PHYSIOLOGICAL MECHANISMS OF ADAPTATION TO PHYSICAL EXERTION

Adaptation

- This is an adaptation of the body to environmental conditions.
- Physical activity is an environmental factor that affects the human body and causes the development of a complex of adaptive reactions.

Stages of Adaptation

- **Urgent**

It occurs in response to a single muscle load and can be implemented on the basis of ready-made, previously formed physiological mechanisms and programs.

- **Long-term**

It occurs gradually, as a result of long-term or repeated effects on the body of muscle training.

Systems Involved in Physical Activity Adaptation

- Musculoskeletal system
- Respiratory system
- Cardiovascular system
- Blood system
- Digestive system
- Excretory system
- Vegetative nervous system
- Endocrine system

Urgent Adaptation of Skeletal Muscle

- The source of energy for muscle activity is ATP.
- Its reserves in the muscle are sufficient to provide 3-5 single contractions of maximum strength.
- Therefore, when working in the muscle, there are constant processes of ATP resynthesis.
- At rest, 90% of ATP is resynthesized by aerobic oxidation.
- In conditions of intensive or prolonged physical activity, anaerobic processes are consistently activated.

ATP Resynthesis

Aerobic glycolysis

Anaerobic mechanisms:

- Creatine phosphokinase reaction (0.5 min.)

Creatine phosphate + ADP → Creatine + ATP

- Myokinase reaction (2-3 min.)

ADP + ADP → ATP + AMP

- Anaerobic glycolysis

Glucose → ATP + lactic acid

Oxygen Debt

- This is the additional amount of oxygen required for the oxidation of anaerobic metabolites (lactate, pyruvate) after the end of work.
- As a result of splitting incomplete decomposition products, a significant amount of CO2 is released.
- The respiratory rate increases to 1 - 1. 5.
- **Respiratory Coefficient (RC)** is the ratio of the volume of carbon dioxide released to the volume of oxygen consumed.

Components of a Functional Oxygen Transport System

1. Respiratory system (respiratory link).
2. Cardiovascular system (circulatory link).
3. Blood system (red blood cell link).
4. Mechanisms of neuro-humoral regulation.

Urgent Adaptation of the Respiratory Link

1. Increase lung ventilation.
2. Bronchodilation.
3. Equalization of the ventilation-perfusion ratio.
4. The acceleration of gas diffusion through the aerogematic barrier.

