METABOLISM

Note: At the end of the instructions, you will find a table which must be filled in to complete the exercise.

Basal metabolic rate:

The lowest level of metabolism (during sleep) is the **basal metabolic rate** (*BMR*). Measurement during sleep is difficult, therefore BMR is measured at rest **after a 12-hour sleep**. The proper name for such measurement is resting metabolic rate *RMR*), but the RMR/BMR terms are used interchangeably in practice.

Total metabolic rate = basal metabolic rate + physical activity

How to measure the metabolic rate?

In the past, the amount of heat produced by the human body was measured (direct calorimetry): The measurement was performed in so-called calorimetric chambers, surrounded by a water circuit. Energy, defined as the **heat generated by the studied patient**, was measured on the basis of the increase in the temperature of the water surrounding the chamber walls.

Currently, the following are used:

- Body Composition Analyzers
- Mathematical formulas
- Respiratory gas analyzers

The daily energy needs (expressed in kcal) can be determined using each of these methods. Enter the task results in the measurements record sheet (at the end of the section).

TASK 1: Read your body composition and daily caloric needs (total metabolic rate) from the Body Composition Analyzer*

- The measurement must be taken with no socks nor shoes on
- Please provide your age and gender
- Your activity level must be estimated according to the scale provided by the analyzer; thanks to this, the caloric needs calculated with the analyzer will be closer to the total metabolic rate (taking your physical activity into account), i.e. slightly higher than your BMR
- The analyzer will display the following parameters (note the model!):

BC-731 Scales (glass)	Body mass (kg)	BMI	PERCENTAGE OF FAT (%)	MUSCLE MASS (kg)	BODY MASS INDEX	BONE MASS (kg)	DAILY CALORIC NEEDS (kcal)	BMR (KJ)	METABOLIC AGE (years)	PERCENTAGE OF WATER (%)
BC-581 Scales (plastic)	BODY WEIGHT (kg)	PERCENTAGE OF FAT (%)	PERCENTAGE OF WATER (%)	MUSCLE MASS (kg)	DAILY CALORIC NEEDS (kcal)	METABOLIC AGE (years)	VISCERAL FAT (1-10)			

Enter the results into the measurement record sheet (at the end of the section)

TASK 2: Calculate your basal metabolic rate using the Harris-Benedict mathematical equation:
Equation for women = 665.09 + 9.56 x body weight (kg) + 1.85 x body height (cm) – 4.67 x age (years)
Equation for men = 66.47 + 13.75 x body weight (kg) + 5 x body height (cm) – 6.75 x age (years)
The obtained result is the NUMBER of kcal/day = the resting metabolic rate (*RMR*), without taking physical activity into account.
NOTE: Body weight was measured in Task 1!

**** Example of applying the Harris-Benedict equation in a clinical setting:***
How to estimate ***how many calories are required by a person with severe underweight*** *(which must be treated by increasing the body weight)?*

We add the TARGET BODY WEIGHT to the equation!
For women = 665,09 + 9,56 × 665.09 + 9.56 x TARGET body weight (kg) + 1.85 x body height (cm) – 4.67 x age (years)
For men = 66.47 + 13.75 x TARGET body weight (kg) + 5 x body height (cm) – 6.75 x age (years)
The resulting score ***is the NUMBER of kcal/day which the patient should consume so that their body weight increases to the correct value (without taking into account the physical activity and potential energy losses associated with such factors as fever, disease and stress).***

TASK 3: Calculate your total metabolic rate by adding the basal metabolic rate calculated in Task 2 to the number of calories you burn while performing your daily activities.
The energy cost of the activities you perform can be estimated with the use of converters which assign a certain level of energy consumption per unit of time to each activity. List the activities you performed yesterday, along with information on the duration of each activity.
NOTE! You should list all activities, including sleep, studying, or walking while shopping etc.
Converters providing the calorie expenditure required to perform each activity are available in the room. They can be used to calculate how much energy was consumed by these activities.

TASK 4: Calculate your BMR based on your resting oxygen consumption per minute.
Analysis of respiratory gases:
The analysis of respiratory gases is a form of indirect calorimetry. The following measurements are used to evaluate the metabolic rate:
VCO_2 – the volume of carbon dioxide expired [liters per unit of time]
VO_2 – resting oxygen consumption [liters per unit of time]
VCO_2/VO_2 – the ratio of CO_2 produced to O_2 used, the so-called respiratory exchange ratio (*RER*).
At rest, RER corresponds to the value of the respiratory quotient (RQ), the value of which depends on energy substrates used for metabolism.
It is assumed that the RQ equals:
1.0 – for a pure carbohydrate diet; 0.8 – for a protein diet and 0.7 for a high-fat diet.

RQ is the highest for carbohydrates because their metabolism requires a lower oxygen use than the metabolism of proteins and fats.
A mixed diet translates into an RQ of ~0.8, which corresponds to 4.8 kcal obtained by consuming 1 liter of oxygen.

BMR measurement based on resting oxygen consumption and RER:
Having calibrated and entered the basic data into the measuring device, breathe through the analyzer mouthpiece for about 5 minutes. After this time, read the average value of resting oxygen consumption per minute (VO_2) and the RER value.

EQUATION: BMR (kcal/day) = VO_2/day x kcal/LO_2

Convert the recorded value of oxygen consumption per minute into oxygen consumption per day:
VO_2/min x 1440 =_____ VO_2/day,

whereas VO_2/min is the value read from the analyser.
1440 is the number of minutes in 24 hours.

