

Lecture 14. Fatigue and adaptation

Physical and mental
work.

Basic mechanisms of
fatigue.

Training

Workability

- **Workability** depends on the balance of two processes - the cost of energy and its recovery are mixed in different periods of physical activity (G.Folbort)



3 periods of workability

- **Start-up period**- characterized by a gradual increase of capacity at the beginning of physical activity
- **Steady state period** - disability is accompanied by relatively stable during the performance.
- **Fatigue period** - characterized by a decrease in performance during physical activity

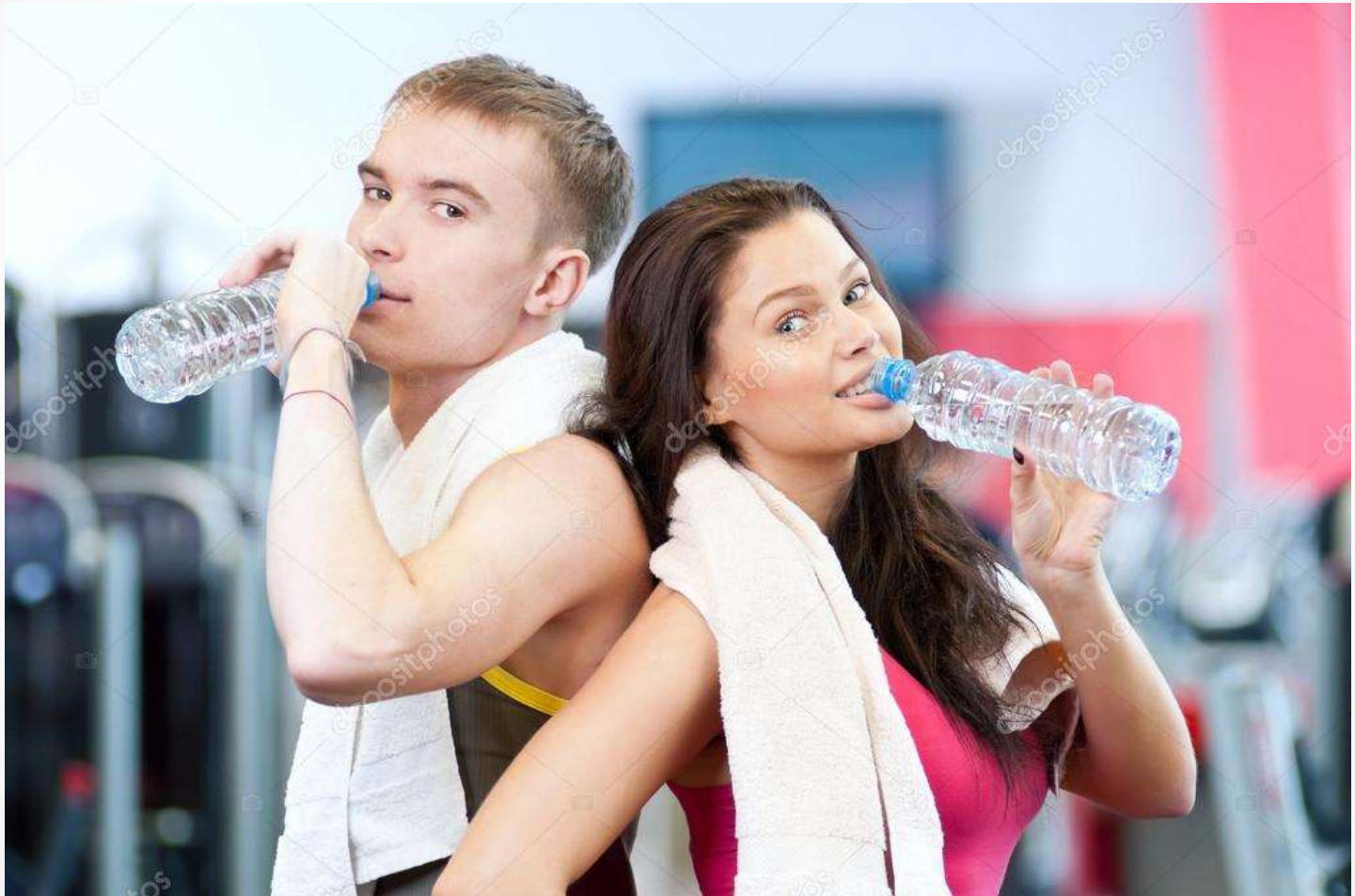
Muscle workability

Workability indicators:

