Unit IX – Problem 1 – Physiology: Exercise

- **What is strength?**
  - It is the maximal contractile force of a muscle (equal to 3-4 kg/cm^2 of muscle cross-sectional area) and it is determined mainly by the size of a muscle (e.g. a big muscle such as quadriceps will have a high muscle strength).
- **What is endurance?**
  - It means the amount of time during which the muscle can stay contracted and it mainly depends on glycogen content of the muscle.
- **Muscle hypertrophy:**
  - **Definition**: increase in the size of muscle fibers.
  - **Causes of muscle hypertrophy include the following:**
    - ✓ ↑ number of myofibrils.
    - ✓ ↑ mitochondrial enzymes.
    - ✓ ↑ components of phosphagen system.
    - ✓ ↑ stored glycogen.
    - ✓ ↑ stored triglycerides.
- **There are two types of muscle fibers:**
  - **Slow tension (red muscles):** which are rich in myoglobin and mitochondria, used for long-term exercises and predominant in endurance athletes.
  - **Fast tension (white muscles)**: which lack myoglobin and mitochondria, fatigue easily, used for very short but intense exercises and predominant in weightlifters.
- **Role of testosterone and estrogen:**
  - **Testosterone**: which is the main anabolic hormone in males increases the deposition of proteins in muscles. Therefore, increasing the muscle mass and muscle strength.
  - **Estrogen**: increases deposition of fat in females. Therefore, decreasing muscle mass. Note: even without exercise, male muscles are 40% larger than females.
- **Metabolism (more details are mentioned in biochemistry note):**
  - **Phosphagen system:**
    - ✓ Ready ATP stores in muscles: sustain contraction for 1 second.
    - ✓ Creatine phosphate (CP): the muscle contains 2-4 times CP than ATP. Therefore, breaking down the high energy bond between phosphate and creatine generates energy for nearly 6 seconds.
    - ✓ Suitable for: jumping, weightlifting and 100 m run.
  - **Glycogen-lactic acid system:**
    - ✓ Stored glycogen (in liver and muscles) will be broken down to provide glucose that will be converted to pyruvate (there is a net generation of 2 ATPs during this process). With lack of oxygen, pyruvate will be converted to lactic acid (instead to acetyl CoA that enters Krebs cycle) → lactic acid will diffuse out of cells and cause fatigue. This system provides energy for 1-2 minutes.
    - ✓ Suitable for: 200 m run.
  - **Oxidative system:**
    - ✓ In which there is oxidation of glucose, fatty acids and amino acids (in mitochondria) to provide energy. After 4-5 hours of exercise, most of energy is derived from fat instead of carbohydrates thus burning fat storage and aiding in weight loss.
    - ✓ Suitable for: marathon run and jogging.
- **The stored oxygen in the body is equal to = 2 liters.**
  - **0.5 L** in the lungs.
  - **0.25 L** dissolved in body fluids.
  - **1 L** combined with hemoglobin (in blood)
  - **0.3 L** combined with myoglobin (in muscles)

- **Oxygen debt**: the defect in oxygen due to intense exercise (oxygen which is needed after intense exercise and this is equal to = 11.5 L):
  - **2 L to replenish the stored oxygen in the body.**
  - **9 L for metabolic recovery** (since all energy systems are recovered by aerobic mechanisms).
- **Respiratory changes during exercise:**
  - **Increased oxygen consumption.**
  - **Increased pulmonary ventilation.**
  - **Increased VO_2 max:**
    - ✓ What is VO_2 max? → it is the maximum amount of oxygen an individual can utilize during maximal training (measured in: ml kg^{-1} min^{-1}).
    - ✓ How to calculate VO_2 max?
      - ❖ VO_2 max (Fick equation) = maximal Cardiac Output x maximal arterio-venous O_2 difference
      - ❖ Notice that Cardiac Output (CO) = Heart Rate (HR) x Stroke Volume (SV).
    - ✓ Changes in VO_2 max is mainly by changes in stroke volume.
    - ✓ Training increases VO_2 max mainly by increasing stroke volume (SV) although hear rate (HR) is reduced. Increased stoke volume (SV) is due to:
      - ❖ ↑ preload: due to increased venous return and ventricular volume.
      - ❖ ↓ afterload: due to decreased arterial constriction.
      - ❖ ↑ contractility.
- **Blood flow is mainly increased in skeletal muscle during exercise.**
- **What cardiovascular changes happen during exercise (very important!):**
  - **↑ Heart Rate (HR)**
  - **↑ Stroke Volume (SV)**
  - **↑ Cardiac Output (CO)**
  - **↑ arterial blood pressure**
  - **↑ blood flow**
  - **↓ total peripheral resistance**
- **What is the difference between dynamic exercise and static exercise?**
  - **Dynamic exercise**: in which systolic blood pressure will be increased. Examples include: walking, jogging, swimming and cycling.
  - **Static exercise**: in which both systolic and diastolic pressures will be increased (due to muscular contractions compressing peripheral arteries). Examples include: weightlifting and isometric muscular contractions.
- **Endocrine changes during exercise: there is increased secretion of**
  - **Aldosterone.**
  - **Cortisol.**
  - **Catecholamines.**
- **Thermal changes during exercise:**
  - There is increased body heat.
  - Distribution of heat from core to the skin → sweating.
- **Benefit of exercise to cardio-respiratory systems:**
  - Stronger heart and lower resting heart rate.
  - Increased aerobic capacity and muscle endurance.
  - Maintinence of healthy weight and fat percentage.
  - Management of stress.
  - Increased muscle tone and enhanced physical appearance.