Ministry of Healthcare **of** *Ukraine*
O. O. Bogomolets National Medical University

department of hygiene and ecology №2

METHODICAL INSTRUCTIONS

for individual work of students
during preparing for practical lesson in the discipline "Occupational safety in the health"
on the topic:

HYGIENE AND PHYSIOLOGY OF LABOR, IMPORTANCE FOR THE CREATING OF SAFE WORKING CONDITIONS

Kiev - 2020

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Discussed and approved by the Academic Council of the Faculty of Medicine No. 4 dated January 11, 18, protocol No. 5

Theme actuality.

The beginning of the 21st century is characterized by a new technological revolution on the basis of computer technology. The application of new technologies, types of energy is accompanied by a significant informational and emotional information load on the body and an increase in its negative impact on the health of workers. Problems of improving working conditions, ensuring high productivity and maintaining the health of the working population became increased due to the change in the socio-economic structure of society, the transition to a market economy and the appearance of different forms enterprises ownership.

Hospital work can be surprisingly hazardous—more hazardous than even manufacturing or construction. According to the Bureau of Labor Statistics, each year more full-time employee days are lost in healthcare than in industries such as mining, machinery manufacturing, and construction, and the incidence rate (the likelihood of getting hurt) in hospitals is also higher. Significant deterioration of the working population health indicators due not only to the deterioration of the working environment, but also to the impact on the body of significant information, neuro-emotional (psycho-emotional) loads in combination with factors of social stress, which leads to the development of occupational stress, chronic fatigue syndrome, occupational diseases, increased mortality, including sudden death at the workplace, accidents.

Therefore, is of great importance in the practical activity of various doctors specialties play role scientific substantiation and ensuring the application of a complex of measures aimed at the preservation and improvement of efficiency, prevention of diseases. Among these measures prominence is taken by measures to prevent the development of fatigue, the development of rational regimes of work and rest on the basis of determining the functional state of the of health care workers. Knowledge about methods of physiological research in occupational conditions and criteria of research results evaluation, knowledge about normative documentation is necessary to solve these problems.

Improving the students training quality on theoretical issues of occupational physiology, the development of practical measures and their implementation in practice will contribute to a skilled solution of the practical problems of maintaining health and improving the capacity of the of health care workers.

2. Specific objectives:

Interpret the concept of the physiology of labor as an integral part of the medical and preventive discipline and theoretical science.

Classify forms of labor depending on the degree of muscular activity, the burden on the central nervous system (CNS), from the worker relation to the subject of work.

Analyze the dynamics of human performance and the causes of its change during the working day.

Interpret the physiological essence of fatigue, existing theories and the modern understanding of the mechanism of its origin.

Demonstrate the possibilities of using of physiological assessment methods to evaluate of occupational factors impact on the health of workers.

Propose the ways to prevent the fatigue development, evaluate the rationality of work and rest.

Propose measures for increasing the efficiency and prevention of occupational diseases.

3. Basic knowledge, skills needed to study the topic (Interdisciplinary integration)

Title of discipline	Skills learned
Human anatomy	Know the human organs structure and functions physiology. Determine human anthropometric indices and analyze their role in work activity
Normal physiology	Determine the functional state of organs and physiological systems of the organism on the basis of physiological criteria, to identify the features of its changes in the process of work activity
Biological chemistry	Interpret the significance of biochemical processes of metabolism and its regulation in ensuring the functioning of the organism in the dynamics of the working day and during the rest period in the process of work activity
Biological physics	Explain the general physical laws that underlie human life and activity
Medical biology	Explain the regularities of human activity manifestations at the molecular biological and cellular level

4. Tasks for independent work during preparing to the lesson

4.1. List of main terms, parameters, characteristics, which should study the student:

Terms	Definition
Occupational	An integral part of occupational hygiene and the section

physiology	of general physiology that studies the laws of the human body functional state changes under the influence of various types of work and production environment, substantiates the scientific basis of the organization and physiological regulation of the work process factors e and develops measures aimed preventing fatigue, maintaining a high level of efficiency and the health of workers
Work: - as social category - as biological category	This process, in which a person mediates his conscious activity, regulates the metabolism between themselves and nature, creates an added value; This is an important function of the organism, which is characterized by a certain physiological value.
Mental work	The type of work in the field of material and non-material production, in which the central nervous system is dominated, analyzers, mental processes (attention, memory), is the perception and processing of information, the implementation of the adopted decisions and which is performed by a pre-designed algorithm
Intellectual (creative) work	The type of work in the field of intangible production, which is related to the perception and processing of a significant amount of information, the attention and memory stress, creative thinking and involves the creation of new algorithms.
Efficiency	The state of human, in which a set of physical, mental and emotional capabilities allows the worker to perform the work of a certain content, volume and quality
Fatigue	Functional state of human organism caused by intense or prolonged work and characterized by a temporary decrease in the quantity and quality of work and the deterioration of coordination of work functions
Dynamic stereotype (I.P.Pavlov doctrine)	A stable system of conditioned reflexes, which is formed as a result of multiple repetition of conditioned stimuli in a definite sequence and at definite intervals of time, and ensures automatic operation without function of attention
Regime of work and rest	Alternate periods of work and breaks (rest) in different periods of time (working shift, day, week, month, year)
Rational regime of work and rest	The alternation of periods of work and regulated breaks, which is established on the basis of the dynamics of efficiency analysis and involves the reduction of the phase of entry into work, the extension of the phase of stable working capacity, the removal of the phase of reducing the capacity for work due to the development of fatigue and provides increased productivity and health
Attention	The property of mental activity, human

	consciousness, is aimed at the selective perception of certain objects and phenomena.
Memory	The property of the human psyche to memorize, preserve and reproduce in the minds of the phenomena, actions, objects, emotions that have taken place in the past
Emotions in the work process conditions	Mental processes associated with human assessment of the work environment. In the work activity emotions are expressed by the joy of work, the feeling of mutual help, confidence, etc.
Occupational diseases	Diseases in which the decisive role belongs to the influence of unfavorable factors of the industrial environment and the work process
Incidence due to the work	The incidence (standardized by age) for general diseases of a variety of etiologies (predominantly polyethiologic), which has a tendency to increase with an increase in work experience in adverse working conditions and exceeds that in professional groups that do not come into contact with harmful factors

