

## Physiology

● Sheet

○ Slide

number

9

Done by

Obada Zalat

Correction

Yaman Jarrar

Doctor

Mohammad Khatatbeh

# *Energetics*

## *Metabolic rate*

### *Measurements of metabolic rate:*

According to the thermodynamics laws, (the energy neither be created nor destroyed, but can be transported from one form to another), and the final form of all energetic process is **heat**. If we are measuring the heat produced per time unit, we will measure the metabolic rate of the body. So we can measure the heat by different methods: (The unit for measuring heat is Calorie)

#### **-Direct method:**

We place the person in a closed chamber(insulated; **No** leakage of heat), and we have constant flow of water through the chamber, then if you know the temperature of water before entering the chamber, and after getting out, and the rate of flow. So you can get how much heat has been produced by the person and was accepted by the water, and we can estimate the metabolic rate by direct method, but this method is very complicated; so we use other methods.

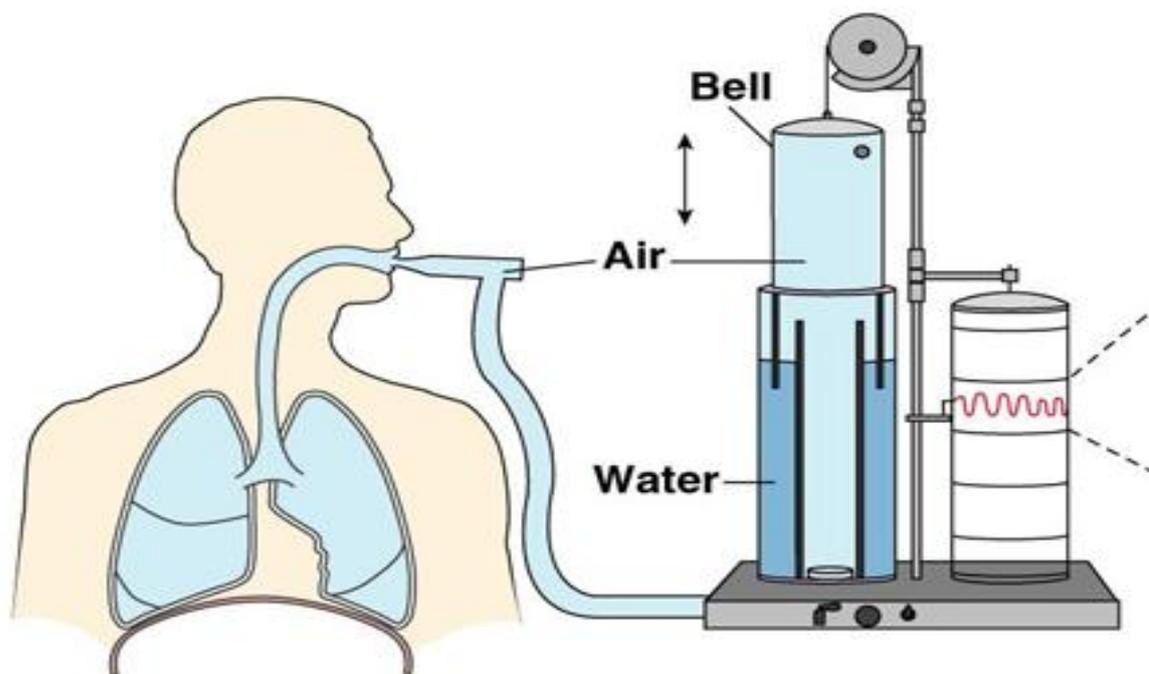
#### **-Indirect method:**

We estimate the amount of heat by estimating the amount of oxygen consumed. For each liter of O<sub>2</sub> consumption, we generate 4.8 Calories, so if you know how many liters of O<sub>2</sub> consumed, you can get any estimation about the amount of heat produced, this is called **the energy equivalent of oxygen**.

To calculate the amount of O<sub>2</sub> consumption, we will use:

**\*Closed method:**

We use device called **spirometer**. We place air with certain concentration of O<sub>2</sub> in that device. Now we are creating a closed system with the lung, so that person will respire, and then expire back toward the device, and we put a substances to adsorb CO<sub>2</sub> produced, so what is returning back is only the non-consumed O<sub>2</sub>, with time the volume will decrease (instead of 10 liters we will find it 8 liters), in this case the 2 liters are the amount of O<sub>2</sub> consumed, and by knowing the period of time in which the O<sub>2</sub> was consumed (for example 10 min), we can do some simple calculations; to get the amount of heat produced per hour.