- 1. The force of muscle contraction**
- 2. Velocity of contraction.**
- 3. Endurance (measured retention time of 50% of the maximum muscle strength)**

- **Muscle strength** - a force that can develop a muscle or group of muscles in the process. The maximum force considered force developed by the muscle during the contraction, he barely moves from place maximum load.
- **Capacity of contraction** - explosive component strength and speed: $\text{power} = (\text{force} \times \text{distance}) / \text{time}$.
- **Maximum muscle strength** depends on the amount and the initial length of muscle fibers, which are reduced; AP frequency generated in their motor units; muscle physiological cross-sectional, which significantly increases due to training, leading to its hypertrophy, increase strength contraction

Gender difference



- **Testosterone** has significant anabolic effect - increases protein synthesis in muscle. Even with little physical activity muscle mass in men is almost 40% more than women
- **Estrogens** stimulate the synthesis of fat, which is predominantly deposited in the chest, thighs, subcutaneous tissue, fat women have about 27% of body weight, and men - about 15%.
- Sex hormones also affect temperament, **testosterone increases aggression, goal under extreme situations in the sport**, while the effect of **estrogen is associated with mild temperament traits.**

Fast & Slow Muscles

- a. **white or fast** skeletal muscle fibers , have few mitochondria , reduced ability to carry on aerobic respiration and tend to fatigue rapidly . (ex. extra ocular muscles) . Designed for speed , fatigue easily.
- b. **Red or slow** skeletal muscle fibers , have many mitochondria , are designed for endurance , and can contract for long periods of time

The speed of muscle contraction

- It is congenital phenomenon. Based on the analysis of the factors that affect the speed of motor responses, are the following parameters:
- **mobility basic nervous processes in the central nervous system,**
- **the ratio of fast and slow muscle fibers, their motor units.**

Specialization in some sports may be selected depending on the types of muscle fibers predominate: "Children born to become sprinters or stayers or jumpers"

Kinds of sport	% of fast muscle fibers	% of slow muscle fibers
Marathon	18	82
Swimmers	26	74
Sprinters	63	37
Jumpers	63	37
The average person	55	45