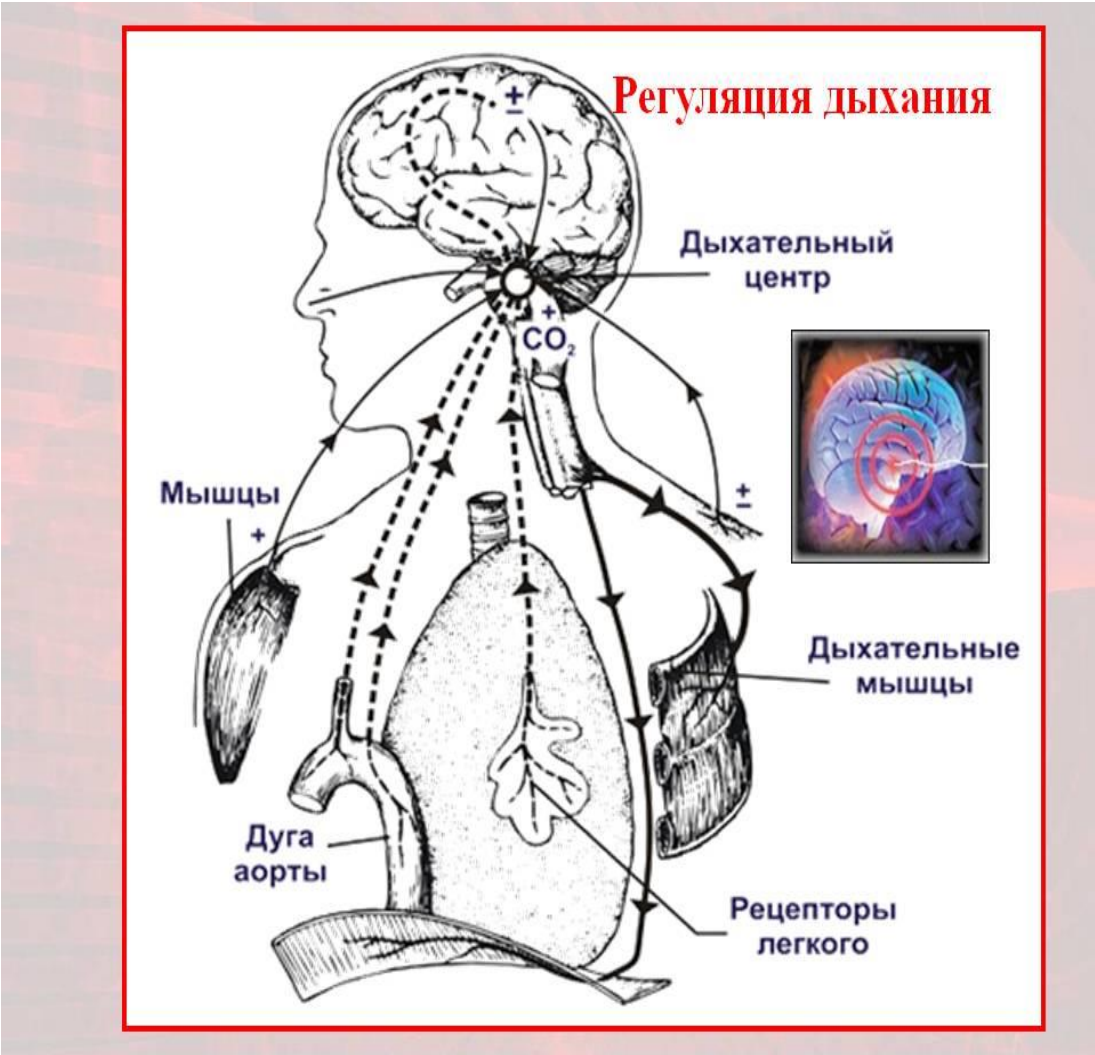
Mechanisms for Increasing Pulmonary Ventilation

First phase (increased breathing depth):

- Stimulating effect of the motor cortex of the brain
- Impulses from proprioceptors of the muscles

Second phase (increased respiratory rate):