Assign the recorded RER value to the number of calories obtained from the 1L O_2 according to the table below:

RER	**kcal/L O_2**
0.70	4.69
0.75	4.74
0.80	4.80
0.85	4.86
0.9	4.92
0.95	5.04
1,00	5.05

Body composition and the metabolic rate Even while at rest, muscles consume more oxygen in comparison with the adipose tissue (its content, expressed in %, was provided by the body composition analyzer used in Task 1).
Methods of assessing the body composition:
-**Densitometric method**, also known as dual-energy x-ray absorptiometry (DEXA) - a reference method (the most accurate but also the most expensive and difficult to access, involving the use of X-rays); an imaging method which makes it possible to assess bone density and the amount of adipose and muscle tissue.
-**Bioelectrical impedance analysis (BIA)** makes use of the fact that individual tissues have a different water content, thus exhibiting varying degrees of electrical conductivity (adipose tissue is an insulator, while muscle tissue is a conductor). This method is used in body composition analyzers, such as the analyzer in Task 1.

-Anthropometric method involves assessing the thickness of skinfolds (e.g. on the shoulder, underneath the shoulder blade, on the stomach) using a skinfold caliper and inserting the values of individual folds into the equation; it makes it possible to estimate the amount of body fat and lean body (muscles and bones). This method requires skill, as it is characterized by a high measurement error.

Estimating body fat – the body mass index (BMI).
The relative body mass index (BMI) can be used to assess the correct body mass.
TASK 5: Calculate your BMI using the following equation:
body weight [kg] / body height^2 [m]
Interpretation:
Underweight: BMI below 18.5
Normal weight: BMI 18.5 - 24.9
Overweight: BMI 25.0 - 29.9
Obesity: BMI over 30.0

TASK 6: Calculate your WHR
Distribution of fat - the waist-hip ratio (WHR)
As it turns out, it is not only the amount of accumulated fat but also its distribution that has a significant impact on health. The waist-hip ratio (WHR) indicates the distribution of adipose tissue within the human body. WHR is calculated by dividing waist circumference by hip circumference.
EQUATION:
waist circumference (cm) / hip circumference (cm)

**NOTE:* Waist circumference in both sexes is located at the largest narrowing between the lower costal arch and the iliac crests. If the waist is poorly visible, you can determine the area between the costal arch and the hips. This measurement is usually performed above the navel.

INTERPRETATION:
WHR: <0.9 in men and <0.85 in women indicates lower body obesity (the "pear-shaped" waist type)
WHR: >0.9 in men and >0.85 in women indicates abdominal obesity (the apple-shaped waist type), which correlates with the amount of visceral fat, the excess of which increases the risk of developing a cardiovascular disease.

NOTE! If the patient shows a normal BMI index, the indicator must not be interpreted as a poor-prognosis factor!

References:

1. Human physiology: an integrated approach. D.U. Silverthorn, 7 ed., Pearson
2. Wybrane zagadnienia z nauki o żywieniu człowieka. J. Biernat, Wydawnictwo Uniwersytetu Przyrodniczego we Wrocławiu, 2009
3. Megnien JL i in., Predictive value of waist-to-hip ratio on cardiovascular risk events., Int J Obes Relat Metab Disord. 1999.

TASK 1 – BODY COMPOSITION ANALYSER:										
BC-731 Scales (glass)	Body mass (kg)	BMI	PERCENTAGE OF FAT (%)	MUSCLE MASS (kg)	BODY MASS INDEX	BONE MASS (kg)	DAILY CALORIC NEEDS (kcal)	BMR (KJ)	METABOLIC AGE (years)	PERCENTAGE OF WATER (%)
BC-581 Scales (plastic)	BODY WEIGHT (kg)	PERCENTAGE OF FAT (%)	PERCENTAGE OF WATER (%)	MUSCLE MASS (kg)	DAILY CALORIC NEEDS (kcal)	METABOLIC AGE (years)	VISCERAL FAT (1-10)			

TASK 2: BASAL METABOLIC RATE - HARRIS-BENEDICT EQUATION	
Calculated number of calories:	_____ KCAL

TASK 3: TOTAL METABOLIC RATE			
The number of kilocalories resulting from physical activity:	_____ KCAL	DAILY CALORIC NEEDS (BMR from task 2 + the value from the previous box)	_____ KCAL

TASK 4: BASAL METABOLIC RATE – RESPIRATORY GAS ANALYSIS				
Resting oxygen consumption per minute according to the analyzer (VO_2):	_____ L/min	Daily resting oxygen consumption (VO_2* 1440):	_____ L/24h	RER value: _____
kcal/L O_2: [1]	_____		Number of calories: _____	

TASK 5: BMI INDEX				
Body height (in meters):	_____ m	BMI:	_____ kg/m^2	INTERPRETATION (tick): UNDERWEIGHT NORMAL WEIGHT OVERWEIGHT OBESITY MORBID OBESITY

TASK 6: WHR INDEX						
Waist circumference:	_____ cm	Hip circumference:	_____ cm	WHR:	_____	INTERPRETATION (tick): MAN – "PEAR-SHAPED" TYPE WOMAN – "PEAR-SHAPED" TYPE MAN – "APPLE-SHAPED" TYPE WOMAN – "APPLE-SHAPED" TYPE

1 Value corresponding to RER read from the table.