Energy Requirements, Estimating

What Is the Procedure for Estimating Energy Requirements?
› Indirect calorimetry (IC) is the gold standard for estimating energy requirements. IC, however, is not widely used by dietitians in clinical practice. Reasons cited for not using IC are mainly due to cost and practicality. Predictive equations are commonly used in practice as an alternative. Various predictive equations are available for use, each with limitations. In addition, some equations have been cited as being more accurate in estimating energy requirements when compared to IC, but all have a margin of error. A search of the literature has indicated there are over 240 predictive equations available for use. Commonly used equations used to calculate basal metabolic rate (BMR) or resting metabolic rate (RMR) include the Harris-Benedict (HB), the Schofield, the Mifflin-St. Jeor (Mifflin), and the Ireton-Jones (IJ). These predictive equations take several factors into consideration, such as age, sex, and body composition. Activity factors (AFs) and injury factors (IFs) are also commonly used in conjunction with the HB, the Schofield, and the Mifflin equations to estimate energy expenditure due to activity and any associated illness. The IJ equation takes BMR, AFs, and IFs into consideration
• What: Estimating energy requirements entails estimating BMR or RMR and combining this figure with an appropriate AF or IF
• How: Energy requirements are estimated through the use of predictive equations, such as the HB, Schofield, Mifflin, or IJ, and the application of appropriate AFs and IFs
• Where: Energy requirements are estimated in inpatient clinical settings
• Who: Registered Dietitians (RD) should be involved in estimating energy requirements for obese and non-obese hospitalized adult patients

What Is the Desired Outcome of Estimating Energy Requirements?
› The desired outcome of estimating energy requirements is to provide an accurate starting point and/or range for energy requirements that do not underestimate or overestimate energy needs. Energy requirements should be re-assessed and monitored with ongoing patient care

Why Is Estimating Energy Requirements Important?
› Estimating energy requirements is an important part of developing a nutrition support or care plan for a patient or client
› Both underestimating or overestimating energy requirements can have a detrimental impact on health outcomes

Facts and Figures
› IC is considered to be the gold standard for estimating energy requirements, especially in the ICU
• IC uses respiratory gas exchange to estimate fuel consumption for an individual
• IC is cited as being time-intensive, expensive, and not widely available for use to most dietitians
› Besides IC, other methods of estimating energy requirements include the following:
• Direct calorimetry, which measures energy expenditure by assessing the body’s heat production (not commonly used)
• Doubly labelled water technique, which is used primarily in research and estimates energy expenditure based on free-living subjects

Energy expenditure consists of three components: BMR, energy expenditure from physical activity (PA), and the thermic effect of feeding (TEF)

• BMR is the least amount of energy necessary to sustain the body’s primary metabolic processes necessary for life, such as breathing, circulating blood, and growing and repairing cells; it is the value for the metabolic rate of an individual who has just awoken and is in a relaxed and motionless state
  – BMR and RMR are often used interchangeably but are different. Resting metabolic rate (RMR) is an approximate measure of BMR, which does not require an individual to be in a rested state but does require an individual to be in a fasted state
  – Both BMR and RMR can be determined through IC or predictive equations
• PA energy is the amount of energy expended from daily activities and physical exercise
• TEF is the amount of energy utilized by the body in the process of digestion and absorption of food to be used or stored
  – Other terms used for TEF include: diet-induced thermogenesis, postprandial thermogenesis, and thermic effect of a meal

The Physical Activity Ratio (PAR) protocol has been determined to be an accurate method for determining nationally representative estimates of estimated energy requirements and average daily physical activity ratios for a representative sample of U.S. adults. The results of this validated method has implication for developing public policy recommendations related to physical activity and health outcomes (Archer et al., 2013)

Research studies have documented the wide inconsistency and variability in estimating energy requirements as a result of applying varying stress factors and different methodologies

