



Medical Physics

Energy, Work, and Power of the Body

Lecture Three

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Introduction

All activities of the body, including thinking, involve energy changes.

Energy usage under resting (basal) condition

- Skeletal, muscle and heart: 25%
- Brain: 19%
- Kidneys: 10%
- Liver and spleen: 27%
- Another work cycle such as walking: 19%

The body basic energy (fuel) is food. The body uses the food energy for:

- Operation of various organs.
- Maintenance of constant body temperature.
- External work.
- 5% of the food energy is excreted in faeces and

Urine.

- Any energy that is left over is stored as body fat.

Conservation of Energy in the Body

The first law of thermodynamics:

$$\Delta U = \Delta Q - \Delta W$$

Note: the work done by the body is negative.

Energy Changes in the Body

Several energy and power units are used in relation to the body.

Physiologists usually use **Kilocalories (Kcal)** for food energy and **kilocalories per minute** for the rate of heat production.

Energy requirement:

1. Male = 2500 kcal/day
2. Female = 2000 kcal/day

Notes from some studies and research:

1. Calorie deficit of 500 kcal/day \approx weight loss of 0.5 kg/week.
2. No calorie intake at all \approx weight loss of approximately 2kg/week.

Basal metabolic rate BMR

When completely at rest, the typical person consumes energy at a rate of about 92 Kcal/hr or 107 W.

Basal metabolic rate BMR is the amount of energy needed to perform minimal body functions such as breathing and pumping blood through the arteries under resting conditions.

Factors of affecting BMR

1. Hormones:

BMR depends primarily upon **thyroid function**

2. The Mass of the body and surface area:

Since the energy used for basal metabolism becomes heat which is primarily dissipated from the skin, the basal rate is related to the surface area or to the mass of the body.

3. The temperature of the body:

When the temperature increases, the chemical reactions are fastened and the opposite is true.

If the body temperature changes (increases or decreases) by 1°C , there is a change of about 10% in metabolic rate (O_2 consumption).

4. Other factors affecting BMR: Age & sex

Work and Power

Chemical energy in the body is converted into external mechanical work as well as in life-preserving functions.

We now discuss external work:

External work = force x distance

$$\Delta W = F \times \Delta x$$

Note: the force and the motion Δx must be in the same direction.

The rate of doing work = power

$$P = \Delta W / \Delta t$$

$$P = F \times \Delta x / \Delta t$$

$$P = F v$$

We want to study the human body as a machine for doing external work.

The efficiency of the human body as a machine can be obtained from:

Efficiency = work done / energy consumed