4.2. Theoretical questions to the lesson:

1. Occupational physiology - definition, purpose, tasks, methods of research.
2. Basic physiological signs of physical and mental work. Classifications
3. Physiological changes occurring in organs and systems of the human body during physical work performing.
4. Physiological changes occurring in organs and systems of the human body in the performance of mental work.
5. Phases of the functional state of the central nervous system during work.
6. The human efficiency, dynamics and causes for its change during the working day.
7. Physiological essence of fatigue, existing theories and modern understanding of the mechanism of its origin.
8. Processes occurring in the human body in the recovery period (after the end of work).
9. Methods of physiological research in the work conditions.
10. Ways to prevent the development of fatigue. Methodology for the development of work and recreation rational regimes.
11. System of measures aimed the preservation and improvement of efficiency, prevention of diseases in the performance of physical and mental work.

4.3. Practical work (tasks) that are performed at the lesson:

Solve situational tasks:

Task 1

The surgeon's average energy consumption during the working day was 270 J / s. During evaluation of the doctor functional state it is established: the average heart rate per shift is 85 per 1 minute; the muscular endurance at the end of the working shift decreased by 25%, the operational memory capacity - by 20%, latency of the simple and complex visual motor response increased by 25% and 35% respectively, while the time of concentration of attention - by 30%.

Task:

Give an estimation of the doctor physiological functions load using the scale of the DU "Institute for Occupational Medicine of the Academy of Medical Sciences of Ukraine".

Task 2

The duration of the working day of the dentist is 6 hours, the density of loading of working time by work - 90%. Average heart rate (fatigue) during work - 95 beats / min, while resting - 75 per 1 minute. Maximum allowable value of an average HR is 100 beats / min (corresponding to work of moderate severity).

Task:

Calculate the regulated breaks for rest required total time to design a rational mode of work and rest in this type of work.

Content of the theme:

Physiology of labor - definition, purpose, tasks, methods of research

Physiology of work (WP) - part of the occupational health and general physiology section that studies patterns of changes in the human body functional state under the influence of work and working environment, substantiates the scientific basis of working process factors physiological regulation and scientific organization of work process to support high performance and maintaining health.

Object of the study of WP - organization of work process and workplace; physiological changes in the organism of workers in conditions of work and rest; workers health.

The purpose of WP - improving the efficiency and productivity of workers; preservation and strengthening of workers health; the prevention of occupational diseases associated with physical overload and over-strain of individual organs and systems and the influence of the production environment factors, the increasing of work longevity;

Tasks of WP:

a) Development of theoretical foundations of work physiology: the study of physiological mechanisms of fatigue, dynamics of efficiency, development of compensatory-restorative processes; evaluation of the work process factors of; studying the regularities of changes in the physiological state of a person in conditions of work activity; the scientific substantiation of the requirements for the physiological organization of work processes, work movements, the workplace, rational regimes of work and rest, optimal conditions of work of the "man-machine" system taking into account the personal anthropometric and psycho physiological parameters, methods and criteria for assessing the difficulty and intensity of work, professional selection methods and criteria, psycho physiological bases of vocational guidance.

b) Development of practical tasks: carrying out an assessment of the difficulty and intensity of work; physiological-ergonomic evaluation of the "man-machine" system; development of rational regimes of work and rest; the development of a system of physiological and hygienic measures for the prevention of physical and emotional loads, including at the stage of designing and applying new technologies and equipment.

Work is a prerequisite for human existence and is considered as a social and biological category.

Work as **social category** - the process, in which a person mediates his conscious activity, regulates the metabolism between themselves and nature, creates an added value.

Work as **biological category** - this is an important function of the organism, which is characterized by a certain physiological value.

Research methods

Due to the fact that one of the central tasks of the physiology of labor is the study of physiological processes in the body of a person who works, an important place is occupied by physiological and biochemical methods of studying the functions of the central nervous system, analyzers, cardiovascular, respiratory and muscular systems, blood systems, etc. Methods of determining the effectiveness of work, time characteristics of work processes, work movements and poses are also widely used.

A number of issues relating to individual aspects of work, in the physiology of work is solved on laboratory models that simulate work processes or its separate elements. These are, for example, models of working furniture, control panels, simulators, etc.

The main physiological signs of physical and mental work. Classifications

Distinguish physical and mental work. The physical and mental work differentiation is conditional, because any activity can`t take place without the participation of the higher regions of the central nervous system, and mental activity - without the participation of the muscular system. Physical work depending on the nature of the muscles activity is divided into **dynami**c and **static**.

Dynamic physical work is associated with the movement of the body and its parts in space, the implementation of work movements. At the same time there is a change in the length of muscle fibers, periodic contraction and relaxation of skeletal muscles. In the performance of dynamic work there is an increase in heart rate, blood pressure, shock and minute volume of blood, oxygen consumption, energy consumption, changes in vascular resistance.

Dynamic work is positive when the movement is carried out in the direction opposite to the action of gravity (lifting the load). Dynamic work is negative, when the movement is carried out in the direction of the action of gravity (lowering the load).

The power of external work is determined by the formula:

$$N = \frac{A}{T}$$

The work is calculated by the formula: $A = (PH + \frac{PH_1}{2} + \frac{PL}{9}) \times 6 \times K$,

Where N - power of external work, W;

A - work, J;

T - time of execution of this work, c;

P - weight of cargo, kg;

H - height of lifting of cargo, m;

H1 - height of lowering of cargo, m;

L - distance of cargo moving horizontally, m;

6 - coefficient of conversion of useful mechanical work into external mechanical work;

K = 9,81 - conversion ratio of the value of the index in units of kgf • m (kilogram-force-meter) in the unit CI in joules.