• In a research study that surveyed dietetic practitioners to explore methods used to assess resting energy expenditure (REE) and determine the impact of the patient’s condition and the dietitian’s work profile to stress factors used, investigators found that a wide variety of stress factors were used by the dietetic professionals (Green et al., 2008)
• In another study that surveyed the practice of estimating energy requirements in hospitalized underweight and obese patients requiring nutrition support, researchers found significant variation in the methodologies used by dietitians to estimate energy requirements, especially in obese patients (Judges et al., 2012)

Though IC is considered to be the gold standard, especially in ICU settings, but not widely used in hospital settings, researchers continue to explore its practicality and feasibility

• In an exploration of adult ICU patients to compare the feasibility and practicality of IC with the use of a predictive equation, investigators found that there were large differences between the calculated energy requirements using IC and predictive equations. These investigators also reported that the use of IC was feasible, useful, and not too time intensive when used based on a structured protocol and conducted by dedicated and experienced team members (Da Waele et al., 2013)

What You Need to Know Before Estimating Energy Requirements

• Familiarity with predictive equations for calculating BMR or RMR, their limitations, and AFs and IFs typically used with applicable predictive equations
  • Schofield equation
    – An extension of the FAO/WHO/UNU work on energy requirements; sometimes referred to as the WHO equation
    – Based on a large data set of more than 7,000 healthy subjects from 23 different countries; some research has shown the Schofield equation may overestimate energy requirements in older and hospitalized patients, since the data used to develop the equation were based on young males
    – Mostly used by dietitians in in the United Kingdom and Australia
    – Does not require a value for height
    – Requires the use of an AF and/or IF to estimate energy requirements in hospitalized patients

<table>
<thead>
<tr>
<th>Age</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–17</td>
<td>74 W + 2,754</td>
<td>56 W + 2,898</td>
</tr>
<tr>
<td>18–29</td>
<td>63 W + 2,896</td>
<td>62 W + 2,036</td>
</tr>
</tbody>
</table>
30–59  48 W + 3,653  34 W + 3,358  
Original equations over 60  49 W + 2,459  38 W + 2,755  
Modified equations 60–74  49.9 W + 2,930  38.6 W + 2,875  
Modified equations over 75  35 W + 3,434  41 W + 2,610

– Adapted from Ferrie & Ward (2007); W = weight (kg)

• Harris-Benedict (HB) equation
  – Developed from a single small study of 239 healthy Americans
  – The HB equation is believed to overestimate requirements in healthy individuals by about 5% in men and about 15% in women
  – The HB equation requires weight and height, which may not always be available
  – Commonly used in the U.S. and in medical literature
  – Requires the use of an AF and/or IF to estimate energy requirements in hospitalized patients

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>66.5 + 13.8 W + 5.0 H – 6.8 A</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>655.1 + 9.6 W + 1.8 H – 4.7 A</td>
<td></td>
</tr>
</tbody>
</table>

Coefficients are rounded to one decimal place

W = weight (kg); H = height (cm); A = age (year)

– Adapted from Ferrie & Ward (2007)

• Mifflin-St. Jeor (Mifflin) equation
  – Based on 498 healthy adult subjects with a wide range of ages and weights; measures RMR
  – Uses actual weight and predicts significantly lower requirements when weight is high in comparison to the Schofield and HB equations
  – Requires values for height and weight
  – Considered to be more reflective of modern U.S. population, be appropriate for use in obese individuals, and have less bias estimation compared to other predictive equations
  – Recommended by the Academy of Nutrition and Dietetics
  – Requires the use of an AF and/or IF to estimate energy requirements in hospitalized patients

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>10 W + 6.25H – 5 A + 5</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>10 W + 6.25H – 5 A – 161</td>
<td></td>
</tr>
</tbody>
</table>

W = weight (kg); H = height (cm); A = age (year)

– Adapted from Ferrie & Ward (2007)

