Physiology Lab Sheet

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This sheet was written according to the record of practical sections of pack 1 (section 3,4, and 5)

Last time we started talking about energetics (in theory lectures), and now we will continue talking about the practical aspect of this subject.

Metabolic rate

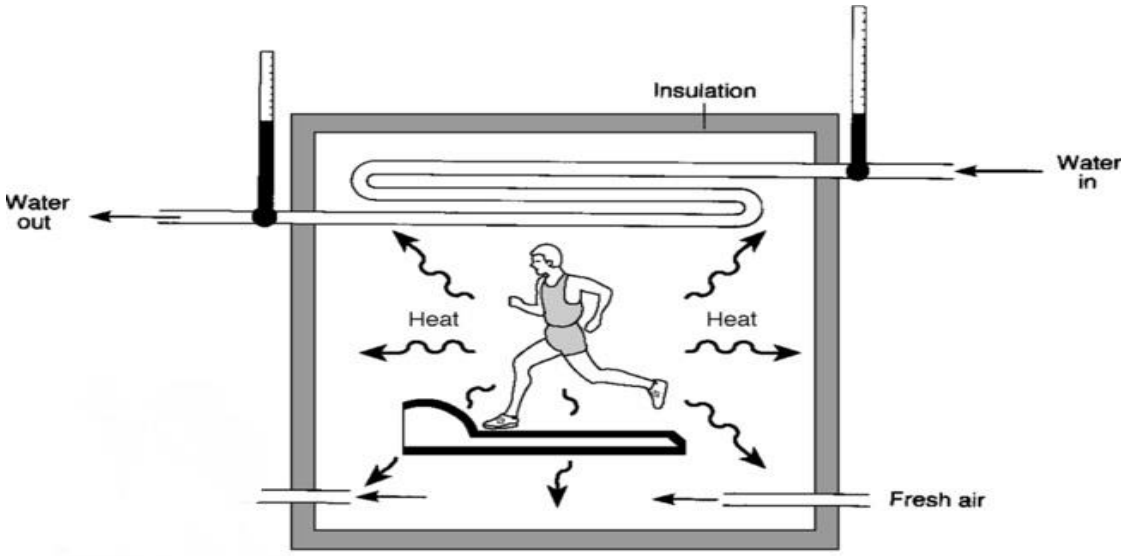
*** Definition:**

Metabolic rate is defined as the energy expenditure/output per unit time.
How to measure metabolic rate?
We can estimate the amount of **heat** produced by the body, which reflexes the metabolic activities which are taking place in our body, and by that we can measure the metabolic rate. Because, as you know, the **final** state of conversion of any type of energy is heat. To clarify that, you know we have a lot of works in our body, for example the mechanical work : your heart is pumping blood through vessels, at the vessels level we have friction, and friction generates heat. Also other forms of activities that we are having inside the body is the process of consuming ATP molecules, which are micro energetic molecules, that there final energy is converted to heat. So every type of energy in the body **finally** is converted to heat. So, if we can measure the amount of heat produced in the body, we can make an estimate about the metabolic activities that are taking place in our body, and accordingly, we can find the metabolic rate.

***Measurements:**

To measure heat, we use the **Calories** unit (1 Cal = 1 kilo cal = 1000 cal). the unit time which is used is **Hour**. So we measure heat as Cal/Hour.
To measure the **amount** of calories that are irradiated by the body per unit time, we have direct and indirect methods.
-Direct method: Is made by a special installation which involves a closed chamber (without any source of heat - **heat insulated**),oxygenation, and we have a flow of water (inside and outside of that room). Inside the room we can place the person, and measure the temperature of water flowing in, and the temperature of water flowing out. Certainly we will have a difference between the two temperatures, and that's because the temperature irradiated by the body is absorbed by water. So if we know the temperature difference of water, and the rate of flow per hour, we can

estimate the amount of heat which is irradiated by the body and absorbed by water, and by that we can estimate the metabolic rate.

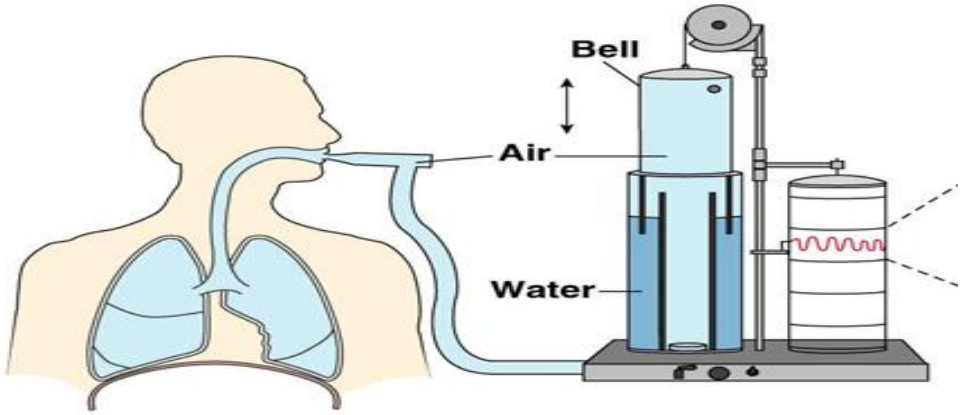


-<u>Indirect methods:</u> It's achieved by measuring the oxygen consumption, because the process of producing heat (and energy) in our body needs oxygen. So if we have an estimate of oxygen consumption, we can estimate the metabolic rate in our body. For each liter of oxygen consumed, according to previously made experiments, results in producing 4.8 Calories, which is called the energetic equivalent of oxygen.

So 1 L of oxygen= 4.8 Cal

To measure oxygen consumption we have two methods: closed method and opened method.

