Ministry of Healthcare of the Russian Federation
Federal State Educational Government-Funded Institution of Higher Education
“Siberian State Medical University”

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MANUAL TO PRACTICAL SESSIONS ON MEDICAL SUPERVISION IN PHYSICAL EXERCISE, SPORTS AND CLINICAL PRACTICE

Teaching guide

2nd revised and expanded edition

Tomsk
Siberian State Medical University
2019

УДК 615.825.1(075.8)
ББК 53.541.1я73
М 26

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М 26 Manual to practical sessions on medical supervision in physical exercise, sports and clinical practice: teaching guide / A. N. Vykhodtsev, N. V. Grebenkina, V. K. Pashkov, E. N. Pashkova, L. I. Shpilevaya. – Tomsk: Siberian State Medical University, 2019. – 83 p.

The teaching guide presents medical supervision techniques according to the “Exercise Therapy” course. The manual describes the main methods used in performing medical examination of persons engaged in physical training. Besides, the guide demonstrates the ways to determine physical working capacity and perform medical and pedagogical supervision in clinical practice.

The manual is intended for students and may be also of interest for medical doctors and specialists working in the field of recreational physical culture.

The guide is compiled in accordance with Federal State Educational Standards of Higher Education for students with majors in “General Medicine” and “Pediatrics”.

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ББК 53.541.1я73

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Approved and recommended for publishing by the Review Commission of the General Medicine Department, Siberian State Medical University.
(protocol No. 95 of May 24, 2018).

Contents

LIST OF ABBREVIATIONS

BE – base excess

P – pulse

pH – acidity or basicity of an aqueous solution degree

PWC – physical working capacity

W – workload wattage

ATP – adenosine triphosphate

MS – medical supervision

W – watt

DBP – diastolic blood pressure

MU – motor unit

PVC – proper vital capacity

VC – vital capacity

AVC – actual vital capacity

CP – creatine phosphate

Kgm – kilogram-meter

ET – exercise therapy

MET – metabolic equivalent of task

LA – lactic acid

MOC – maximum oxygen consumption

AT – anaerobic threshold

PP – pulse pressure

HRR – heart rate reserve

SBP – systolic blood pressure

HR – heart rate

ECG – electrocardiography

INTRODUCTION

MEDICAL SUPERVISION in physical education and sports is a complex of medical measures aimed at effective use of means and methods of physical education in order to strengthen health, improve physical development, and achieve sporting excellence.

Medical supervision is one of the sports medicine sections. P.F. Lesgaft is the founder of scientific ideas in physical education. The foundations of medical supervision as a system of medical service for athletes and sportsmen were developed by his student, V.V. Gorinevskiy. In 1950, a network of medical facilities and medical exercise dispensaries was established; and this contributed to organization and development of medical supervision. Currently, medical supervision as a system of medical control for individuals engaged in physical training and sports is implemented by medical exercise dispensaries and medical supervision offices in hospitals, higher education institutions and sports schools for children and youth. Current medical control regulation includes participation of general practitioners from medical and preventive facilities in supervision of individuals engaged in physical training and sports.

Medical supervision in physical education and sports consists of several sections (medical measures):

- medical examination of individuals engaged in physical training;
- medical sports consultations;
- medical and pedagogical supervision during exercising;
- sanitary and hygienic control of exercises and sports facilities;
- sanitary health education;
- medical and sanitary services at competitions and restorative activities.

Topic 1. MEDICAL EXAMINATION OF INDIVIDUALS ENGAGED IN PHYSICAL TRAINING

Goal: to master distribution of individuals engaged in physical training into medical groups.

Questions for self-study:

1. Definition of medical supervision in physical education and sports practice.
2. Medical measures of medical supervision.
3. Description of somatoscopic features.
4. Techniques to measure the main anthropometric parameters.
5. Evaluation of physical development level using the standard and indexes methods.
6. Goal, performing techniques and evaluation of tests with standard workload (Martinet test, dynamic spirometry, Shtange-Serkin test).
7. Prescription of stress tests in clinical practice.
8. Exercise types and intensity of their performance.
9. Characteristics of medical groups.

Theoretical part

When performing medical examination, specialists use methods of clinical examination and functional diagnosis as well as specific techniques developed in sports medicine. Periodicity, extent and content of medical examination are determined considering specific features of exercising individuals (their age, gender, occupation, sports qualification). Following these principles, examination is performed using either brief or thorough methodology.

Brief examination is conducted using a medical supervision card of an athlete (form 061-y) validated by the USSR Ministry of Health in April of 1980. Subjects of medical examination are individuals who are engaged in physical training as part of a mandatory program of physical education in educational institutions, individuals in groups of general physical training and the ones in athletic teams of enterprises and establishments.

The goal of medical examination is to determine a medical group for physical education classes of an individual.

Medical examination is objected to evaluate:

- the level of physical development;
- the state of health;
- the functional state.

