Muscle and Blood Physiology

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Muscle

- All cells can transform chemical energy to movement bu muscle cells have the highest capability.

- There are three types of muscle in human body:
  1. Skeletal Muscle (Striated muscle)
  2. Smooth Muscle
  3. Cardiac Muscle

Skeletal Muscle

- Skeletal muscle;
  - is under voluntary control.
  - is innervated by somatic nervous system.
  - is consisted of polynuclear cells and has **no** gap junction.
  - is differentiated on highest degree.
  - has no cell division.

- One skeletal muscle cell is called «**muscle fiber**». Muscle is consisted of lots of muscle cells which are wrapped by connective tissue.

Skeletal Muscle

- Muscle fiber's (muscle cell=myocyte);
  - Cytoplasm is called «*sarcoplasm*»,
  - Membrane is called «*sarcolemma*»,
  - ER is called «*sarcoplasmic reticulum*»

- Skeletal muscle looks striated because of the «**myofibrils**» in its cytoplasm.

- There are two types of myofibrils:
  1. Thin Filaments
  2. Thick Filaments

Thick and Thin Filaments

- Thick filaments are consisted of a protein called «myosine».
  - Myosine binds to actine
  - Head portion of myosine uses ATP

- Thin filaments are consisted of «actin, troponin and tropomiyosine» proteins.
  - Actin has binding sites for myosine.
  - Troponin detects the Ca^{+2} concentration of sarcoplasm.
  - Tropomyosine covers the bindins sites of actin, during resting state.

Sarcomere

- The **sarcomere** is the basic mechanical unit that makes muscles work. It is the repeating unit between two Z lines.
- Contraction = Shortening the length of sarcomere
- Transformation of action potential to contraction is called «**excitation-contraction coupling**».
- The impulse coming from motor neuron is transported to muscle through «**neuro-muscular junction**».

Neuro-muscular Junction

- It is the synapse between motor neuron and the skeletal muscle.
- The neurotransmitter of the neuro-muscular junction is «Acetylcholine» (ACh).
- ACh, binds to its receptor on the sarcolemma which is coupled with Na^+ channels.
- Effect of ACh is terminated by a highly active enzyme called «**cholinesterase**».

Neuro-muscular Junction

- Binding of ACh, opens the Na^+ channels and creates the «skeletal muscle action potential».
- Skeletal muscle depolarization, induces a calcium release from sarcoplasmic reticulum which is the main calcium depot of skeletal muscle.
- Rise of calcium concentration is the main signal for initiation of contraction. After calcium rise, a process called «**cross-bridge cycle**» starts.

Cross-Bridge Cycle

1. ATP is bound to myosine. Actin and myosine detaches.

2. ATP is broken down to yield energy by myosine head. Myosine head enters into a charged state.

3. Charged miyosine binds to actin.

4. Myosine makes the «**power stroke**» and spends the energy.

Types of Contraction

- «**Isometric contraction**», is one in which the muscle is activated, but instead of being allowed to lengthen or shorten, it is held at a constant length.

- In an «**isotonic contraction**», tension remains the same, whilst the muscle's length changes.
  a. Contractions that permit the muscle to shorten are referred to as **concentric contractions.**
  b. An **eccentric contraction** is the motion of an active muscle while it is lengthening under load.

Tetanus

- One action potential induces one contraction whick is called «twitch».
- If the muscle is stimulated repeatedly without giving time for relaxation, contractions can overlap.
- Tetanus is evoked when the motor nerve that innervates a skeletal muscle emits action potentials at a very high rate. If stimuli are delivered slowly enough, the tension in the muscle will relax between successive twitches.
- If stimuli are delivered at high frequency, the twitches will overlap, resulting in tetanic contraction. A tetanic contraction can be either unfused (**incomplete**) or fused (**complete**).
- The frequency needed to create complete tetanus is called «**critical frequency**».

Electromyography (EMG)

- «Electromyography» (EMG) is an electrophysiological technique for evaluating and recording the electrical activity produced by skeletal muscles.
- An electromyograph detects the electric potential generated by muscle cells, when these cells are electrically or neurologically activated.
- EMG is used as;
  - a diagnostics tool for identifying neuromuscular diseases,
  - as a research tool for studying kinesiology, and disorders of motor control.
  - guide to botulinum toxin or phenol injections into muscles.
  - a control signal for prosthetic devices such as prosthetic hands, arms, and lower limbs.

Electromyography (EMG)

- First skin is cleaned with alcohol.
- Surface electrodes may be used but they are able to provide only a limited assessment of the muscle activity.
- Needle electrode is placed to muscle of interest.
  - EMG is more effective on superficial muscles as it is unable to bypass the action potentials of superficial muscles and detect deeper muscles.
  - Body fat weakens the signal.

