كلية المستقبل الجامعة

قسم الفيزياء الطبية

المرحلة الثالثة

Medical Physics

Lecture Four

Conservation of Energy

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Conservation of Energy :

All the bodies, like all living organisms, are energy conversion machines. The fraction going into each form depends both on how much we eat and on our level of physical activity. If we eat more than is needed to do work and stay warm, the remainder goes into body fat .

Conservation of energy : Means that the chemical energy stored in food is converted into work, thermal energy, and/or stored as chemical energy in fatty tissue.

Conservation of energy formula :

$\boldsymbol{E_t = E_i + W + Q}$

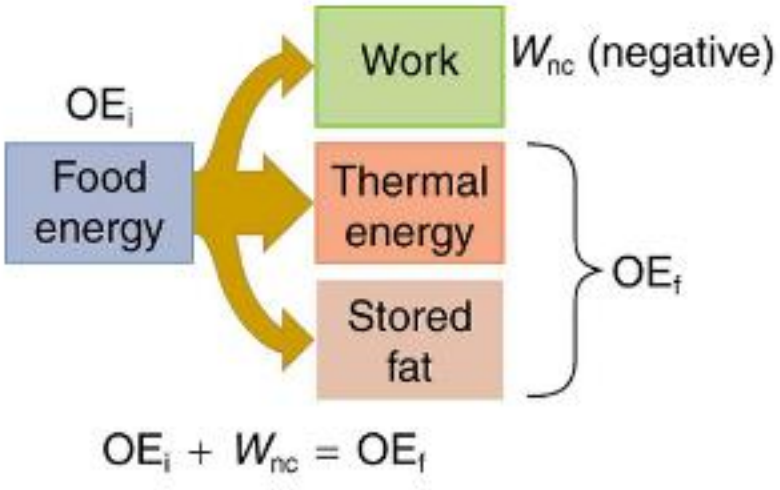
$\boldsymbol{E_t}$**:** The total internal energy of the system **.**

$\boldsymbol{E_i}$**:** The initial internal energy of the system .

W: Work done by the system

ΔE = W + Q

Energy consumed by humans is converted to work, thermal energy, and stored fat. By far the largest fraction goes to thermal energy.



Energy, Work, and Power of the Body :

The rate at which the body uses food energy to sustain life and to do different activities is called the metabolic rate.

The total energy conversion rate of a person at rest is called the basal metabolic rate (BMR) and is divided among various systems in the body .

The largest fraction goes to the liver and spleen, with the brain coming next. Of course, during vigorous exercise, the energy consumption of the skeletal muscles and heart increase markedly. About 75% of the calories burned in a day go into these basic functions.

Basal Metabolic Rates (BMR):

Organ	Power consumed at rest (W)	Oxygen consumption (mL/min)	Percent of BMR
Liver & spleen	23	67	27
Brain	16	47	19
Skeletal muscle	15	45	18
Kidney	9	26	10
Heart	6	17	7
Other	16	48	19
Totals	85 W	250 mL/min	100%

Factors Effecting on BMR :

1- Age

2- Gender

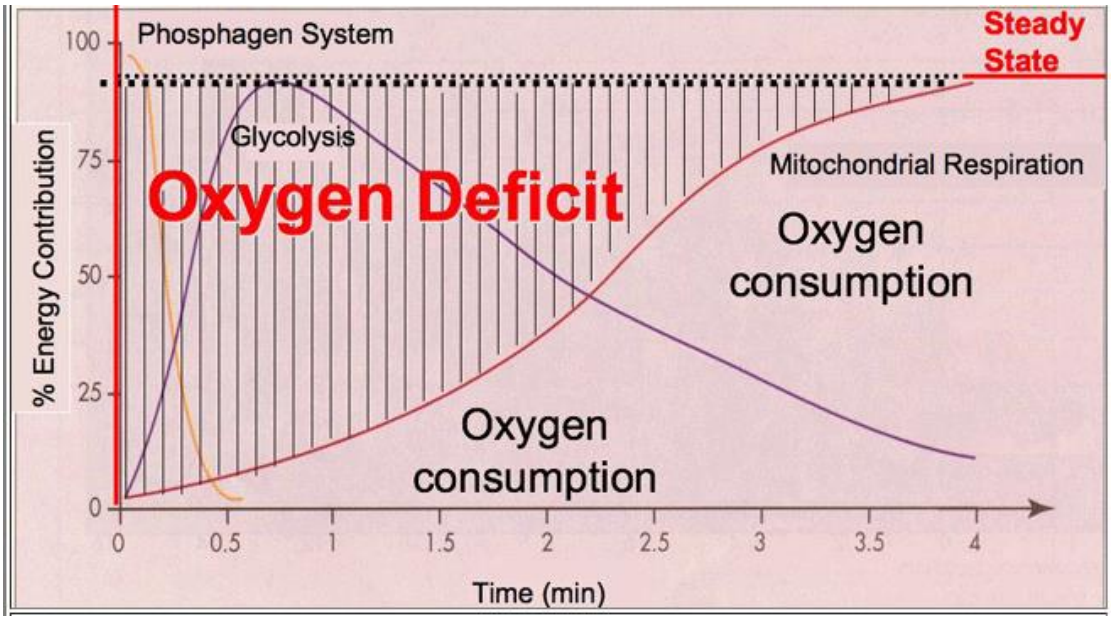
3- Total body weight.