Determination of physical development level

Physical development of a human is a change of body forms and functions in a process of its development. The greatest shifts in physical development appear under the age of 18.

A level of physical development is a complex of morphological and functional features of a certain individual that determine functional possibilities of his or her body.

It is important to differentiate between two terms: functional possibilities and functional capabilities. Functional possibilities are characterized by anthropometric figures obtained at rest. They indicate what a certain person can do. However, they can be realized only if an individual has certain functional capabilities that are obtained by performing correctly selected physical exercises.

Physical development depends on several causes. There are three groups of main factors that determine the orientation and level of physical development:

a) endogenic factors such as heritage, pre-natal effects, congenital anomalies, prematurity;

b) natural factors such as climate and landscape;

c) social and economic factors such as a degree of economic development, cultural level, national traditions and other.

Practical part

According to the 061-y form (Appendixes 1a, b, c), medical examination starts with completing the date, passport information, life history, and athletic and sports history sections (paragraphs 1-16).

Determination of a physical development level consists in its description and evaluation. Description of the physical development level can be carried out using two methods: somatoscopy and anthropometry.

Somatoscopy represents data of external examination (paragraph 18). The state of *skin* is described by mentioning its cleanliness, elasticity, moisture, and color. *Visible mucous membranes* are characterized by color, moisture, and existing pathology. *Lymphatic system* is evaluated by palpation of lymphatic nodes.

Fat deposition (the degree of subcutaneous adipose tissue development) can be moderate, excess or insufficient. The degree of fat deposition and its distribution equality are determined by the palpation method. A 5-cm-wide skin fold is grabbed by a thumb and an index finger, then the fingers are brought together. The moderate fat deposition implies that the distance between the fingers is approximately 1 cm (0.9 cm, if caliperometry is used). The locations for fat deposition degree evaluation are the following:

- abdominal wall at the intersection of the mid-clavicular line and the horizontal line that passes through the navel (the skin fold is grabbed vertically);
- back – under the inferior angle of the scapula (the fold is grabbed downwards and from inside outwards);
- hip – the upper third of the anterior lateral surface in the sitting position (the fold is measured in parallel to the inguinal fold);
- shoulder – the middle of triceps (the skin fold is grabbed vertically).

The medical decision is made based on the result acquired in most of the locations and problem zones are pointed out.

Musculature is evaluated by layout of muscles, their tone and amount. The quality of its development may be good, fair, and poor. It is important to consider that muscular layout and the amount of muscles depend on the nature of performed physical exercises.

Condition of the hernia gate. Locations that are most common for hernias are examined thoroughly. These locations are abdominal wall and inguinal area. If a hernia is detected, the location must be indicated.

Thoracic cage form depends on the position and configuration of clavicles, ribs, sternum as well as on the value of the sternal angle, the ratio between transverse and longitudinal diameters, and the severity of spine curvature. Thoracic cage exam is performed in frontal and sagittal planes. When evaluating the chest form, it is important to consider anatomical and age-specific features. Healthy individuals may have a conic, cylinder or flat form. The cylinder form of the thoracic cage has an angle of 80-90°. During examination, it is necessary to detect deformations and asymmetry of the thoracic cage caused by diseases and traumas (keeled chest, funnel chest, barrel chest, etc.).

Back form may be correct, circular, round or flat and depends on physiological spine curvatures, such as lordosis and kyphosis. If the posture is correct, kyphoses are located on one vertical axis and the depth of lordoses is 4-6 cm.

When examining the back, it is essential to detect sideways spine curvatures (scoliosis). When determining the back form, the examiner should pay attention to the location of the head, shoulder girdle, inferior scapula angles, gluteal folds and ileac crests as well as to the value and symmetry of waist triangles. Then palpation of the vertebral column is performed in parallel with evaluation of the muscle tone in symmetric areas.

Foot. Supporting and spring functions of a foot are provided by its longitudinal and transverse arches. The foot may be of different forms: normal, flattened, or flat.

Examination starts with an examinee standing on a firm plain surface (floor, bench, stool), with his/her bare feet being placed in parallel to one another, at a distance of 10-15 cm. The location of the heelbone is determined by its relation to the tibia (rear view). If the foot is normal, the tibia and the heel match; if not, they form an outside open angle (valgus heel placement).

Then the sole of the foot is examined. The examinee is asked to stand on his/her knees on a chair facing its back. The supportive surface of the foot is clearly visible in this position and can be distinguished by its more intensive color. Normally the support part of the foot takes 1/3 – ½ of its transverse size. If it is larger and takes more than ½ of the transverse size, the foot is considered flattened, if it takes more than 2/3 of the transverse size, it is flat.