- Impulse from chemoreceptors of the carotid sinus and aortic arch



The Mechanism of Bronchodilation

Sympathoadrenal system→

→ β2-adrenoceptors →

→ bronchial dilation

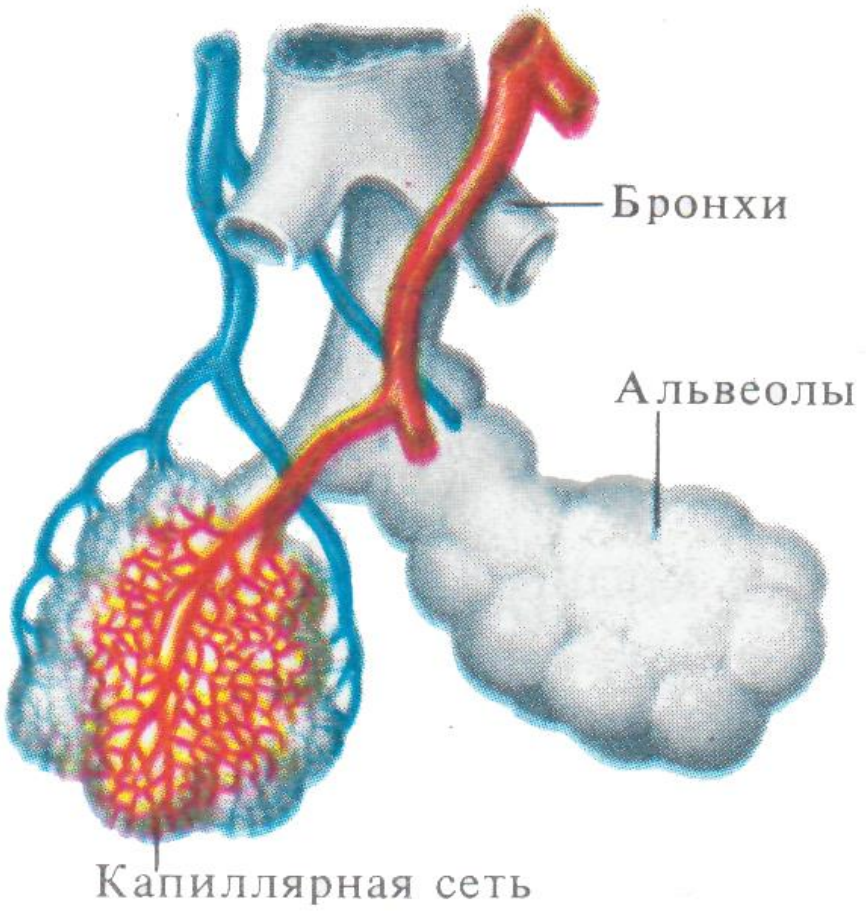
Equalization of the Ventilation-perfusion Ratio

