

# Measurement of basal metabolic expenditure (BME) using indirect calorimetry

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## Key words:

Indirect calorimetry, direct calorimetry, basal metabolic expenditure, resting metabolic expenditure, catabolism, anabolism, energy balance, nitrogen balance, energetic equivalent of oxygen

## aim:

To learn how to measure the basal metabolic expenditure in man. To practically manage measurement of basal metabolic expenditure using indirect calorimetry in different situations.

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## Procedure:

### *Actual energy expenditure in rest*

1. Examined person lies down on examination bed. Place the mouthpiece and nose clip.
2. Connect examined person to the Krogh respirometer and keep the side valve in the position "open", which means that the experimental persons breaths atmospheric air. After this setup, leave the examined person to breath quietly for about 30 minutes to adapt for the respirometer.
3. Start the program BASAL METABOLISM by double-clicking the icon.
4. Start the recording and then turn the valve to the position "closed", which means that the experimental subject will start breathing air from and into the reservoir of Krogh respirometer.
5. record for 5 minutes (examined person is breathing peacefully and lies on the examination bed).

### *Actual energy expenditure in standing position*

1. The same examined person is still connected to the respirometer and stands up. record another 5 minutes in standing position.

### *Actual energy expenditure after workload*

1. Disconnect examined person from the respirometer. After disconnection, examined person start walking the Master's steps for 5 minutes in the frequency of 80 steps/min (rhythm is set using metronome and one beat corresponds to one step). one crossing of the Master's steps consists of 5 steps.
2. In the meantime, ask the laboratory staff to refill the oxygen into respirometer.
3. After finishing the workload, examined persons immediately lies down on the examination bed. As fast as you can, connect the examined person to the respirometer (don't forget to turn the side valve in the expiration of the examined person and keep in mind, that after exercise, you must turn the valve really quickly, since the examined person cannot hold the breath in expiration for a long time).
4. record 5 minutes of breathing.
5. At the end, insert the comments about each situation and save the record under the name "Basal metabolism XY" where XY corresponds to the initials of the name of examined person. File type is Data Chart File (\*.adicht),

## Evaluation:

In each situation, choose the linear part of the recording of volume decrease without artifacts; average value of oxygen consumption in l/s appears in mini-window. Measured values need to be **corrected** to eliminate the effect of barometric pressure, room temperature and water vapors tension in the room. From the corrected values, you

can further calculate actual energetic expenditure in each situation.

*Correction of oxygen consumption  $v_r$  (l/s):*

Measured values of oxygen consumption ( $v_m$ ) in each situation will be corrected to 0°C and 101.325 kPa (760 mmHg) according to the following formula:

$$v_r = v_m \cdot \frac{273}{273 + t} \cdot \frac{B - e}{101.325} \text{ (l / s)}$$

Where:  $v_r$  = corrected consumption of  $O_2$  in l/s  
 $v_m$  = measured consumption of  $O_2$  in l/s

B = barometric pressure in kPa (1 torr = 1 mmHg = 0.133 kPa)

e = partial pressure of water vapors (see Table 12)

t = room temperature in

t (°C)	0	1	2	3	4	5	6	7	8	9
10	1.219	1.303	1.391	1.485	1.585	1.691	1.801	1.920	2.044	2.174
20	2.314	2.462	2.617	2.781	2.953	3.134	3.328	3.529	3.741	3.965
30	4.201	4.449	4.709	4.986	5.269	5.570	5.887	6.225	6.567	6.933

Table 12: Partial pressure of water vapors (e) in kPa at various temperatures (t)

**Calculation of actual energy expenditure (aee)** by indirect calorimetry can be performed using one of the following equations. In this practical, we will use equation number 1):

1) Since know the amount of consumed oxygen in liters per time unit, we can used the equation with energetic equivalent of oxygen for mixed diet (EE = 20.19 kJ/liter of  $O_2$ ):

**aee (kJ/time) = 20.19 ×  $v_{O_2}$**  (about 8% error)

2) If we know the amount of both consumed oxygen and produced  $CO_2$  (in l/time unit)we would use following equation:

AEE (kJ/time) = 16.3 ×  $VO_2$  + 4.6 ×  $VCO_2$

3) If we know the amount of consumed oxygen, amount of produced  $CO_2$  (in l/time unit) and nitrogen excretion (in grams)we would use following equation:

AEE (kJ/time) = 16.47 ×  $VO_2$ + 14.62 ×  $VCO_2$  – 9.07 × N

**Protocol:**

Define keywords and the aim of the exercise. Briefly describe the principle of indirect calorimetry. Process the results of your measurements clearly and for each situation, determine the value of AEE in kJ/s and kJ/day.

**Interpretation and conclusions:**

Compare all obtained AEE values in rest, in standing position and after workload. Explain observed differences.

# Calculation of energy expenditure

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## Key words:

Basal energy expenditure, rest energetic expenditure, catabolism, anabolism, metabolic syndrome, energy balance, nitrogen balance

## aim:

To learn how to calculate the energy expenditure as in the clinical practice.

## Introduction:

In the clinical practice we need to know actual energy expenditure (AEE) quite often, however, the measurement by indirect calorimetry is usually inaccessible. In such cases, tables or formulas are used. These tables and formulas were derived from data obtained in population studies.

### a) Basal energy expenditure (BEE):

The most often and widely used estimation of BEE is based on the calculation according to Harris-Benedict formula (1919):

For men:  $\text{Bee} = 66 + (13.7 \times m + 5 \times h) - (6.8 \times r)$

For women:  $\text{Bee} = 655 + (9.6 \times m) + (1.7 \times h) - (4.7 \times r)$

where:  $m$  = body mass in kg,  $h$  = height in cm and  $r$  = age in years.

The result in kcal/day must be transformed to kJ/day and kJ/s (1 kcal = 4.18 kJ, 1J = 0.2388 kcal).

### b) Calculation of actual energy expenditure (AEE)

is based on the following formula:

$$\text{aee} = \text{Bee} \times \text{aF} \times \text{tF} \times \text{iF}$$

Where the factors are:

<b>activity</b>	lying patient	1.1
<b>(aF – activity factor)</b>	lying but mobile patient	1.2
	mobile patient	1.3
	healthy light working	1.55 ♀ 1.60 ♂
	healthy middle working	1.64 ♀ 1.78 ♂
	healthy hard working	1.82 ♀ 2.10 ♂

(tF – temperature factor)	38 °C	1.1
	39 °C	1.2
	40 °C	1.3
	41 °C	1.4
<b>injury</b> (IF – Injury factor)	non complicated patient	1.0
	after surgery	1.1
	fractures	1.2
	sepsis	1.3
	peritonitis	1.4
	multiple injuries	1.5
	multiple injuries + sepsis	1.6
	burnings 30–50 %	1.7
	burnings 50–70 %	1.8
burnings 70–90 %	2.0	

Note: In this practical, use „healthy light working“ as an activity factor for your calculations.

### **Protocol:**

Define keywords and the aim of the exercise. Briefly describe the principle of used method. Calculate BEE and AEE and express the results in kJ/s and kJ/day.

### **Interpretation and conclusions:**

Compare AEE obtained by calculation and AEE measured by indirect calorimetry at rest. Is there any difference? If yes, explain why.