Static physical work is a kind of muscular work when there is a continuous tension of the muscles without changing the length of the skeletal muscles (keeping the load, applying effort). In this case, the motor center, which regulates the activity of the corresponding muscle groups, continuously enters the flow of impulses, which quickly causes the depletion of functional potential and the development of fatigue. In addition, with static tension of the muscles there is a mechanical compression of the blood vessels, which disturbs blood circulation and reduces the functionality of the corresponding muscle groups. In static work there

is a slight increase in oxygen consumption, minute volume of blood, energy consumption, significant increase in biometric activity of the muscles.

Mechanical energy that develops muscles in all types of physical work, is formed due to the oxidation of carbohydrates, fats, proteins.

Intellectual (mental) work is a type of work in which the CNS, analyzers, mental processes loads prevails. It reflects the cognitive-rational side of the processes of human thinking, that is, the system of mental operations associated with the solution of problems that require a quick cognitive activity and actions in accordance with a given purpose. Prevailing processes of processing information, accumulation of new knowledge and the formation of conclusions, decision-making, control over the implementation of solutions.

Mental work is characterized by low energy consumption, insignificant muscular activity, complexity and variability of action programs, increased demands for attention, memory and emotional sphere. The main negative characteristics of intellectual work can be nervous-emotional stress, overstrain of analyzers and mental processes, hypodynamia.

Muscular work is characterized by indicators of "the difficulty of work," and the work of the central nervous system, analyzers, mental processes - an indicator of "intensity" of work.

Physical work

Forms of work that require significant muscular activity. These work are characterized by a direct link between the worker with the subject of work, the general physical activity, the increased requirements for the cardiovascular and respiratory systems.

Works require high energy consumption (over 21 kJ / min). In a rational mode of work, the time regulated breaks for rest should be about 50% of the operational time of the work shift. This form of physical labor is marked by low productivity, little attractive in the social plan, creates unfavorable conditions for the harmonious development of personality.

Mental work is classified according to different criteria*:*

1. *Depending on the sphere of activity of the enterprise, the institution:*
   - ✓ The form of mental labor in the field of material production - designers, engineers, craftsmen, technicians, dispatchers, operators, etc.
   - ✓ The form of mental labor in the field of non-material production - scholars, teachers, doctors, translators, writers, composers, artists, and others.
2. *By way of processing information and making a decision:*

The form of reproductive mental work - in the work used known requirements with fixed algorithms of operations and actions (counting operations,

comparisons, identification, decoding of signals, etc.) in the professions of engineers and technicians, economists, operators, controllers, etc.

The form of productive, creative (intellectual) mental work - in the activity of the prevailing creative thinking (in the perception and processing of information), the creation of new algorithms, an initiative and responsible decision of various nature of the tasks in the professions of scientists, designers, managers, engineers, writers, composers , artists, etc.

3. *According to ergometric characteristics (ergos-robot, metro-measure) - the work process indicators action terms and severity:*

Mental work, which link with nervous load - an executive type of mental work. Performed by a pre-designed algorithm with sufficient information, low density of signals and messages using known stereotyped actions. Represents high requirements for attention and memory functions.

Nervous-emotional mental work. The peculiarity of this work is a high emotional load, which is associated with great responsibility, the possibility of emergence of unexpected situations, the need to make the right decisions and their implementation in short times, insufficiency of information or its extraordinary increase, etc. Emotional components are associated with the reactions of the autonomic nervous system and manifest in the mood of man - a sense of joy, anger, irritation, sorrow, etc.

This form of labor includes the following subspecies: operational work management work, the work of students.

The work of medical workers. Characterized by the nervous-emotional load caused by increased responsibility for the health and life of patients, the need to make the right decisions under conditions of insufficient information and time deficit, communication with sick people and their families, possible negative results of treatment.

- Characterized by the need to perceive and memorize a large amount of information; reproduction of knowledge in the conditions of a time insufficiency during fieldwork and examinations, including lack of knowledge; increased individual reaction to stressful situations.
- Creative (intellectual) mental work. Type of work in the field of intangible production, which is associated with the perception and processing of a significant amount of information, in the conditions of a insufficiency of time, stress of attention and memory, creative thinking and involves the creation of new algorithms. Nervous-emotional stress is conditioned by the continuation of creative thinking outside of working time and working environment - throughout the day.

Physiological changes occurring in organs and systems of the human body when performing physical work

Exercise is accompanied by the development of functional changes in the working organs and systems: in the muscular system, as well as in systems that provide the work of the working system - cardiovascular, respiratory. In addition, changes occur in systems that regulate, coordinate the activities of all systems of the body - the central nervous system sympathoadrenal system, pituitary adrenal system.

The nature and level of functional changes depends on the type of physical activity (dynamic, static) and the level of loading (light, heavy work).

Muscular system. When performing dynamic work there is an expansion of blood vessels (working hyperemia), increased blood flow in the muscles to saturate blood with oxygen. In light work, blood flow meets the needs of the muscles, metabolism and energy is carried out aerobically using carbohydrates or fats. When performing difficult work, the speed of blood flow can be increased up to 20 times, but does not meet the needs of the muscles; therefore, the splitting of an additional amount of glycogen and the production of energy by anaerobic way, with the formation of lactic acid in the hydrolysis of adenosine triphosphate (ATP), prevails. When accumulated in the cells and blood a significant amount of lactic acid (about 5 mmol / l) develops metabolic acidosis, which contributes to the development of fatigue.

When performing static work, blood flow in the muscles becomes inadequate when the force of muscle contraction exceeds approximately 15% of the isometric maximum. Reduced blood flow is due to an increase in intramuscular pressure, which exceeds capillary pressure. Therefore, metabolism and energy production are carried out anaerobically, with the formation of lactate in the muscles. Fatigue is developing very quickly during static work.

Respiratory system. In the transition from rest to work changes in the respiratory system (RS) are due to the increased need for oxygen and the need to remove excess CO2 from the body.

The volume of pulmonary ventilation (VPV) can be increased to 100 l / min. At rest, the VPV is within 4-8 l / min. An increase in VPV or minute volume of breath occurs due to the depth and frequency of breathing. The increase in VPV predominantly due to the depth of breath, as the most favorable response to physical work, is observed in trained individuals, and due mainly to the frequency of breathing - in the absence of training, as well as in case of maintaining an awkward working position.