Increase oxygenation of the lungs →

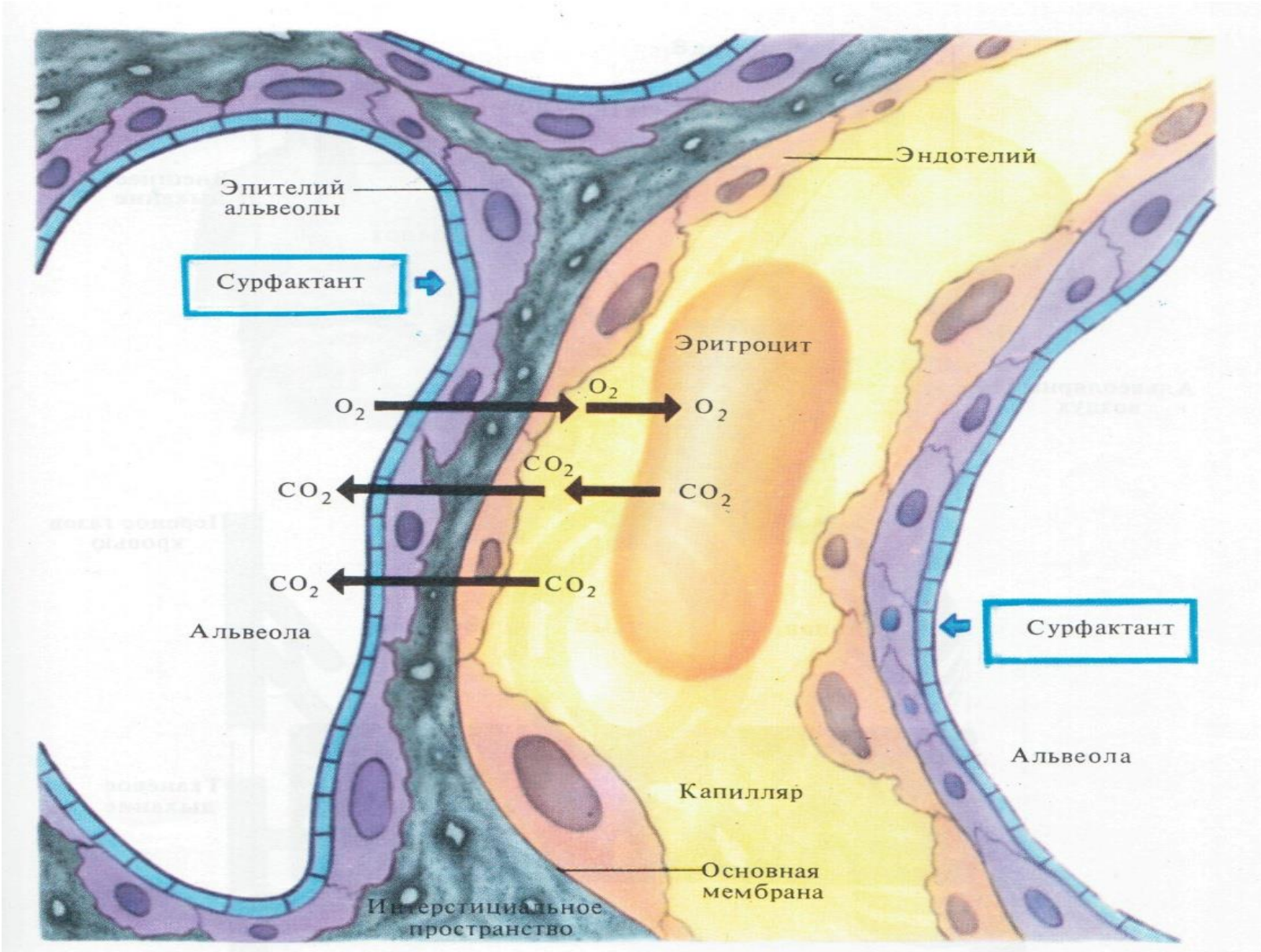
→ vasodilatation→

→ increasing the number of alveoli involved in gas exchange →

→ the ventilation-perfusion ratio is approaching 1.



The Acceleration of Gas Diffusion



Urgent Adaptation of the Circulatory Link

1. Increasing of the minute volume of blood
2. Redistribution of vascular tone