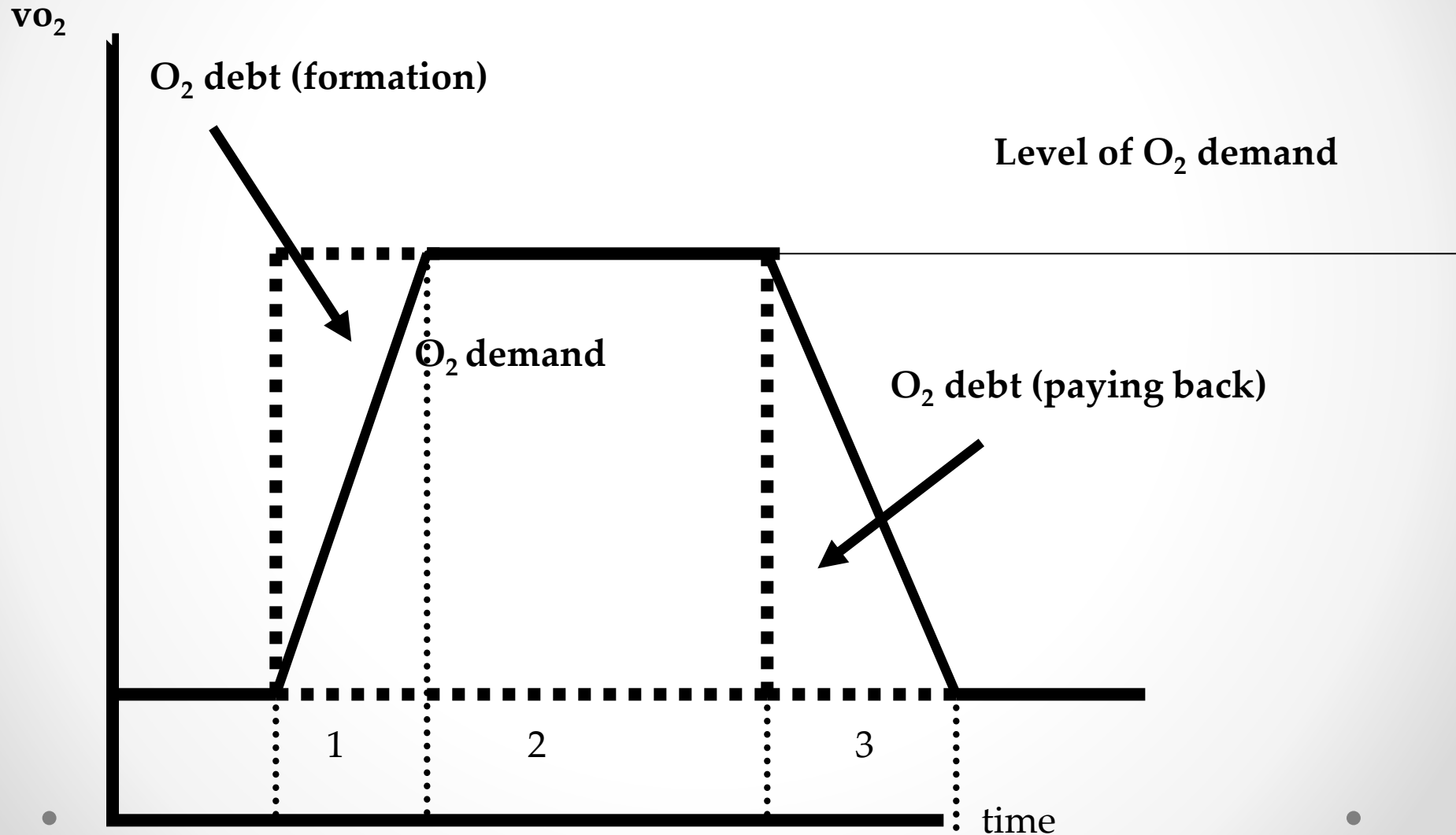
Energy Supply

- Energy Supply during muscle activity depends on the visceral body systems - primarily, breathing and circulation of blood that carries oxygen and nutrients to the muscle cells and make them waste products. Therefore, the definition of functional parameters that characterize these systems adapt to physical activity is an important test evaluation periods of physical activity of the body and its efficiency
- Muscle contraction depends on the amount of energy produced by the hydrolysis of ATP from ADP and FN. In one muscle fiber contains about **4 mmol / L ATP**, which is enough to minimize performance for **2 seconds**. After this time a new molecule of ATP, which provides the following contraction will synthesized

long-term muscle contraction

- It requires large supplies of ATP. The sources of its formation are:
 1. **Creatine phosphate**, which is characterized by high-energy phosphate bonds, the hydrolysis is released more energy than the splitting of ATP. Liberated energy is the binding of ADP to the new phosphate synthesis of new molecules of ATP, which provides muscle contraction. However, stocks KF too small, it is enough for 6-8 sec.
 2. **Glycogen** constantly present in the muscle fibers. Through glycolysis, which does not require oxygen, glycogen is rapidly converted to pyruvic acid and then - in lactic acid, which releases energy for the conversion of ADP to ATP. However, glycolysis accumulate a large number of end products (lactate), adversely affecting the muscle contraction.
 3. The most reliable supplier of energy for muscle contraction is the **oxidative system**, which provides **95% of the energy** needed for long-term and continuous operation. Products for the oxidation of glucose, fatty acids and amino acids

Dynamics of metabolism at work



Oxygen dept

- a. During rest or moderate exercise , O_2 is sufficient to support aerobic respiration (using many ATP molecules) .
- b. During strenuous exercise , O_2 deficiency may develop and lactic acid may accumulate as a result of anaerobic respiration .
- c. The amount of O_2 needed to convert accumulated lactic acid to glucose and restore supplies of ATP and creatine phosphate is called oxygen dept .

Muscle Fatigue

- a fatigued muscle loses its ability to contract .
- muscle fatigue occurs due to accumulation of lactic acid and ATP exhaustion.



Basic mechanisms of fatigue

- ■ central mechanisms - fatigue as a result of changes in the central nervous system that occur during braking, poor coordination of motor function, decreased motor neuron activity and decrease their frequency generation PD;
- ■ peripheral mechanisms - fatigue happens at the cellular level as a result of lack of ATP synthesized in the mitochondria and accumulation of acidic foods that cause acidosis. If the central mechanisms may occur in untrained subjects, the significant and maximum exercise lead to the development of fatigue due to lack of energy at the cellular level, and damage to working muscles.