**\*Open method:**

We know that the concentration of O<sub>2</sub> in the atmosphere is 20% , so what we are going to do is collecting the expired air during physical activity by a bag, for example we collected 100 liters of that expired air in 10 min, then we calculate the amount of O<sub>2</sub> in that 100 liters, instead of finding 20% as in the atmosphere, we found it 17%, so you will have 3 liters consumed per 10 min , then we can calculate metabolic rate.

- Actually, for more standardization of that rate, we convert all these results according to the **surface area** of the body (we will use the surface area in the calculations). So the final unit of metabolic rate is **Calorie/hour.m<sup>2</sup>**

-Also, for more standardization we calculate the **basal metabolic rate**, the calculation under **basal conditions** which are:

1. Not eaten for at least 12 hours; because if you ate something, the O<sub>2</sub> consumed and the heat produced will be changed, and the metabolic rate as will.
2. Measurement after a night of restful sleep.
3. No exercise and physical activities in at least one hour; because during exercise you will utilize O<sub>2</sub> that was stored in myoglobin in muscles, so we need one hour; to replenish the myoglobin with oxygen. As a

result the O<sub>2</sub> consumption will increase; that will make errors during measurement.

4. Elimination of all factors that may cause excitement during the test.
5. Comfortable temperature during measurement. Because at low temperatures the metabolic activity is going to increase.

### *Factors affecting metabolic rate:*

**-Exercise:** increases metabolic rate.

**-Daily activities:** the metabolic rate depends on the activity itself. For example, a person sitting on his chair all the day has a lower metabolic rate than a person working.

**-Age:** aging decreases metabolic rate; due to the decreasing in the surface area with age.

**-Sleep:** decrease the metabolic rate (Sleep is not considered as one of the basal condition because the person must be awake while measuring the basal metabolic rate)

**-Climate:** the metabolic rate increase in people who live in cold climate than those living in hot climate.

**-Fever:** the metabolic rate will be increased

**-Malnutrition:** the metabolic activity will be lower. To say, there is a person is placed on a diet of protein, the same person after few days replaces the diet by a diet based on carbohydrates, they found that when this person was on a diet

of protein has a higher rate than when he was on a carbohydrates diet. This is explained by the action of certain amino acids that increase the metabolic rate of the body, and this phenomenon called **specific dynamic action of specific amino acid**.

**-Effect of hormones:**

**\*Thyroid hormones:** increase the metabolic rate.

**\*Sex hormones:** increase the metabolic rate (male sex hormones have more effect than female sex hormones)

**\*Growth hormones:** increase metabolic rate.

**-Effect of sympathetic stimulation:** increase the metabolic rate.

---

## ◇ *Dietary balance*

-The food has a certain energetic value; for example each gram of fat produce 9 Cal and each gram of carbohydrate produce 4 Cal.

-To create a **neutral balance** (no gain or loss weight), we must have the energetic value of the eaten food equally to the expenditure (output).

-Sometimes, there is an increase in the energetic value of the eaten food than the body expenditure which result in **positive balance** that may develop **Obesity**.

- If the energetic value of eaten food is less than the body expenditure, we have a negative balance.

## ◊ *Regulation of food intake*

### *Hypothalamic control of food intake:*

- In the hypothalamus there are centers (clusters of cell bodies of neurons) that control food intake.
- We have two centers: **Feeding center** and **Satiety center**.
- If you have stimulated feeding center, the person will start to eat.
- if you have stimulated the Satiety center, the person will stop eating.
- In addition to these centers, we have other structures that regulate the feeding behavior process such as **amygdala** and **prefrontal cortex**.
- The destruction of amygdala will result in **psychic blindness**; which result in eating anything in front of that person.
- prefrontal cortex is involved in the appetite.
- These centers (**amygdala** and **prefrontal cortex**) involved in regulation of the Quality of eaten food rather than quantity, but the (**Feeding center** and **Satiety center**) are involved in the regulation of feeding behaviors of the body(how much we eat).
- The **Feeding center** and **Satiety center** receiving signals from the body about the status of food storage and the need of the cells, that will result in stimulation or inhibition of food intake.

-To understand the food intake regulation, we divide the regulatory mechanism into:

**A) Long term regulation (we will discuss many theories that explain this type of regulation)**

**1- Glucostatic theory**

The amount of glucose in the blood is the stimulant to eat or not to eat, but it wasn't true; because diabetic patients have a high concentration of glucose in their blood, but they have **hyperphagia** (excess of feeding), then the theory is changed into: the availability of glucose for cellular energy is the stimulus to eat or not.