3. Increased blood pressure
4. Increased venous return of blood to the heart

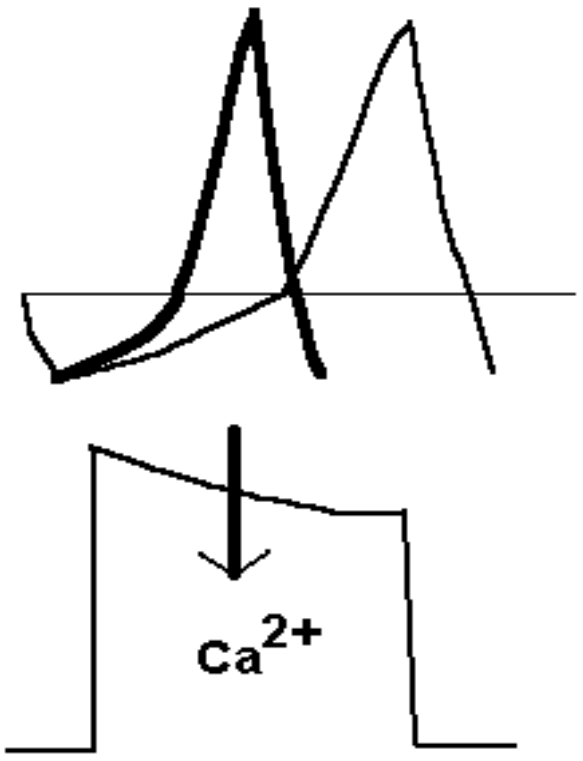
The Increase of the Minute Volume of Blood

Sympathoadrenal system →

→ β1 - adrenergic receptors of the myocardium →

→ the increase in calcium permeability →

→ increasing the frequency and strength of heart contractions.