Muscle pain

- Intense exercise accompanied by is related to nature;
- ■ increasing concentrations of muscle enzymes in the blood plasma;
- ■ presence of myoglobin in the blood;
- ■ presence of inflammatory response;
- ■ violation of the muscle structure.

Muscles overload has the following sequence:

- 1 High Voltage elastic contractile system of muscle leads to structural damage of the membrane of the muscle fibers and muscle.
- 2 Damage to muscle cell membrane causes disturbance of calcium homeostasis in damaged fiber, which leads to cell death, which peaks observed at 24-40 hours.
- 3 Products activity of macrophages and intracellular content (prostaglandins, histamine, kinins, ions K^+ , H^+) accumulates outside the cells and irritate nerve endings of muscle.
- Also found that the occurrence of pain in the muscles is the result of damage to structures, accompanied by an increase in intracellular protein and myosin and actin exchange. In the process of muscle damage and recovery involving lysosomes, Ca^{2+} ions, free radicals, connective tissue, inflammatory reactions myofibril intracellular proteins.
- Prevention of detected changes is to reduce the component eccentric muscle activity at the beginning of the gradual increase in the intensity of the load from minimum to maximum.



Active rest by Sechenov

- Despite the full visceral and metabolic maintenance of physical activity, a person feels fatigue, which leads to lower efficiency and takes time to restore it.
- Sechenov (1903) first showed that the recovery of tired muscles after long human handwork abruptly accelerated, if this person lift load by other hand.
- The same pattern was observed in other types of physical activity. It named by Sechenov as **active rest**.
- This was due to the impact of active recreation relationship in the centers of regulation of these muscles

Basic laws of fatigue and recovery processes (by Folbort)

- 1. Performance depends on the ratio of fatigue and recovery processes, with direct connection – the depletion is growing faster and the recovery will be faster too.
- 2 Restorative processes do not develop wavy. It has two phases - the initial phase achieve efficiency and phase stable, permanent performance.
- 3 Knowing the duration of work and rest afterwards, you can achieve two states - chronic fatigue and gradually build stable performance. Obviously, this is a well-known process of training. If the exhausting workload performs Authority, the state has not had time to change, on the contrary, the recovery process is slowed and weakened - developing chronic state of exhaustion.

Mental capacity

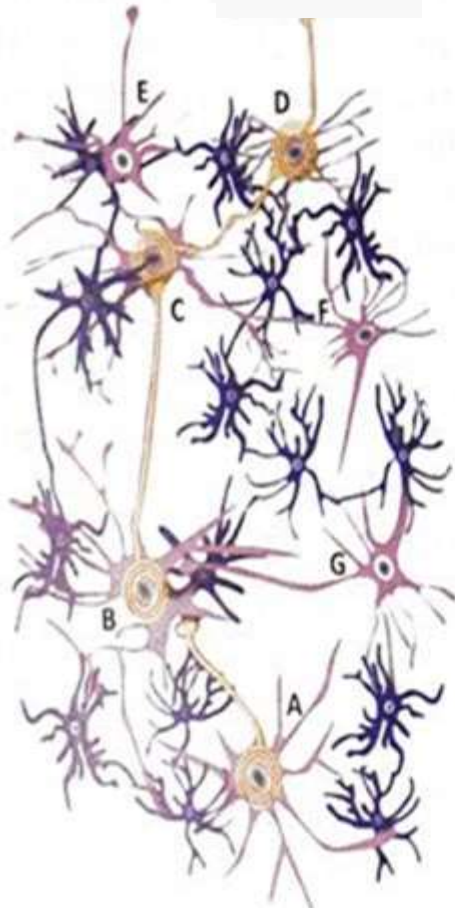
- Mental work reflects the perception and processing of information by the brain. It is characterized by high stress activities hemispheres of the brain, increasing essential function of certain sensory systems, concentration, memory and thinking. In the process new information is comparing it with existing and previously learned and their integration. Integration of information enriches memory, helping to build a program of action and decision making. In the process of mental work increased attention and memory.
- Deep mental capacity mechanisms are not fully understood. However, we know that when damage to the frontal lobes lost the ability to form sentences, solve problems, analyze information. With the destruction of the hippocampus lost the ability to remember information that comes.
- Mental work accompanied by neuro-emotional stress, where increased energy and blood circulation of the brain, there is a redistribution of cerebral blood flow towards its increase by 50% in the frontal lobes, increasing the amplitude and frequency of biopotentials. Parallel increases heart function, blood pressure, depth of breathing, muscle tone changes.