The degree of increase in VPV, as a rule, is directly proportional to the increase in consumption of O2 and the allocation of CO2. The vital lungs capacity

(VLC) may decrease when performing work operations that impede external respiration. When the body is tilted forward, VLC can be 88.5%, and when straightening the body - 75% of the value of this indicator in the upright position of the body.

Cardiovascular system. During physical dynamic and static work, the main indicators of adaptive changes by the cardiovascular system (CVS) are Heart Rate (HR), Stroke Volume (SV), Cardiac Output (CO), Blood Minute Volume (BMV), Heart Cycle Time, Arterial Blood Pressure.

The heart rate at rest is 60-80 in 1 min. When performing light work or work of moderate difficulty with a constant value of the load, the heart rate increases during the first 5-10 minutes; reaches a constant level (90-100 per 1 min), kept on it until the end of work and is restored within 3-5 minutes. At heavy physical activity, the heart rate is constantly increasing (as fatigue develops) to a maximum value for the appropriate level of loading and can reach 170-200 per 1 minute. The recovery period can take several hours. Between the intensity of physical work and heart rate there is almost linear dependence. The increase in heart rate at work is due to the influence of impulses from muscle receptors, which sharply stimulate the blood circulation center under conditions of anaerobic metabolism.

The Stroke (systolic) volume of the heart at rest is 60-80 ml. At the beginning, the SV increases by 20-30%, while in the process of work it can increase by 2-3 times, reaching 200 ml in the untrained person. With maximum physical activity SV may decrease a little bit, because under conditions of significant increase in heart rate, the heart does not have time to completely fill with blood.

BMV is the volume of blood that is emitted by the heart to the aorta in 1 minute. In the rest of the BMV is 3-6 liters, and with muscular work can reach 30-40 liters. BMV increases in untrained people mainly due to heart rate, and in the trained - mainly at the expense of SV. During heavy physical work in the heart, blood can flow more than pushed out into the aorta. In this case, part of the blood remains in the ventricle cavity, which leads to its dilatation and can lead to the development of left ventricular hypertrophy.

The time of a cardiac cycle in conditions of considerable physical activity can be reduced due to an increase in the duration of diastole. At heart rate 75 for 1 min the cardiac cycle is 0,1 + 0,3 + 0,4 = 0,8 s. The duration of the systole of the atria and ventricles decreases by several hundredths of a second, and the duration of diastole can decrease by 1.5-2 times. Change in the BMV only due to heart rate is unfavorable.

AT with moderate physical activity and normotonic reaction of the organism is characterized by an increase in systolic (up to 29 kPa - 200 mmHg) and

moderate (by 1.33 kPa) decrease in diastolic blood pressure. The average blood pressure is always rising. Possible hypertonic and hypotonic reactions, indicating heart failure.

Water exchange. During heavy physical work changes in water exchange (the ratio of the injected and withdrawn fluid) are due to increased sweating. The increase in sweating depends not only on the severity of labor, but also on the microclimatic conditions and may be associated with increased heat production during muscular work and (or) lack of heat output due to the heating microclimate. During heavy physical work in normal microclimatic conditions, the average rate of sweating secretion is about 1 liter per hour. Workers of heavy physical can spend during the working day at the expense of profuse perspiration of 6-10 liters of liquid. It has been established that dehydration of an organism by 10-15% and more leads to loss of ability to work.

Blood system. During work there is an increase in the number of erythrocytes and hemoglobin in the blood as a result of a decrease in plasma volume due to enhanced capillary filtration. In severe long-term work, a reduction in hemoglobin content may occur with an increase in the number of erythrocytes in connection with the receipt of immature forms from the depot.

The number of leukocytes and their forms varies depending on the severity and duration of work: lymphocytic leukocytosis - with easy and short-term work; Neutrophilic leukocytosis - at work of moderate severity, prolonged; significant (intoxication) increase in the number of leukocytes (30 · 109 in 1 liter and more) - in severe and intensive work.

The content of lactate and carbon dioxide in the blood increases with heavy work. When working lightly, carbon dioxide is removed by the lungs. At rest, the concentration of lactate in arterial blood is about 1 mmol / l, and with heavy prolonged work can reach 2-15 mmol / l. The alkaline reserves of blood are reduced at work of average weight by 10-12%, and at hard work - up to 60%.

Gas and energy exchange. In physical work, in most cases, a directly proportional relationship between the magnitude of physical activity (in terms of heart rate) and oxygen consumption is established. Consumption of oxygen at rest is 0,2-0,3 l / min, and with heavy physical work can reach 3-4 l / min.

The amount of oxygen required by the body to oxidize the low oxidized metabolic products created during the operation is defined as an ***oxygen demand***. The state of equilibrium between the production of low oxidized products and their oxidation is called a ***stable state***. Insufficient activation of breathing and circulation at the beginning of work (the period of entry into work) leads to the fact that oxygen consumption lags behind the oxygen demand. This state is defined as an ***oxygen duty***, the magnitude of which depends on the severity of the work

performed. After activating the activity of the RS and CVS, the consumption of oxygen at work of moderate intensity reaches the level necessary for performance and establishes a stable state. At the end of the work, oxygen consumption and oxygen duty are gradually decreasing.

During hard work, the oxygen demand may exceed the functionality of the RS and the body's CVS - the oxygen barrier.

During static work, oxygen consumption is lower than oxygen demand due to a decrease in blood flow due to an increase in muscle intramuscular pressure with isometric muscle contraction. At the end of the work, the consumption of oxygen sharply increases, after which a long period of recovery comes.

When performing physical dynamic work the energy consumption of an organism increases. This indicator is a criteria for determining the category of work and one of the indicators of the difficulty of work. Light work includes types of activities with an energy consumption of no more than 174 Watts (150 kcal / h), works of moderate intensity - with energy consumption of 175-290 Watts (151-250 kcal / h), heavy work - with energy consumption greater than 290 Watts (250 kcal / h).

Hormonal systems (sympathoadrenal, hypothalamic-pituitary-adrenal). In the process of adaptation of the body to physical work, the essential role play sympathoadrenal and pituitary-adrenal systems.