Redistribution of Vascular Tone

1. Narrowing of blood vessels of the skin and gastrointestinal tract

(α - adrenergic receptors → depolarization of the membrane)

2. Coronary vessel dilation

(β2 - adrenergic receptors → hyperpolarization of the membrane; metabolic vasodilation)

3. Vasodilation of working muscles (products of metabolism: CO2, H+, ADP, phosphoric acid, lactic acid, etc.)

Factors That Contribute to an Increase in Blood Pressure

The strength of cardiac contractions → systolic pressure

Heart rate → diastolic pressure

The lumen of the vessels → diastolic pressure

Blood volume → diastolic pressure

Blood viscosity

Volume Velocity of Blood Flow (Q) is the volume of blood flowing through the cross-section of a vessel per unit of time (l / min, ml / s)

Basic Equation of Hemodynamics:

$$Q = \frac{\Delta P}{R} = \frac{P_A - P_V}{R}$$

P_A _ the pressure in the aorta

P_V _ pressure in the vienna cava

R _ resistance to blood flow

Increasing of the Venous Return of Blood to the Heart

Factors That Contribute to the Movement of Blood Through the veins

- Increasing the pressure gradient
- Suction action of the chest cavity
- The reduction in skeletal muscle

Urgent Adaptation of The Red Blood Cell Link

1. Blood output from the depot.
2. Relative erythrocytosis.
3. Decrease in the affinity of hemoglobin to oxygen (shift of the dissociation curve of oxyhemoglobin to the right).

Sympathoadrenal system →

→ vasoconstriction →

→ blood output from the depot →

→ relative erythrocytosis →

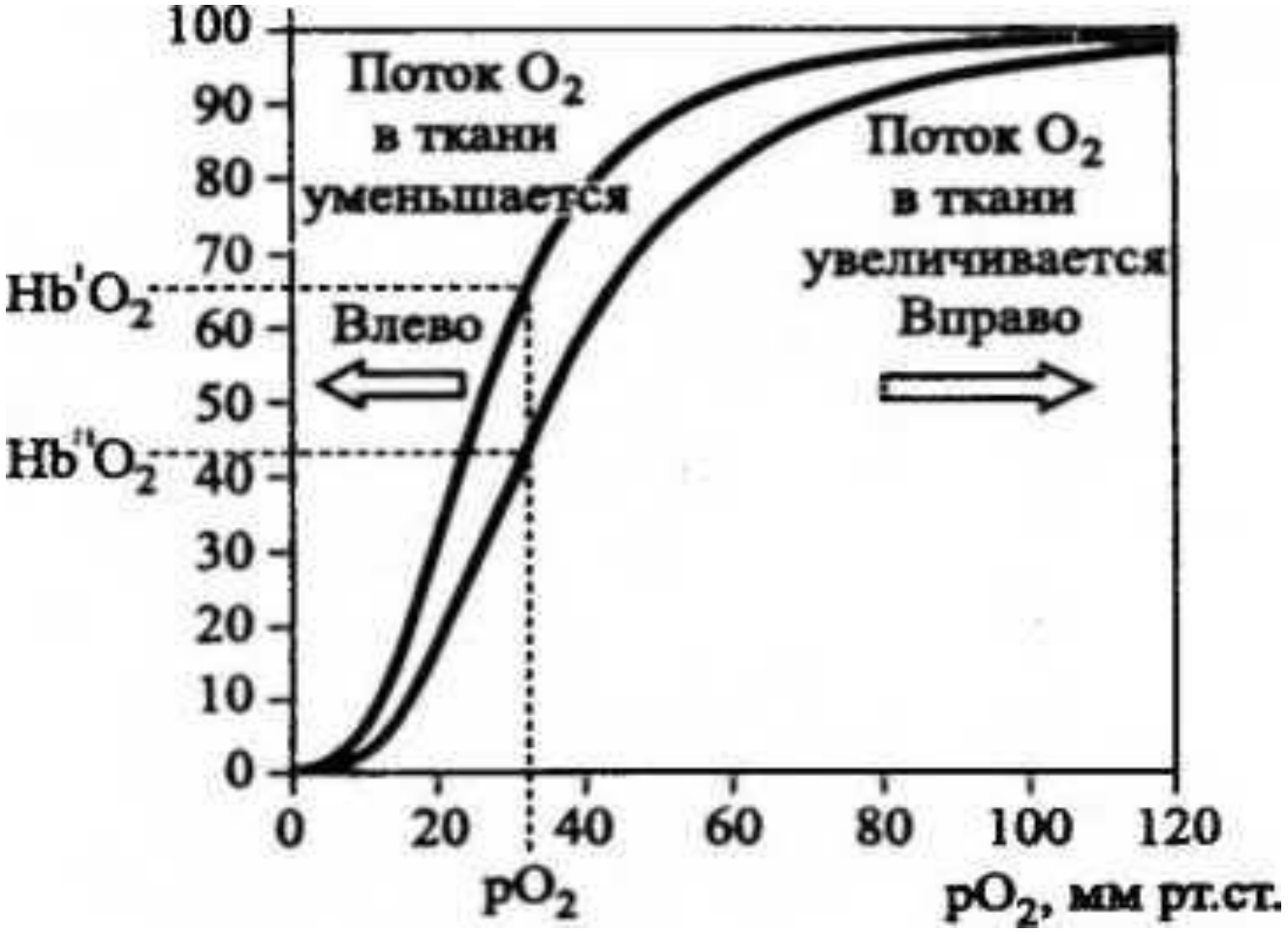
→ the increase in hemoglobin concentration →

