## Estimating Energy Needs for Research Diets

Energy needs of a research subject are based on how much energy is expended in a given situation. A study setting could vary from a free-living situation to a confined chamber room or calorimeter. Hence, estimating energy expenditure with the desired level of accuracy is crucial to metabolic research.

### Components of energy expenditure

There are three main components of Total Energy Expenditure (TEE) in humans:

1. Basal Metabolic Rate (BMR) - Energy expended at complete rest in a post-absorptive state; accounts for approximately 60% of TEE in sedentary individuals.
2. Thermic Effect of Food (TEF) - Increase in energy expenditure associated with digestion, absorption, and storage of food and nutrients; accounts for approximately 10% of TEE.
3. Energy Expenditure of Activity - Further classified as Exercise-related Activity Thermogenesis associated with active sports or exercise and Non-Exercise Activity Thermogenesis (NEAT) associated with activities of daily living, fidgeting, spontaneous muscle contraction etc. Exercise-related Activity Thermogenesis may range from 0% of TEE in sedentary individuals to as high as 10% of TEE in active adults. NEAT accounts for the remainder of the TEE.

### Selection of a suitable method to estimate energy expenditure

Several methods are available to measure one or all components of TEE. The main factors that help decide which method is suitable in a given research setting include:

1. Objective of assessment and level of precision - The purpose of estimating energy expenditure could be as basic as maintaining a subject in a weight-stable condition for a defined period of time or as complex as ensuring absolute energy balance during a 24-hour study in a calorimeter. Generally, more complex purposes require a higher level of precision in measurement or prediction.
2. Resource availability and cost - This is an important factor that affects the decision, especially when studies have limited costs available for the nutrition component of the budget.
3. Subject burden - This generally is related to the objective of the research study. If diet plays an ancillary role, then the subject burden related to metabolic measurements is kept low. On the contrary, complex metabolic research, like chamber studies, pose greater burden on the subjects in order to yield the required data.

### Commonly used methods to estimate energy needs

1. Predictive equations using anthropometric data - This method of estimating BMR poses the least subject burden, is low in cost and relatively fair in precision when compared to the "gold standard" measurements from calorimetry. Out of the various equations validated, we recommend using the Mifflin equation to predict energy expenditure. This equation was found to be the most accurate predictor of energy expenditure in non-obese and obese individuals compared to direct calorimetry. The more commonly used Harris Benedict equation has a tendency to overestimate energy expenditure, especially in obese individuals. The gender specific Mifflin equations are as follows:
   Males: REE = 10 x weight (kg) +6.25 x height (cm) – 5 x age (y) + 5
   Females: REE = 10 x weight (kg) + 6.25 x height (cm) – 5 x age (y) – 161
   TEE = REE x AF (study or population-specific activity factor)

2. Resting Metabolic Rate Measurement - RMR measurement is commonly done using an open-circuit system involving use of hood/canopy/mask based equipment, often referred to as a 'metabolic cart'. The principle of indirect calorimetry is to measure the oxygen consumption and/or carbon dioxide production and convert it to energy expenditure using formulae. RMR measurement is very precise when compared to calorimetry results, and poses moderate subject burden and cost. Use of standard protocol and trained

3. Staff yields accurate results that can even be used to estimate energy needs for chamber studies.
   TEE = measured RMR (kcals) x AF (study or population-specific activity factor)

4. Room calorimetry - This is the most sophisticated form of the open-circuit system that involves placing the subject inside a room/chamber of known volume. The measurement can range from a few hours to several days. Energy expenditure measured through this method is considered the "gold standard" in the field of nutrition and metabolism. This method is very expensive, highly precise and has a high subject burden.
   TEE= 24-hour energy expenditure measurement in chamber room

**Activity Factors**

Activity factors are also referred to as Physical Activity Levels (PALs) and have a wide range based on the population being studied. The following table categorizes PALs based on lifestyle:

| **Lifestyle and level of activity** | **PAL** |
|---|---|
| Seated work with no option of moving around and little or no strenuous leisure activity | 1.4-1.5 |
| Seated work with discretion and requirement to move around but little or no strenuous leisure activity | 1.6-1.7 |
| Standing work (e.g. housework, shop assistant) | 1.8-1.9 |
| Significant amounts of sport or strenuous leisure activity (30-60 min four to five times per week) | +0.3 (increment) |
| Strenuous work or highly active leisure | 2.0-2.4 |

Source: Black et al. PAL – physical activity levels

The Joint FAO/WHO/UNU Expert Committee on Energy and Protein Requirements suggest the following activity levels based on intensity of occupational work:

| | **Light** | **Moderate** | **Heavy** |
|---|---|---|---|
| **Men** | 1.55 | 1.78 | 2.10 |
| **Women** | 1.56 | 1.64 | 1.82 |

## Recommendations

For studies that require high accuracy and have sufficient resources, we recommend using RMR measurement with a suitable activity factor to estimate energy needs. These include studies that involve overfeeding/underfeeding experiments, chamber stays, doubly-labelled water measurements etc. Research studies that have limited resources and can compromise on accuracy should use the Mifflin predictive equation with a suitable activity factor to estimate TEE for subjects. Though predictive equations using fat free mass have been commonly used, the precision of this method is comparable to BMR predictive equations like the Mifflin equation.

## References


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