During physical work or just before physical activity, an increased amount of adrenaline comes into the blood, primarily from the cerebral adrenal gland. Adrenaline mobilizes glycogen and fat from the depot, activates cardiac activity.
1-2 minutes after the beginning of physical work, an increase in the secretion of the pituitary gland of the ACTH, which stimulates the release of corticosteroids from the cortical substance of the adrenal gland, is increasing. Corticosteroids contribute to the enhancement of glycogen mobilization.

Physiological changes occurring in organs and systems of the human body in the performance of mental work

Physiological changes in mental work are not fundamentally different from changes in physical work.

The main feature of mental work lies in the fact that the brain is a working organ, and not only regulatory. A slight increase in energy metabolism is due to the increase in muscle tonus, and not due to the activation of the CNS centers. In mental work, the source of energy necessary for the resynthesis of macroenergy compounds in the nerve tissue is the process of oxidation of glucose in contrast to muscular work, when the main supplier of energy is glycogen.

Performance of mental work that requires nervous load. Nervous load is determined by the degree of activation of certain nerve structures. At the heart of the process of activation is an increase in the level of energy metabolism, impulsive activity, the forces of the excitatory process. Nervous tension is caused by intellectual and sensory loading, perception and processing of information, monotony of sensory and monotony of actions, the regime of work, etc.

In the CNS there is a change in the ratio of processes of excitation and inhibition. The bioelectric activity in the local areas of the brain that corresponds to a specific professional activity increases: during operations involving thinking, in the frontal, parietal areas; with visual loads - in the occipital area.

The condition of conditioned reflex activity (sensorimotor reactions), mental functions (attention, memory, speed of information processing) at the beginning of work is intensified. Long and hard work causes a decrease in the quantitative and qualitative indicators of these functions.

Mental labor, which requires nervous tension and is characterized by negligible muscular stress, is characterized by a lower level of energy metabolism (at 25% kJ / day).

Along with this in the brain, energy metabolism is very intense and requires 20-25% of oxygen consumed by the body alone.

The optimal daily physical activity is an average of 3630-17800 steps, taking into account age, sex, health and physical training. The mechanism of functional changes in hypodynamia and hypokinesia is to reduce the flow of afferent proprioceptive impulses in the central nervous system, which leads to a violation of regulation and adverse changes in many physiological systems. Increases the tone of the sympathetic nervous system. In CVS there is a decrease in pericardial and systolic blood volume, an increase in the peripheral vascular resistance due to the narrowing of the vessels of the muscles that do not work, the blood flow in the skin increases with a decrease in electrical resistance. The excretion of adrenaline in the urine is increasing. Sweating increases.

Changes in the respiratory system are characterized by breathing irregularity (acceleration, deceleration, detention, and deepening).

In general, there is a decrease in the overall tone of the human organism, metabolic disorders, increased sensitivity to the effects of emotionogenic factors.

Performance of neuro-emotional mental work. Nervous-emotional stress is accompanied by an increase in the activity of the sympatho-adrenal and hypothalamic-pituitary-adrenal system. Secretion of catecholamines and glucocorticoids increases, excretion of urine from 17-oxyketosteroids increases. Increasing the secretion of catecholamines may persist until the next day. Catecholamines in small concentrations contribute to the restoration of muscular

performance, the improvement of blood supply to the brain and heart, stimulate the activity of the central nervous system, CVS. Therefore, insignificant and short-term positive emotional stresses have a beneficial effect on the body, improves functionality, improves capacity for work.

At a significant nervous-emotional load, the tone of the sympathetic nervous system increases, which causes a significant increase in heart rate, blood pressure. The influence of a large number of catecholamines results in an increase in the need for cardiac muscle in oxygen, the expansion of coronary vessels, oxygen starvation, and the deterioration of metabolic processes. Changes in the blood system are characterized by eosinopenia, an increase in glucose, inorganic phosphate, cholesterol, creatinine, lowering of alkaline blood reserves. These changes in nervous-emotional stress contribute to the development of hypertonic disease, atherosclerosis, myocardial infarction.

Human efficiency, dynamics and causes of its change during the working day

Modern concepts of performance are based on the P.K. Anokhin theory of functional systems. According to this theory, work can be considered as a task that faces all physiological systems and, accordingly, all functional units of the organism. In the process of work, the main working functional system and the restorative functional system are formed. Different their ratios predetermine different levels of efficiency and phase in dynamics of efficiency. Individual differences in the level of ability to work depend on physical and mental development, health, age, gender, level of functional state of all systems of the organism.

Distinguish non-specific (general) and specific (professional) human performance.

To assess the efficiency of using two groups of indicators:

- ✓ Production - the quantity of manufactured products, the time of work operation, the number of working movements per unit time, the duration of micro pauses, the presence of shortages in work, etc.;
- ✓ Physiological, psychological - indicators of the functional state of the central nervous, endocrine, cardiovascular, respiratory, muscular systems, blood system, mental functions, etc.

Physiological and psychological indicators of efficiency are the most adequate ones.

Change of working capacity during the working day takes place in 3 stages:

The first stage is entry into work. It lies in the transition of the functional systems of the organism to the working condition and gradual increase of efficiency. The transition of the organism to the working condition is accompanied

by the establishment of coordination links between the nerve centers and the working organs of the main functional system, the gradual achievement of the working level of vegetative and somatic functions (respiratory, cardiovascular, muscular and other systems) and ensuring the supply of sufficient quantities of oxygen to working organs.

In the mechanism of physiological changes at the stage of entry into the work a significant role belongs to the system of conditioned reflexes, which are formed on the stimuli of the production environment (verbal, sensory), fixed in the form of dynamic working stereotype. The external manifestation of the stage of entry into work is the gradual increase in production indicators, the activation of psycho physiological indicators of efficiency. Its duration is from several minutes to 1.5 hours or more.

The second stage is stable performance. Characterized by a high stable level of physiological functions. Their intensity may be lower compared to the entry into work. This is supported by the preservation of a dynamic working stereotype and the formation of dominant in the central nervous system. Stage of sustainable working can last 2-2,5 hours or more depending on the difficulty and intensity of work.