→ increase in the oxygen capacity of the blood, (the amount of oxygen that can transport 1 liter of blood in the form of oxyhemoglobin)

Factors That Contribute to the Dissociation of Oxyhemoglobin During Physical Activity

1. Accumulation of acidic metabolic products in tissues.
2. Temperature rise.
3. Increasing the partial voltage of CO2.
4. The increase in the content of 2,3-diphosphoglycerate.

Shift of the Dissociation Curve of Oxyhemoglobin to the Right

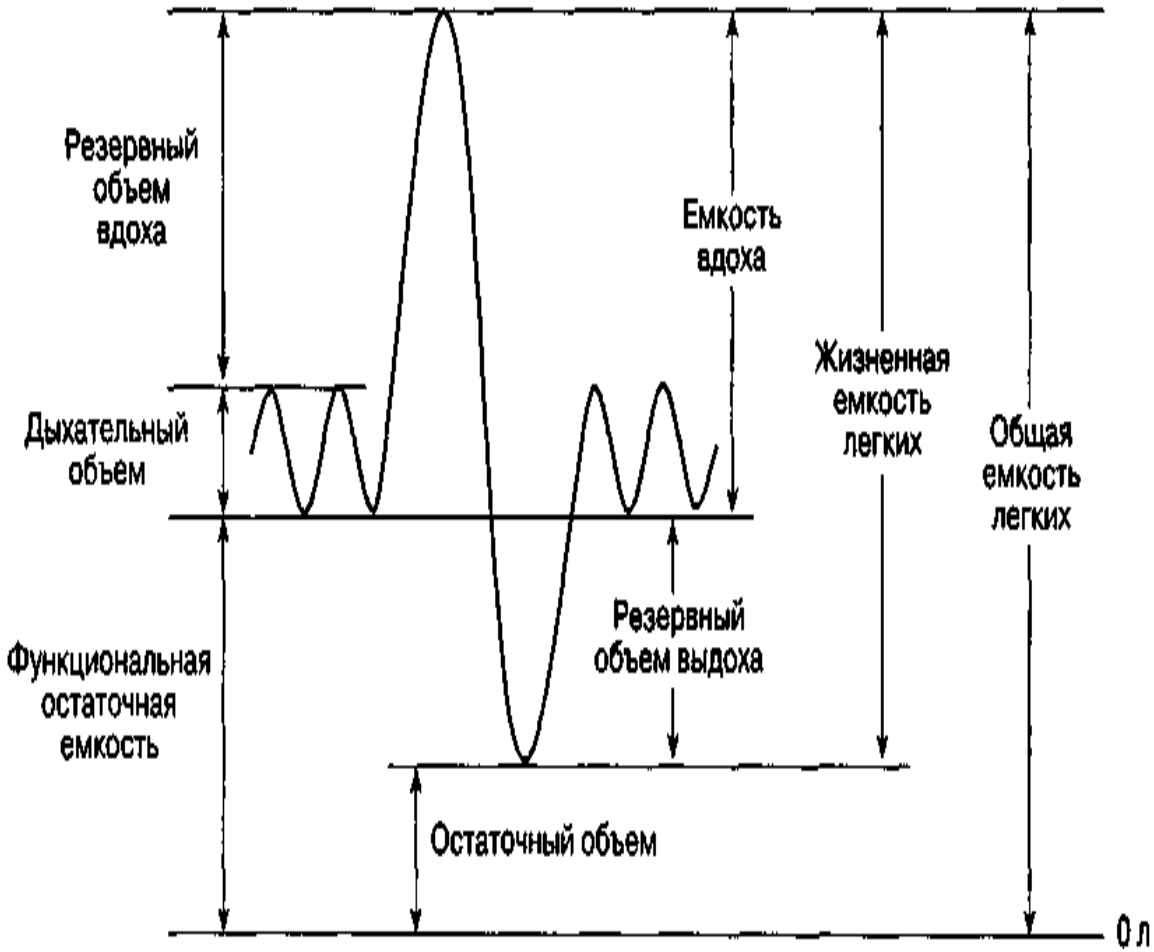


Long-term Adaptation of Skeletal Muscles

1. Increasing the number of motor units involved in the work.
2. working hypertrophy (increase in the size of muscle fibers).
3. Increase in vascularization (increase in the number of functioning capillaries and their neoplasm).
4. Increased activity of enzymes (increases the intensity of aerobic and anaerobic mechanisms).
5. Increased efficiency of metabolism (muscle tissue consumes less oxygen per unit mass).
6. Formation of conditioned reflex mechanisms (motor skills increase the efficiency of the performed activity).

Long-term Adaptation of the Respiratory Link

1. The formation of conditioned reflexes (pre condition).
2. The increase in lung diffusion capacity (increased number of capillaries, reducing the thickness aerogematic barrier).
3. Increased indicators of external respiration (hypertrophy of the respiratory muscles).



Long-term Adaptation of the Circulatory Link

- Triad of fitness (at rest):

- bradycardia (increased Central tone of the vagus nerve),

- hypotension,

- myocardial hypertrophy.

- Increasing the strength and frequency of heart contractions before starting work due to conditioned reflex reactions.

Long-term Adaptation of the Red Blood Cell Link

1. Increased production of erythropoietin.
2. Increased erythropoiesis.
3. Occurrence of true (absolute) erythrocytosis.

Training

This is an Increased physical performance of the body acquired as a result of systematic exercise.

Performance is the ability to perform work effectively for the maximum possible time.

Features of a Trained Body

1. A trained person can perform more intensive load.
2. The person performs the standard load for a longer time.
3. Physiological systems of the body function more economically in a state of rest.
4. Deviations in the work of physiological systems are more pronounced at maximum load.
5. Recovery of the body's systems occurs faster after exercise.