4- Amount of muscle mass (which burns more calories than body fat). Athletes have a greater BMR due to this last factor.

Energy and Oxygen Consumption:

Energy consumption is directly proportional to oxygen consumption because the digestive process is basically one of oxidizing food. We can measure the energy people use during various activities by measuring their oxygen use .

Approximately 20 kJ of energy are produced for each liter of oxygen consumed, independent of the type of food .



Under resting conditions the body energy is being used as follows :

1- 27% by the liver and spleen .

2- 25% by the skeletal muscles.

3- 19% by the brain.

4- 10% by the kidney.

The body's basic energy (fuel) source is food; the food must be chemically changed by the body molecules that can combine with oxygen in the body .

The Body Uses the Food Energy :

1- Operate its various organs .

2- Maintain a constant body temperature.

3- Do external work .

This table for typical energy relationships for some foods.

Food	energy released per liter of O_2 used (Kcal/liter)	Caloric value (Kcal/g)
Carbohydrates	5.3	4.1
Proteins	4.3	4.1
Fats	4.7	9.3
Typical diet	4.8 - 5	-

Work and Power :

Work done by a person is sometimes called useful work, which is work done on the outside world, such as lifting weights. Useful work requires a force exerted through a distance on the outside world, and so it excludes internal work, such as that done by the heart when pumping blood. Useful work does include that done in climbing stairs or accelerating to a full run, because these are accomplished by exerting forces on the outside world. Forces exerted by the body are non-conservative, so that they can change the mechanical energy (KE+PE) of the system worked upon, and this is often the goal. A baseball player throwing a ball, for example, increases both the ball's kinetic and potential energy.

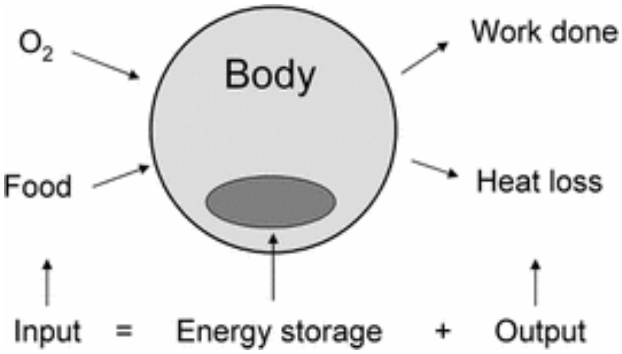
The Internal Work :

Is the force (F) moved through a distance ΔxΔ w= F Δx

The force and the motion Δx must be in the same direction

Power: is the rate of work done.

P=Δ w/Δ t =F Δ x/Δ t = F v (v =velocity)



External work is done when a person is climbing hill or walking up stairs

We can calculate the work by: multiplying the person weight (mg) by the distance (h) moved vertical

W =mg*h

To study the human body as a machine for doing external work, we can measure the external work is done and power supplied by a subject riding on an ergometer on a fixed bicycle. We can also measure the oxygen consumed during any activity.

WORK	POWER
Work is said to be done when a force produces motion.	Power is defined as the work done per unit time or rate at which energy is consumed.
SI unit of work is Joule.	SI unit of power is Watt.
Work done = force × displacement	Power = work/time
Work done is independent of time taken.	Power of an object or body depends on the time taken.