The third stage - reduction of working capacity, development of fatigue. As a result of the development of fatigue, the functional capacity of the main working structures of the body decreases and performance begins to decrease. Reduced performance is manifested by a decrease in the speed of sensorimotor reactions, attention, the appearance of excessive movements and false actions, deterioration of the functional state of the cardiovascular system. There is a subjective feeling of tiredness.

Working capacity during a lunch break can be completely or in part restored. In the second part of the working day (changes) of the stage of workability are repeated. But in the second half of the working day, the level of efficiency can be lower, and the time of development of fatigue earlier.

The efficiency of a person to a certain extent depends on the natural (biological) rhythms of psycho-physiological functions - daily (circadian), weekly, monthly, and yearly. So, the circadian rhythm causes two periods of high level of physiological functions - from 8 to 12 and from 16 to 18 hours. Most people show better working capacity in the morning (morning type, "lark"), while a certain number of people is characterized by high working hours in the evening and at night (evening type, "owls").

During the working week, higher levels of performance are observed on the second and third day (Tuesday, Wednesday).

Physiological essence of fatigue, existing theories and modern understanding of the mechanism of its occurrence

The problem of fatigue is one of the most difficult in physiology and work psychology. Its solution has not only theoretical but also socio-economic significance.

Fatigue is a functional state caused by the intensity or duration of the process and characterized by a temporary decrease in efficiency, which is expressed by a decrease in the work quantity and quality and the working movements and coordination deterioration.

Solving the problem of fatigue covers three cardinal issues:

* Finding out the causes and mechanism of fatigue development;
* Diagnostics of fatigue, fatigue and assessment of work capacity;
* Development of measures of overloading and overwork prevention.

The study of the mechanism of development of fatigue led to the development of several theories.

The humoral-localistic theory was advanced by Pfluger, Lingard, Weichard. According to this theory, fatigue was seen as a process that occurs locally in a working organ - a muscle. The cause of fatigue was the poisoning of muscle tissue with metabolic products, primarily lactic acid.

Central-nervous theory of fatigue was developed by I.M. Sechenov and his disciples. According to this theory, in the mechanism of fatigue, the main role belongs not to the peripheral, but to the central processes.

The modern theory of fatigue is a central cortical theory, which is substantiated on the basis of M.E. Vvedensky, OO Ukhtomsky, MI Vinogradova, V.V. Rosenblata, O.O. Navakatikyan researches. It lies in the fact that the primary link of fatigue development are cortical centers. Development in the cortical centers of the braking process contributes to the stimulation of regenerative processes.

Modern researches show that during the simultaneous mental and physical tasks realization the area of the brain prefrontal cortex (PFC) is activated, that leads to the development of fatigue.

Braking is a consequence and one of manifestations of fatigue. The concept of fatigue and inhibition aren`t the same. The braking process contributes to the intensification of recovery processes. Yu.V. Folbort noted that in the body that works, the recovery process begins already in the process of work, and then goes on during the rest period.

In the work of large muscle groups, intense force loads, when the oxygen demand exceeds the actual consumption of oxygen, and muscle work is carried out in anaerobic conditions with the accumulation of a large number of low oxidized

products (lactic acid), fatigue develops due to powerful impulses from Proprio-chemoreceptors of muscles and chemo-receptors of blood vessels.

In dynamic work, when periods of excitation of certain nerve centers alternate with periods of their inhibition, fatigue develops more slowly.

In work with moderate intensity, low oxidized products don`t accumulate. There is a long excitation of the cortical centers, which regulate the work of the muscles and vegetative functions. Occurs hypoglycemia and thermoregulation process alteration.

On the basis of the study of the peculiarities of the development of fatigue in various conditions of work activity MI Vinogradov has 2 types of fatigue.

Primary fatigue (fatigue with rapid development). It occurs in conditions of maximum intensive work of muscles, when with a slight fall of functional potential an over-threshold inhibitory process in the cortical centers develops. At the same time, the recovery of efficiency comes quickly.

Secondary fatigue (fatigue with slow development). Comes with a little intense but prolonged work, when there is an exhaustion of functional potential, falling lability and the development of protective inhibition. In this case, the efficiency is restored after a long period of rest.

Thus, the **physiological essence** of fatigue is the reducing of the nervous system lability in connection with the consumption of energy resources and the development of the braking process, which results in a disturbing working dynamic stereotype and coordination of work functions.

The **biological nature** of fatigue is a normal physiological reaction that plays a protective role, saves individual physiological systems and organs from overloads.

There are the following signs of fatigue:

* Technical and economic;
* Physiological;
* Psychological;
* Medical.

Technical and economic signs of fatigue are manifested in a temporary decline in efficiency, usually expressed in a decrease in the quality of products, a decrease in work productivity - a decrease in output, an extension of the "piece" time, etc.

Physiological signs of this phenomenon include unnecessary movement, reduced endurance, tremors in the fingers, increased time of the motor reaction, increased sweating, and temperature of the scalp and hands. In severe muscular load fatigue usually leads to a sharp increase in respiration and pulse, increase blood pressure.

Psychological signs of fatigue are a subjective feeling of fatigue, a slowing of mental processes and the performance of erroneous actions, expressed in the growth of traumatism.

Medical indicators of fatigue are production-related diseases, occupational diseases, injuries.

To restore the human functional state to the beginning of the next work period, you need an effective long rest. When the rest is insufficient, the working load of the physiological functions increases. With the continuation of work there is a cumulative fatigue and the appearance of signs of chronic fatigue. Further work in conditions of insufficient rest is accompanied by the development of overstrain of the worker physiological functions.

Overexposure determines the border between the norm and pathology of the organism functional state. Further prolongation of activity without sufficient rest and active preventive measures leads to the development of fatigue. Fatigue is a pathological condition, which is accompanied by a sharp drop in labor productivity and requires medical and rehabilitation measures.

Physical overloads caused by forced working posture can cause a change in the normal configuration of the spine, and muscle tone, deformation of the arch of the foot, promote the development of osteochondrosis, overexertion in the circulatory system, and may lead to the development of occupational diseases.