Methods for Evaluating Physical Performance

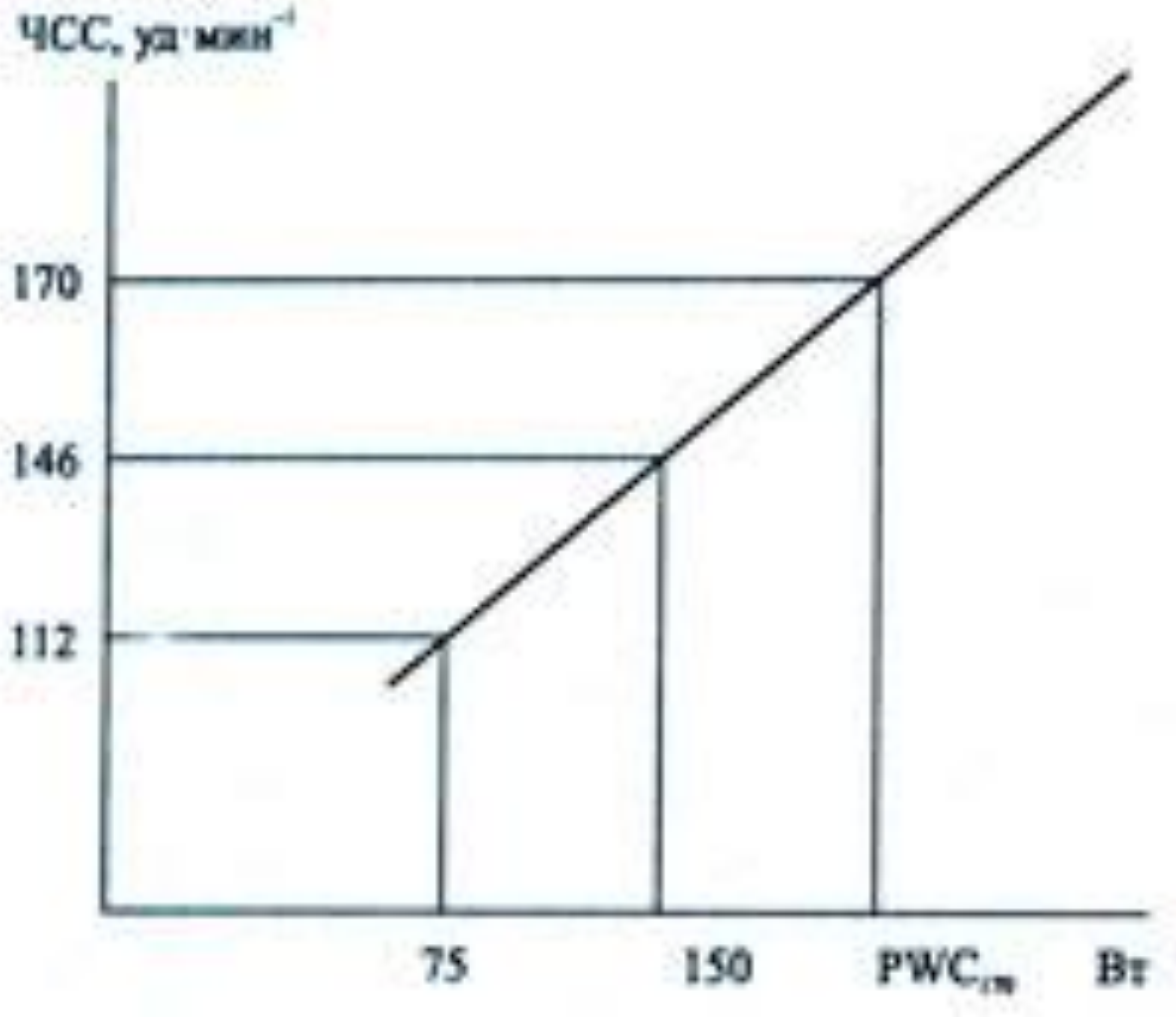
- Anthropometry
- Assessment of the state of physiological systems
- Dynamometry
- Stress test

Test PWC 170 (Physical Working Capacity)

- This is a functional test based on determining the power of muscle work at a heart rate of 170 per minute.
- Metered physical activity is modeled using a Bicycle Ergometer (two loads with a 5-minute break).
- The power of the 1st load is 1 W/kg of body weight.
- The power of the 2nd load is 2 W/kg of body weight.
- Physical performance is calculated by taking into account the power of load 1 and 2 and the heart rate at the end of load 1 and 2.

Test PWC 170

Test PWC 170



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Test Link