• Ireton-Jones (IJ) equation
  – Developed and validated for use in hospitalized patients from a single study of 200 hospitalized patients that included patients with trauma and burns
  – Estimates energy requirements lower for heavier patients in comparison to other equations
  – Uses the patient’s actual weight, does not require a value for height, and predicts total energy expenditure so does not require an AF or IF
  – Takes mechanical ventilation and trauma into consideration
  – The following assumptions are used in developing the equation:
    - Patient is critically ill only while on ventilation
    - Burns and trauma are equal in severity and impact energy requirements only during the ventilated/critical illness period
- Modalities of ventilation have the same effect on energy requirements
- Obese patients have the same body size and composition at a given weight

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-ventilated</td>
<td>629 – 11 A + 25 W – 609 O</td>
</tr>
<tr>
<td>Ventilated</td>
<td>1784 – 11 A + 5 W + 244 S + 239 T + 804 B</td>
</tr>
</tbody>
</table>

**Non-ventilated patients**

**Ventilated patients**

- **A** = age (year); **W** = weight (kg)
- **O** = 1 if obese (body mass index > 27); 0 otherwise
- **S** = 1 if patient is male; 0 otherwise
- **T** = 1 if trauma (include major surgery) is present; 0 otherwise
- **B** = 1 if burns are present; 0 otherwise

- Adapted from Ferrie & Ward (2007)

> Other predictive equations:

- **Owen**

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>10.2 (weight) + 879</td>
</tr>
<tr>
<td>Women</td>
<td>7.18 (weight) + 795</td>
</tr>
</tbody>
</table>

- Weight in kg; height in cm; age in years
- The Owen equation has been shown to overestimate and underestimate RMR energy requirements

- **Frankenfield #1**

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-obese men/women</td>
<td>10 (weight) + 3 (height) – 5 (age) + 207 (sex) + 454</td>
</tr>
<tr>
<td>Obese men/women</td>
<td>10 (weight) + 3 (height) – 5 (age) + 244 (sex) + 440</td>
</tr>
</tbody>
</table>

- Weight in kg; height in cm; age in years; sex (1 = men, 0 = women)
- Has been shown to overestimate RMR in non-obese men/women, but may be effective for use in obese young adults
  (Willis et al., in press)

- **Frankenfield #2**

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-obese men/women</td>
<td>10 (weight) – 6 (age) + 230 (sex) + 838</td>
</tr>
<tr>
<td>Obese men/women</td>
<td>10 (weight) – 5 (age) + 274 (sex) + 865</td>
</tr>
</tbody>
</table>

- Weight in kg; height in cm; age in years; sex (1 = men, 0 = women)
- Has been shown to overestimate RMR in non-obese men/women, but may be effective for use in obese young adults
  (Willis et al., in press)

- **University of Kansas**

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men/women</td>
<td>11.2 (weight) – 7.2 (age) + 237.6 (sex) + 780.3</td>
</tr>
</tbody>
</table>
• Weight in kg; height in cm; age in years; sex (1 = men, 0 = women)

– The University Kansas predictive equation was recently assessed in comparison to five other predictive equations for RMR (Mifflin; HB; Owen; and Frankenfield, 1 & 2) in young adults ages 20–39 and was found to be accurate with regards to predicting RMR with approximately equal rates in over- and underprediction in comparison to the five equations (Willis et al., in press)

– Further research is warranted as these researchers caution that the use of their predictive equation in clinical weight management use is questionable due to the potential large individual error of estimation associated with its use as well as other predictive equations (Willis et al., in press)