***Closed method**: We use spirometer in this method.



Spirometer consists of inverted tube (drum) of oxygen over water path.

By spirometer we can generate a **closed** system with the lungs (closed system: we are getting oxygen only from the device, not from the environment; and the air released is entering the device, and not leaking to the environment). If we consume the oxygen found in spirometer (by our lungs) we will get a decrease in its volume inside the device.
In the process of exhalation, we produce CO2, but we don't want to measure this CO2, so there are certain products in the device, which are called soda limes, that can adsorb the CO2 and prevent it from entering the device. So what are we returning back to the device in the process of breathing?
Pure oxygen.

With time, after a process of breathing, we have been consumed a certain volume of oxygen. The drum (tube) of oxygen is graded, let's say that the initial volume of oxygen inside the trump was 8L, and after 10 minutes of respiration, we find the volume of oxygen was set to 6L. So we have consumed 2L of oxygen per 10 minutes and we can calculate the volume of oxygen consumed per ONE HOUR .
2L/10 minutes = 12L/1 hour.
And by that, and by using the energy equivalent of oxygen (1L of oxygen = 4.8 Cal), we can measure the metabolic rate.
BUT, people are different according to their body sizes, so in order to standardize the measurements for all, we use a third parameter in our calculations (other than Heat unit and Time unit) which is the surface area unit (m^2), so we should convert the results according to $\mathbf{1m^2}$ surface area. So our final results should contain the following units : Cal/Hour/m^2.
According to what we have previously said, consuming 12L of oxygen/Hour = 57 Cal/Hour (about). Let's say that the person in experiment has a body surface area of $1.7m^2$, so the METABOLIC RATE is = 57Cal/ 1 Hour / $1.7m^2$ =
$\frac{\frac{57Cal}{1\,Hour}}{\frac{1.7(m^2)}{1}}$ = 33.53 Cal/ 1 Hour / 1 m^2.
This result can be written as 33.5Cal * $hour^{-1} * m^{-2}$
Note: these calculations are very important for the sake of exam.

***Opened method:**

It's similar to the closed method, but here we have the person aspiring from atmospheric air, and expiring into the path.

The concentration of oxygen in atmospheric air is around 20% (Note: when we breathe, we don't consume all of the oxygen that we have inhaled, we only consume a small portion of it).

Example: a person has consumed 50L of atmospheric **air**, in a time of 10 minutes, after expiring this air into the path, the oxygen concentration was 18%, how many liters of oxygen has he consumed per hour?

Answer: before expiring these 50L of air into the path, the concentration of oxygen was 20%, after expiring it into the path, the concentration became 18%, that means he has consumed 2% of oxygen per 10 minutes. 2% of 50L = 1L per 10 minutes = 6L of oxygen per one hour. and according to what we have mentioned above, we can complete the calculations to find the metabolic rate.

***<u>Basal metabolic rate:</u>**

It's the measurement of metabolic rate under basal conditions. The basal conditions are:

- No eaten food for at least 12 hours.
- Measurement after a night of restful sleep.
- No exercise in the hour prior to the test.
- Elimination of all factors that may cause excitement.
- Comfortable temperature during measurement.

We use these basal conditions to standardize the measurements for everyone, but sometimes we don't measure the metabolic rate under these conditions, we can measure it when someone is running, or sleeping.

Note: sleeping is not included in the **basal** metabolic rate measurement, and a question about this may be in the exam.

Now, let's say in measuring the **basal** metabolic rate for an adult the result should be 38 Cal/ Hour/ m^2 for example, but according to our calculations it came out 42 Cal/ Hour/ m^2 , here we have an increase in the **basal** metabolic rate, the percentage of this **increase** : (42/38)*100 = 10%. We write it as **plus 10% (+10%)**, because we have an increase. But if we have a decrease in the metabolic rate, we write it as **minus 10% (-10%)** for example.

What do we use the **basal** metabolic rate for?
We use it to estimate certain conditions in the body, like hyperthyroidism or hypothyroidism , to see if the person is having normal metabolic rate or not (these conditions can increase/decrease metabolic rate).

***Factors affecting metabolic rate (not basal) :**

- **Exercise**: increases metabolic rate.
- **Daily activities**: may increase or decrease metabolic rate (sleep decreases metabolic rate but walking increases metabolic rate).
- **Age**: increase in age decreases metabolic rate (children have a lot of activities inside them in order to build up their tissues and their whole body)
- **Sleep**: decrease in metabolic rate.
- **Climate**: in cold climate we have higher metabolic rate (in order to produce more heat); in hot climates we have lower metabolic rate.
- **Fever**: in fever we irradiate a lot of heat, in response to an infection for example, so we have higher metabolic rate (don't mix fever with high climate).
- **Malnutrition**: decrease metabolic rate (the body tries to save body energies during malnutrition, so it decreases metabolic rate).
- **Specific dynamic action:** it means the dynamic action of some materials that changes the metabolic rate in response to it. For example, a person who is nourished on a diet of protein has 30% higher metabolic rate than a person who is nourished on a diet of carbohydrates, and that's because we have some amino acids that have specific dynamic action toward the body that increases its metabolic rate, so higher concentration of these amino acids increases the metabolic rate ,and that's called the specific dynamic action of these amino acids. Some people use a diet of proteins to lose more weight.
- **Effect of hormones:**
  Thyroid hormones: increase in metabolic rate (they have more sweating, anxiety...)
  Male sex hormones: increase 10-15%. Female sex hormones also increase the metabolic rate, but males have more increment compared to females.
  Growth hormones: increase 15-20% (kids have higher metabolic rate for example).
- **Effect of sympathetic stimulation**: increases metabolic rate (makes reactions).

THANK YOU !