Electromyography (EMG)

- After assessing resting and insertional activity, the electromyographer assess the activity of muscle during voluntary contraction.
- The shape, size, and frequency of the resulting electrical signals are judged.
- Then the electrode is retracted a few millimetres, and again the activity is analyzed. This is repeated, sometimes until data on 10–20 motor units have been collected in order to draw conclusions about motor unit function.

Blood Physiology

Components of Blood

- Blood is a body fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells.

- It is composed of «**blood cells**» suspended in «**blood plasma**».

- Blood Cells:
  - Erytrocyte (Red Blood Cells)
  - Leukocytes (White Blood Cells)
  - Trombocytes (Platelets)

Blood Plasma

- **«Plasma»**, which constitutes 55% of blood, is mostly water (92% by volume).
- Blood plasma is separated from the blood by spinning a tube of fresh blood containing an anticoagulant in a centrifuge until the blood cells fall to the bottom of the tube.
- Blood **serum** is blood plasma without clotting factors.

Hematocrit (Hct)

- The hematocrit, is the volume percentage (vol%) of cells (especially the red blood cells) in total blood.

- Normal values:
  - Men 41-51%
  - Women 37-47%

- What are the factors that increase or decrease Hct?

Properties of RBC

- **Erythrocytes** also called **Red blood cells** (**RBCs**), are the most common type of blood cell.
- It delivers oxygen (O_2) to the body tissues.
- Normal values:
  - Men: $4{,}9 \times 10^6 – 5{,}5 \times 10^6$ / mm^3
  - Women: $4{,}4 \times 10^6 – 5{,}0 \times 10^6$ /mm^3
- In humans, mature red blood cells are flexible and oval biconcave disks. They lack a cell nucleus and most organelles,
  - They can pass through capillaries.
  - They have more space for diffusion.
  - The can carry more hemoglobin

Properties of RBC

- Their lifespan is 120 days.
- They have the oxygen carrier molecule «hemoglobin». Hemoglobin molecule have iron ions in its structure. This iron gives blood a red color.
  - The hemoglobin which is carrying oxygen is called «oxyhemoglobin»(arterial blood=bright red color)
  - The hemoglobin which has no oxygen is called «deoxyhemoglobin»(venous blood=dark red color)

Hemoglobin (Hb)

- All of the hemoglobin in blood is found in RBC. There is no hemoglobin in plasma.

- Normal values:
  - Women 12-16 g/dL
  - Men 14-18 g/dL

- What is «glycated hemoglobin» (HbA1c)?

Erythrocyte sedimentation rate (ESR)

- The erythrocyte sedimentation rate (ESR or sed rate) is the rate at which red blood cells sediment in a period of one hour.

- Normal Values:
  - Men: 0-15 mm/saat
  - Women: 0-20 mm/saat

Erythrocyte sedimentation rate (ESR)

- It elevates because of;
  - Infection
  - Tumour
  - Anemia
  - Mensturation
  - Pregnancy
  - Lactation (Breastfeeding).

Blood Types (AB0 and Rh System)

- There are lots of blood type antigens in erythrocyte membrane. The most important ones are A and B antigens (**agglutinogens**).
- A person may be A, B, AB or 0 blood type according to AB0 system.
- Humans carry antibodies (**agglutinin**) in their plasma against the antigen which they don't have.
- Rh system is also important in blood transfusion.
- The antigen is «D» in Rh system. If a person has D antigen his blood type is Rh+, if not it is Rh-

Blood Types

Blood Type	Agglutinogen	Agglutinin	Percentage
0	-	Anti-A, Anti-B	45
A	A	Anti-B	41
B	B	Anti-A	10
AB	AB	-	4

White Blood Cells (WBC)

- **Leukocytes,** are the cells of the immune system that are involved in protecting the body against both infectious disease and foreign invaders.

- There is 4000-10.000 leukocytes in 1 mm^3 blood.
  - If the count is under 4000 it is called «leukopenia».
  - If the count is more than 10000 it is called «leukocytosis».

Type of Leukocytes

1. Neutrophils
2. Eosinophils
3. Basophils
4. Monocytes
5. Lymphocytes

Thrombocytes (Platelets)

- Platelets, also called thrombocytes are a component of blood whose function (along with the coagulation factors) is to react to bleeding from blood vessel injury by clumping, thereby initiating a blood clot.
- There is 150.000-300.000 thrombocytes in 1 mm^3 of blood.
- If it is lower than 150.000 it is «thrombocytopenia», if it is more than 300.000 it is «thrombocytosis».

Thank you