› Other considerations when estimating energy requirements include the following:
• Patients may be underweight, overweight, or edematous, which presents a challenge in which value to use for weight in predictive equations since the equations are based on actual weight
  – However, there are times when using an adjusted or modified body weight is appropriate:
    - If a patient is underweight, use of the patient’s current weight may be best for energy needs. However, caution and monitoring must be used so as not to underestimate the patient’s energy needs
    - If a patient is overweight, obese, or edematous, using actual weight can lead to overestimation of energy needs
    - Use of an adjusted body weight, which consists of using ideal body weight plus 25–50% of the excess weight, may be appropriate. However, caution and monitoring must be used so as not to overestimate the patient’s energy needs
    - If an obese patient is ambulant, it may be more appropriate to use an obesity validated equation like the Mifflin, if height is available. Otherwise, the IJ equation using the obesity factor may also be appropriate

› The use of predictive equations involve many factors
• Individual characteristics of the patient and situation must be taken into consideration when selecting an equation
• Expressing energy requirements as a range may also be better so as not to imply a level of unrealistic accuracy

› Predictive equations are a starting point and require ongoing monitoring and regular re-assessment

**How to Estimate Energy Requirements**

› Review the patient/client’s medical chart, and consider the individual’s
  • medical history and condition
  • level of activity
  • height, weight, BMI, adjusted body weight (if appropriate)
  • presence of edema or ascites

› Based on a review of the patient’s/client’s medical chart and information available (e.g., height, weight), select predictive equation

› Use AFs and IFs as appropriate
  • Suggested AFs

<table>
<thead>
<tr>
<th>Resting</th>
<th>(Lying or sitting)</th>
<th>1.0–1.4 x BMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedated or asleep</td>
<td>0.9–1.1</td>
<td></td>
</tr>
<tr>
<td>Conscious</td>
<td>1.0–1.1</td>
<td></td>
</tr>
<tr>
<td>Bedrest</td>
<td>1.15–1.2</td>
<td></td>
</tr>
<tr>
<td>Sitting out of bed, long periods</td>
<td>1.1–1.3</td>
<td></td>
</tr>
<tr>
<td>Mobilizing, occasionally</td>
<td>1.15–1.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sedentary/light activity</th>
<th>(Standing, long periods)</th>
<th>1.4–1.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilizing, frequently</td>
<td>1.4–1.5</td>
<td></td>
</tr>
<tr>
<td>Regular, intensive physical therapy</td>
<td>1.5–1.6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moderate activity</th>
<th>(Continuous movement/slow walking)</th>
<th>1.6–1.8</th>
</tr>
</thead>
</table>

• Adapted from Ferrie & Ward (2007)
• Suggested IFs

| Medical (inflammatory bowel disease, liver or pancreatic disease) | 1.1–1.2 |
| Surgical (transplant, fistula) | 1.1–1.4 |
| Cancer (tumor or leukemia) | 1.1–1.4 |
| Trauma (skeletal or head injury or minor burns) | 1.2–1.4 |
| Sepsis (or other major infection) | 1.3–1.4 |
| Major burns | 1.4–1.6 |
| Critical illness and/or major surgery/trauma | |
| Mechanical ventilation | 1.2–1.4 |
| After first week, for next 2–3 weeks | > 1.6–1.8 |

• Adapted from Ferrie & Ward (2007)

› Update the patient's plan of care, as appropriate, and document the following in the patient's medical record:
  • Method or methodologies used to calculate BMR and total energy requirements, rationale
    – Cite patient's/client’s
    - medical history and condition
    - level of activity
    - height, weight, BMI, adjusted body weight (if used)
    - presence of edema or ascites

Other Nutritional Interventions That May Be Necessary Before or After Estimating Energy Requirements

› None

What to Expect After Estimating Energy Requirements

› Monitor and re-assess patient’s weight and medical condition
› Adjust recommended energy requirements based on re-assessment

Red Flags

› IC is the best tool for estimating energy requirements in critically ill patients
› Exercise thoughtfulness and monitoring in using adjusted body weights for estimating energy requirements when using predictive formulas

What Do I Need to Tell the Patient/Patient’s Family?

› A patient’s energy requirements are calculated using the best suitable methodology or combination of methodologies specific to the individual’s condition and characteristics

References