Mental fatigue

- Mental performance is variable, it varies throughout the day. First, it is low (during start of working), then raised and maintained at a high level (period of sustained performance), and then reduced (during fatigue).
- Fatigue develops due to decreased excitability of excitement and relaxation nerve centers through powerful impulses from the sensory systems. For example, visual fatigue reduces the ability to process information received through the visual analyzer, which leads to defects in memory and thinking, relaxation determination, endurance, self-control, the appearance of sleepiness. Neuro-emotional fatigue associated with reticular system activity which the cortex and subcortical structures (according to EEG) is significantly reduced. When mental fatigue increases the tone of the parasympathetic nervous system, as evidenced by a decrease in heart rate, lower blood pressure.
- At the beginning of the XXI century formed the hypothesis that mental fatigue develops due to accumulation of nerve cells chain amino acids (BCAA): free tryptophan, 5-hidroksytryptaminu (serotonin) bound fatty acid tryptophan. Recently appeared studies using MRI, which found that mental fatigue (less than - physical) is accompanied by accumulation of **glutamate** in the cell space through its failure to dispose of astrocytes. Increased concentrations of neurotransmitter is penalized synaptic transmission processes in nerve cells

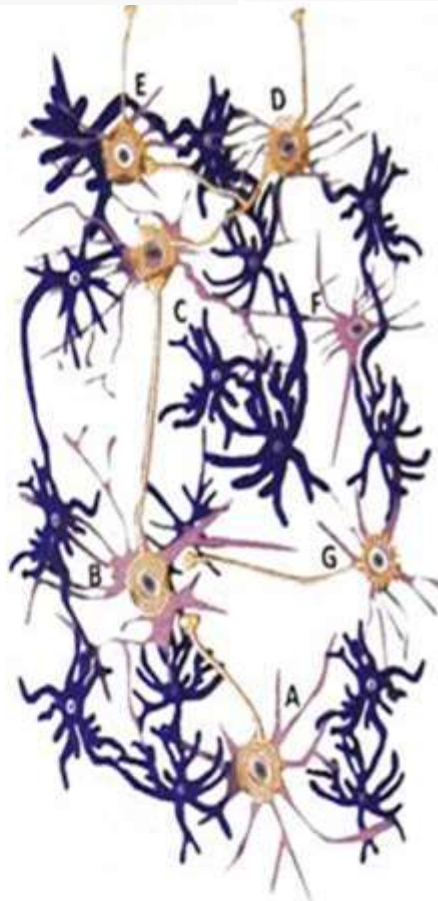
Normal status

Specific
activation



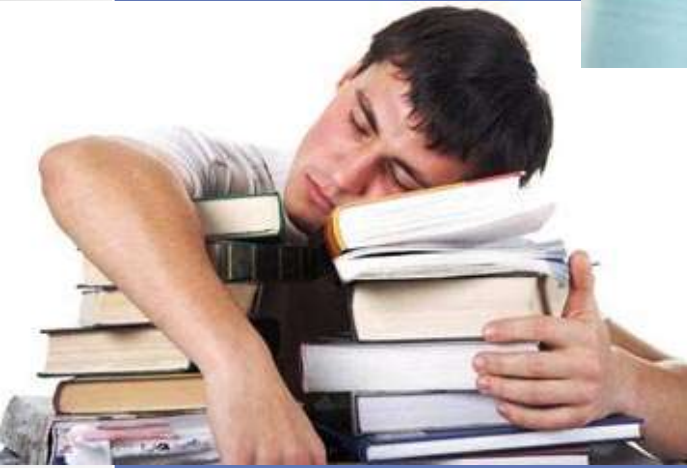
Mental fatigue

Nonspecific
activation



Specific
activation

Neuronal network of the brain under conditions of normal and mental fatigue. Left - normal conditions, neuronal networks composed of neurons A - G (pink and gray). A cell activates the cell B, then C and D. Later surrounding astrocytes (blue) recognize neuronal processes and then interact with them. In mental fatigue - it is - there is growing endings neural processes. This phenomenon is called sprouting, manifested in the activation of neurons neuron C D and E. Due to the release of glutamate, which causes a slight increase in its extracellular concentration of activated neurons G. This in turn will activate the neuron B, the larger excitation of neuronal networks. Consequently astrocytes swell, network feature decreases, fatigue develops



Your

choice???