**2-lipostatic theory**

Lipids deposition in our body is the stimulus to eat or not. The fat stored in adipocytes, the adipose cells will release a hormone called **leptin**; this leptin hormone can act over specific receptors in the hypothalamic centers to reduce the feeding behaviors. There is a gene called **OB gene (obesity gene)**, that responsible for the expression of the leptin hormone.

\*Some people who are developing obesity have a defect in OB gene, which results in defective leptin; No inhibition of feeding centers and the person will develop obesity.

**3-Aminostatic theory**

The concentration of amino acids in the blood has an effect in the feeding behaviors.

#### **4-body temperature**

In the winter there is tendency to eat more than in the summer; because there is relation between temperature regulatory (thermoregulatory centers) centers and feeding centers.

#### **5-psychsocial factors**

Some people eat 3 meals a day, but others eat one meal a day. Now that person who is used to eat 3 meals a day, once he misses one meal; he will feel hungry. On the other hand, that person who is used to eat one meal a day, if he misses the time of the second or third meal; he will not be affected.

### **B) Short term regulation**

#### **1-Gastrointestinal filling**

Once you have filled your stomach and duodenum, this will cause activation of signals (neural and hormonal signals); that will change the activity of feeding centers (stopping food intake)

#### **2-Hormonal factors**

The presence of food in GI tract will result in the release of hormones, those hormones such as: insulin, cholecystinin and nuropeptide (Y); which influence feeding behaviors.

#### **3-Suppression by oral receptors**

Some people believe that there are receptors in the pharynx, and once you swallow the food, the receptors

will estimate the amount of eaten food; so, after certain number of swallowing, there will be signals to inhibit feeding process. Some people use this theory; by chewing the food into small pieces, so they reduce feeding behaviors.

---

## ◊ *Obesity*

- Once a person has more intake than the expenditure (positive energy balance); he will develop obesity.
- Obesity is defined as an increase in the amount of adipose tissue by more than 20% of the ideal body weight (the increase must be only by fat).

### Causes of obesity

#### **1-Neurogenic abnormalities**

As you know, hypothalamus centers need specific strength of stimuli to be activated. In some people, satiety center need stronger stimuli to be activated, as well as, stronger stimuli to inhibit the feeding centers; that will result in changing the **set point (minimal strength of stimuli needed to activate or inhibit certain centers)**, and it's determined by the number of receptors in that center. For example; high number of receptors in certain centers will make the set point low; so any small stimuli will cause an effect.

#### **2-Genetic factors**

Genetic mutation in **OB gene** will generate obesity; because **leptin** will be unable to inhibit feeding centers

due to that mutation. Also, the genetic variations in some receptors (leptin receptors for example) will affect the response of centers.

### **3-psychogenic factors**

Some people develop obesity after emotional changes or mental depression. Also, some people are eating to release their tension.

### **4-Childhood over nutrition**

The over nutrition of a child (forcing them to eat more than they need) will result in new formation (hyperplasia) of fat cells. This will increase the capacity of adipose cells to store more fat (especially once they become adults). So, the fat cells will need huge amount of fat; to fill that cells and release leptin. So these kids will grow with a high probability of having obesity.

### **5-Other causes**

\*Endocrine disorders such as in hypothyroidism which leads to decrease in the metabolic activity.

\*Lack of exercise

## Treatment of obesity

- \*Decreasing the input
- \*increasing the output
- \*Doing the Both
- \*Using drugs that inhibit feeding centers

## *◊Inanition*

- The opposite of obesity. This condition is caused by inadequate availability of food (negative balance)
- It is related to some psychogenic abnormalities, for example; some people when they depress, they eat much less than necessary for their body need of energy, and this condition is called **anorexia nervosa**, but there are some people when they depress, they eat more than their body need of energy (the most important cause of that behavior is the abnormal set point)

## Starvation

- When there is no food at all, the body will use its stores of food.
- The body will start utilizing the carbohydrate, but within 48 - 72 hours, the body will consume all carbohydrate stores.
- Then, the body will begin to use fat and proteins **at the same rate** for one week (**First phase**)

-After one week, the body starts to **utilize proteins at low rate** (preserve functional proteins), and continue to use fat deposits (**Second phase**).

-After 5-6 weeks, all fat stores will be depleted; so, the body will retain to use proteins at a **higher rate (Third phase)**, This phase will be followed by death.

\*The doctor asked a question at the end of the lecture:  
If a person is in the second phase, what is the RQ (Respiratory quotient) of this person at this stage?  
Answer: It is going to be 0.7 because the major source of energy is going to be fat.

*“Do not fear failure but rather fear not trying.”*  
— Roy T. Bennett

*The End*