning. *Equation 2* Body composition measured using skinfold	Johnson *et al.* 1997

		ambulatory and 1 for ambulatory; sex = 0 for female and 1 for male *Equation 2* 669.0 + (height x 9.7) + (ambulation x 385.5) – (% body fat x 11.74) + (sex x 134.0) Height (cm); ambulation = 0 for non-ambulatory and 1 for ambulatory; sex = 0 for female and 1 for male		thickness measurements at seven sites (triceps, biceps, sub-scapular, axilla, chest, abdomen and supra-iliac) to estimate % body fat using the Jackson Pollock equation.	
Head injury	N = 45 adult patients with isolated traumatic brain injury; Glasgow Coma Scale score ≤ 11 on admission; not ventilated or sedated at study inclusion; mean age 36 years; mean BMI 21.2 kg/m^2.	**REE (kcal/day)** -4166 – (50 x GCS) + (330 x patient status) + (144 x temperature) + (14 x weight) GCS = Glasgow Coma Scale score; patient status = 1 if eyes open and 0 if eyes closed; temperature (^{o}C); weight (kg)	Regression equation not validity tested in a similar clinical population.	Patients fasted for only 4 hours.	McEvoy *et al.* 2009
Neuro-developmental disability	N = 12 (7 female) adult patients with severe central nervous system disorders; age range 10 to 30 years; non-ambulatory (totally dependent on others for all activities of daily living); energy intake ≤ 7 to 8.2 kcal/cm.	**REE (kcal/day)** (13.4 x length) - 925.6 Length (cm)	Validity tested in 20 subjects living at the same residential facility in the same age range as the study subjects. Two groups i.e. *Group A* - energy intakes similar to those of the study group (≤ 8.2 kcal/cm) *Group B* - energy intakes higher than those of the study group (>8.2 kcal/cm).	For those with energy intakes >8.2 kcal/cm (test group B), the regression equation significantly underestimated energy needs. N.B. this study includes data from pre-pubertal, pubertal and adult subjects.	Bandini *et al.* 1995

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Renal					
Haemodialysis	N = 67 adult patients (73 % male) on maintenance haemodialysis; mean age 67 years; mean BMI 28.7 kg/m^2; 75% African American.	**REE (kcal/day)** 808.2 + (4.96 x weight) + (-8.66 x age) +(192.52 x albumin) + (4.38 x CRP) + (140.14 x sex) Weight (kg); age (years); albumin (g/dl); CRP (mg/dl); sex = 0 if female and 1 if male	Regression equation not validity tested in a similar clinical population.	Used best predictive model when CRP is available. Other regression equations also reported.	Byham-Gray *et al.* 2014
	N = 200 adult patients (59.5% male) on maintenance dialysis; mean age 63 years; mean BMI 26.2 kg/m^2	**REE (kcal/day)** (-2.497 x age x age factor) + (0.011 x height$^{2.023}$) + (83.573 x weight$^{0.6291}$) + (68.171 x sex factor) Age (years); age factor = 0 if aged < 65 years and 1 if ≥ 65 years; height (cm); weight (kg); sex factor = 0 if female and 1 if male	Validity tested in 20 subjects (no subject details provided).		Vilar *et al.* 2014
Respiratory disease					
Chronic obstructive pulmonary disease (COPD)	41 (31 female) adult underweight patients with COPD; mean age 63.5 years; mean BMI 18.8 kg/m^2; mean FEV$_1$ 39% predicted.	**REE (kJ/day)** 1856 + (76.0 x FFM) FFM = fat free mass (kg)	Validity tested in 37 (26 female) patients with COPD; mean age 66.5 years; mean BMI 23.8 kg/m^2; mean FEV$_1$ 44% predicted.	Different methods used to measure body composition in the study group (DEXA) and the validation group (BIA).	Nordenson *et al.* 2010

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Clinical condition	Population	Regression equation	Validity testing	Comments	References
Other					
Huntington's disease	N = 9 patients with early-stage Huntington's disease; mean age 49 years; mean BMI 29.6 kg/m².	**TEE (kJ/day)** $(30.8 \times FFM) + (17.5 \times CS) + 832.2$ FFM = fat free mass; CS = Chorea score using the Unified Huntington's Disease Rating Scale (UHDRS)	Regression equation not validity tested in a similar clinical population. REE measurements compared with 9 age and sex matched healthy controls.	Energy expenditure measured over 24 hours in a respiratory chamber. FFM measured by air displacement plethysmography (BODPOD).	Gaba *et al.* 2005
Rheumatoid arthritis	N = 66 (40 female) adult patients with rheumatoid arthritis (RA); mean age 62.7 years; mean BMI 26.5 kg/m²; mean C-reactive protein (CRP) 11.0 mg/l Energy expenditure measured after overnight fast.	**REE (kcal/day)** $127.74 \times (FFM^{0.62}) \times (CRP^{0.068})$ $421.57 \times (weight^{0.51}) \times (age^{-0.25}) \times (CRP^{0.075})$ FFM = fat free mass (kg); CRP = C-reactive protein (mg/l); age (years)	Validity tested in 22 patients with RA; mean age 60.3 years; mean BMI 25.4 kg/m²; mean CRP 11.0 mg/l.	Energy expenditure also measured in 16 healthy controls and results were compared with RA patients.	Metsios *et al.* 2008

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