Nervous-emotional overload can lead to the development of general somatic pathology (vegetative-vascular dystonia, hypertonic disease, ischemic heart disease, mental illness, sudden death at the workplace, etc.), as well as occupational diseases (neuroses).

Psycho-emotional load leads to the formation of the phenomenon of "Burnout syndrome ", which is described by scientists in the United States, Japan, Finland. In the United States, stress-related diseases are recognized as a professional pathology.

Processes occurring in the human body in the recovery period (after the end of work)

After the work, all physiological functions are gradually returned to the initial level.

The duration of the recovery period depends on the difficulty and duration of the non-reducing physical or emotional stress during the work and on the conditions in which it took place, the training and the initial state of the worker. Thus, in conditions of high air temperature, intense noise, the exposition of toxic

substances, the restoration of all functions is slowed down. In untrained workers, the recovery process takes longer than that of the trained.

After easy work, the recovery is fast enough and finishes, as a rule, within 30-40 minutes. During the work of moderate weight, the recovery period is delayed to several hours. And finally, after prolonged difficult work, restoration of the functions of the organism may not end before the next working shift. First of all, the Heart Rate and the respiration frequency, then the Stroke Volume and the depth of breathing, along with the volume of blood per minute, blood pressure , the concentration of O2 and CO2 in the blood are returned to the baseline level, eliminates the oxygen duty. Later, the functional state of the central nervous system, changes in the muscular system, blood morphology, alkaline reserves, water metabolism, and the content of catecholamine are restored.

Methods of physiological research in the conditions of work

Physiological research in the conditions of work is carried out with the aim of assessing the functional state of the organism, diagnosis of fatigue and determining the degree of fatigue development, assessment of workers' capacity, etc.

The list of methods necessarily include methods for studying the state of the central nervous system, analyzers, autonomic functions, and mental functions.
Depending on the purpose of the study, a minimum set of adequate methods for determining the state of 3-4 physiological systems that provide objective results is used.

Methods of studying the functional state:

- central nervous system: reflexometry - latent period of simple sensory-motor reaction to light and sound stimuli, latent period of complex (differentiated) sensorimotor reaction; Critical frequency of fusion of light shimmers (CCCHM);
- mental functions: short-term and long-term memory for numbers and geometric shapes, concentration and stability of attention, speed of information processing, throughput of the visual analyzer (Anfimov's tables, table with Landolt rings), volume, distribution and switching of attention (black and Red tables, table Schultz-Platonov);
- analyzers: sound, vestibular, skin, visual (auditory, vibration and pain sensitivity, visual acuity);
- muscular system: dynamometry - maximum muscular strength and endurance to the static strength of the muscles of the hands, strength of the muscles of the body (strength of the staff); tremometry - coordination of movements, tremor of muscles of hands;
- cardiovascular system: heart rate, arterial pressure, electrocardiography;

- respiratory system: spirometry - respiration rate, minute volume of breath, respiratory volume, lung, pulmonary ventilation by the Douglas method or other methods, energy consumption by determining gas exchange, oxygen consumption.

Estimation of the intensity of physiological functions during physical work On the scale of the DU "Institute for occupational health of the National Academy of Medical Sciences of Ukraine"

Load degree of physiological functions	Average energetical losses, J / s	Average heart rate per minute, per shift	Changing functions after the end of the working day (changes),%.				
			reduction		augmentation		
			Muscular endurance	The amount of operative memory	Latent period of simple visual-motor reaction	Latent period of complex visual-motor reaction	The time of differentiation (concentration of attention)
I	before 174	before 80	before 10	before 5	no augmentation	before 5	before 5
II	175-290	81-95	11-30	6-25	1-25	6-30	6-25
III	291-406	96-110	31-50	26-50	26-50	31-60	26-50
IV	407 i >	111 i >	51 i >	51 i >	51 i >	61 i >	51 i >

According to the degree of intensity of physiological functions, determine the category of severity and intensity of labor:

I degree - little hard, little stressed;

II degree - moderately heavy, moderately tense;

III degree - heavy, intense;
IV degree - very heavy, very tense.

Ways to prevent the development of fatigue. Methodology for the development of rational regimes of work and recreation

Prevention of the development of fatigue in the process of work is based on the determination of fatigue as a normal physiological state and involves solving the following tasks:
- slowing down development of fatigue, prevention of overload and fatigue;
- acceleration of renovation of physiological functions.

The main ways of solving these problems are:
A) the development and implementation of rational regimes of work and rest - intrinsic, daily, weekly, monthly, annual;
B) rational organization of rest during working hours and out of working hours.

Rational internally-changing mode of work and rest is a definite alternation of periods of work and regulated breaks, which is established on the basis of the analysis of the dynamics of efficiency and involves the reduction of the phase of entry into work, the extension of the phase of stable working capacity, the removal of the phase of reduction of efficiency due to the development of fatigue and provides for increased productivity and maintaining health.

Thus, the main task of rationalizing the internally-variable mode of work and rest is to reduce the phase of entry into work, increase the phase of stable working capacity, reduce the phase of development of fatigue.

During working hours include regulated breaks of scientifically substantiated duration, breaks for personal (natural) needs of a duration of 10-15 minutes per shift, micropause. The amount and duration of micropause (from several seconds to 1-2 minutes) depends on the "free" or "imposed" (conveyor production) mode of operation and indicates the development of fatigue (in the "imposed" mode - a decrease in the duration of micropause, and in the "free" mode - an increase in their number and duration). The time of lunch break during working hours is not included.

The assessment of the efficiency of the regime of work and rest is carried out according to the following criteria:
1. Performance criteria for physiological and production indicators:

A) Duration of the phases of workability. In a rational mode of work and rest and favorable working conditions, the phase of stable working capacity should be not less than 75% of the working hours of the first half and 65% of the second half of the working change; The phase of entry into work - no more than 40 minutes at the beginning of the change and no more than 50% of this time after a lunch break (depending on the complexity of work).
B) Stability of physiological functions during the working change, the indicator of which is a statistical indicator - the coefficient of variation. Its growth indicates an increase in the intensity of the physiological function and an insufficiently effective mode of work and rest. When the coefficient of variation is less than 10, the variability is small, 10 - 20 - average, more than 20 - high.
C) Time to restore functional indicators after the end of work and return them to the original level. If the recovery period is no more than 10 - 15 minutes - the degree of fatigue is low; 16 - 30 minutes - average, restoration does not end before the next working day - high degree, cumulative fatigue.
2. Medical criteria: morbidity with temporary disability; occupational diseases; occupational injuries.
3. Sociological criteria:

* number of employees, satisfied and dissatisfied with the regime of work and rest;
* the number of workers who complain of rapid development of fatigue;
* the number of workers with signs of overwork (complaints of sleep disorder, headache, loss of interest in work, etc.).

4. Economic indicators: work productivity; quantity and quality of products (reduction of the deficit, etc.); use of working time (time costs per unit of product or operation, simple, emergency situations, etc.).

The development of rational working and rest regimes includes the following steps:

* assessment of the existing working and rest regimes according to the above criteria;
* designing an experimental mode of work and rest;
* testing of the experimental mode of work and rest for at least 3 months and assessing its effectiveness on the basis of performance criteria and socio-economic criteria;
* introduction into practice of a rational mode of work and rest as a model for a particular profession.

Timing observations are used to obtain the initial data on the labor process: a photograph of the working day; Detailed selective timing of individual operations.

Based on the results obtained, the indicators are calculated: the density of the working day, the actual time of regulated rest, the time of micropause, the productivity of labor per unit time, the average duration of work operations, the number of defects and mistakes, etc.

Required total time regulated breaks for rest are calculated by the formula:

$$RT/OP = (\frac{ФПр - ФПв}{ГДВзм - ФПв} - 1) \cdot 100, \text{ де:}$$

RT/OP – The ratio of rest time to operational time (the duration of all working operations per shift, excluding the rest time), %;

ФПр – Working physiological index (weighted mean of physiological index during work);

ФПв – Physiological index during rest (take for HR-70 for 1 minute, for blood volume per minute - 6 l, for energy consumption - 4.18 kJ min /);

ГДВзм – The maximum allowable value of the average variable (for heart rate - 100 per 1 minute, corresponds to the work of moderate severity).

The duration of work and rest periods depends on the severity and intensity of work, the conditions of the work environment, the possibility of restoring functions and maintaining a dynamic working stereotype.

Rationalization of daily, weekly, monthly, yearly modes of work and rest is carried out taking into account the natural (biological) rhythms of psychophysiological functions: increasing physiological parameters in daylight hours and reducing their levels at night; Increase of physiological parameters on the 2nd and 3rd day of a working week and their lower levels at 1, 4, 5, 6 day of the week.

Organization of breaks for rest may include active rest, the introduction of industrial gymnastics, self-massage, hydromassage of the hands (feet), functional music, passive rest.

System of measures aimed at preservation and increase of efficiency, prevention of diseases in the performance of physical and mental labor

The system of measures aimed at increasing the efficiency and preservation of health in the performance of physical and mental labor is based on the prevention of combined adverse effects on employees of the factors of physical and neuro-emotional overload and harmful factors of the production environment, that is, labor as such and the conditions for its implementation.

It is proved that such factors of the production environment as elevated air temperature, increased noise level, insufficient illumination accelerate the development of fatigue and reduce the efficiency by 50, 20 and 10% respectively, in comparison with optimal conditions. At the same time, providing of rhythmic work increases the efficiency and productivity by 20-25%, the use of active rest - by 3-15%, optimization of the working position - by 10%, the application of rational regimes of work and rest with the alternation of execution of various technological operations - иу 17%, the influence of positive emotions - by 8-11%.

The system of measures for improving the efficiency and health of workers:

1. **Technological and sanitary-technical measures**: mechanization and automation of production operations, application of technologies and technical means.

2**. Implementation of hygienic, ergonomic and aesthetic level of work equipment**: conformity of design of machines and mechanisms, workplace, control bodies, static efforts, means of displaying information to anthropometric, physiological, psychological features of a person.

3. **Organizational measures:** introduction of scientifically substantiated rational regimes of work and rest - inter shift, daily (schedules of shift), weekly, annual; Application in working regimes of different work with different character and working conditions; measures to reduce monotony of work; the introduction of functional music, work gymnastics; rational organization of breaks for rest during the working day and after work, active rest.

It is necessary to alternate: main and auxiliary works; works of varying complexity and level of monotony; physical and mental work.

Measures to improve the working capacity and to remove the development of fatigue in mental work imply the fulfillment of 5 conditions put forward by M.E. Vvedensky:

1) Gradual entry into work;

2) Uniformity and rhythm at work, individual rhythm of work is possible;

3) Consistency and systematic work, which ensures the formation of a dynamic stereotype;

4) regular interchange of work and rest periods with the change of some forms of work by others, the use of regulated breaks after 3-4 hours of mental work, the use of functional music;

5) Increasing the social value of the results of work, the formation of a positive emotional state.

Functional music is a music that accompanies the process of work in order to maintain a high level and increase work capacity.

4. **Social measures:** the creation of a favorable microclimate in the team, the organization of the technological process that promotes the psychological communication of workers; the formation of a favorable attitude towards the work performed by society.

5. **Medical and preventive measures:**

* provision of conditions for rational nutrition;
* ensuring professional orientation when choosing a profession, conducting professional selection when hiring, forming a team for psychological compatibility;

* In order to prevent general, industrial-caused and occupational diseases, it is necessary to ensure the conduct of medical examinations of employees during the recruitment and recurrent periods in the course of work.

Materials for self-control

A. *Self-control tasks:*

1. Draw the diagram of the modern cortical theory of the fatigue development mechanism.
2. Draw a graph of the dynamics of human performance during the work shift.

B. *The task for self-control*

Two medical nurses of the surgical department together transmits patients who have undergone surgical intervention under general anesthesia from the operating table to the medical bed. In the process, they lift the patients approximately at a height of 10 cm, then move the patient horizontally to 65 cm and lowered to bed. In total for a working shift, nurses perform the specified work 6 times, the average weight that each employee transfers at a time is 35 kg.

Task:

Calculate the work done by every nurse independently in Joule for a work shift.

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