In order to determine the foot form more accurately, it is necessary to get a footprint and evaluate it using the Chizhin index. The examiner will need a sheet of paper moistened with 10% solution of tannin in denatured alcohol. The examinee sits on a chair; his/her soles are smeared with 10% solution of iron sesquichloride. Then he/she stands up placing both feet on the sheet of paper at the same time. A black footprint remains on the paper sheet with no signs of paint on feet. Several lines are drawn on the footprint: 1) tangent line AB that goes from the big toe to the medial part

of the heel; 2) line CD that goes through the basis of the second toe to the middle of the heel; 3) section CD that is split in halves by line EF that is perpendicular to it.

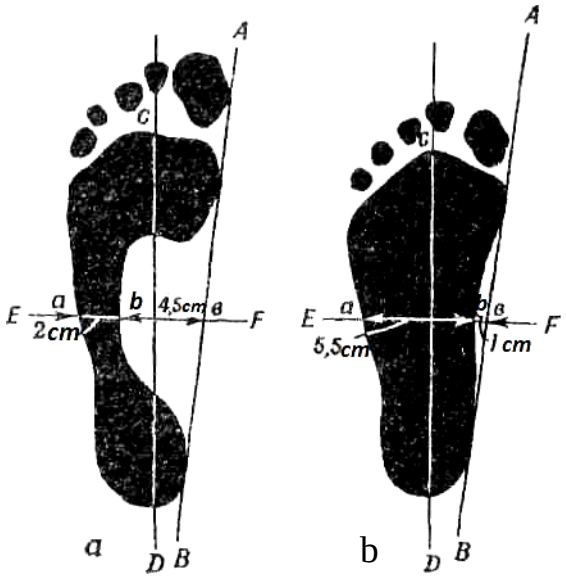


Fig. 1. Evaluation of footprints using the Chizhin method. Chizhin index equals to: a) 0.4 – normal foot; b) 5.5 – flat foot. (A.G. Dembo, 1976)

The footprint width (sections ab and bc) is measured using a ruler. Sections ratio (Chizhin index – ab/bc) determines the foot form (Fig.1). So, if the index ranges from 0 to 1.0, the foot is normal; if it ranges from 1.0 to 2.0, the foot is flattened; if it is 2.0 or more, the foot is flat.

If some pathology is detected, it is necessary to determine the flatfoot degree using x-ray exam.

Legs. Lower limbs may be straight, X-shaped, or O-shaped. In order to determine their form, the examinee should put his/her heels together with toes slightly spread. Legs are considered straight if they come in contact in areas of medial ankles and medial femur condyles, and the longitudinal axes of tibias match the longitudinal axes of femurs.

Anthropometry is an examination method of physical development parameters that is supplementary to somatoscopy (graph 17).

In order to obtain the most accurate anthropometric parameters and evaluate them in dynamics, it is crucial to perform examination in the morning, on an empty stomach or 1.5 hours after light breakfast.

Weight is measured on a scale to the nearest 0.1 kg.

Height (seated and standing up). Height is measured using a height rod that has two scales determining height in seated and standing up positions. When measuring height standing up, the patient stands on a height rod platform, his/her heels, sacral spine department and interblade region contacting the bar. The head is located so that the line connecting the outside angle of an eye and tragus is in parallel to the floor. When measuring height seated, the examinee should sit down so that he/she touches the vertical bar of the height rod with sacral and interblade regions. Head placement is the same as in standing height measurement.

Thoracic cage circumference is measured at rest (pause), on a maximum inhale, and on a maximum exhale. The difference between values of the inhale and exhale characterizes the mobility (excursion) of the thoracic cage. The measuring tape is located under the inferior scapula angle and on the sternum at the 4^{th} rib attachment.

Waist circumference (WC): the measuring tape is located horizontally over ileac crests.

Hip circumference (HC): the measuring tape is located horizontally on the most protruding points.

Spirometry is measurement of lung vital capacity (VC) or, in other words, the maximum amount of air that an individual can exhale after a maximum inhale. The examination is performed using a spirometer. The examinee exhales, then takes a deep breath and exhales evenly during 4-6 sec in the spirometer. The measurement is carried out three times, the maximum value is recorded in the card.

Dynamometry. Strength measurement of hand and back muscles is performed using hand grip and back dynamometers. The hand must be additionally abducted when squeezing hand grip.

Strength measurement of back muscles is contraindicated if an individual experiences back or neck pain, has varicose vein disease of lower limbs, hernias, high degree of refraction anomaly, arterial hypertension, splanchnoptosis, or is pregnant. When performing this examination, the handle of the back dynamometer is located at the level of knee joints with straight lower limbs and slightly bent back.

Evaluation of physical development. Evaluation of all acquired physical development parameters can only be done considering the age and gender of the examinee and sports specialization if he/she is a sportsman. Acquired and due or average values of parameters are compared using methods of standards, indexes, nomograms, correlations, and percentiles. Medical examination uses mainly standards or indexes methods.

Standards method. Anthropometric standards are mean values of physical development parameters acquired by statistical processing of great amount of measurements of persons of one age, gender and living in one area. Physical development parameters evaluated using this method are compared to physical development parameters of a group that the examinee belongs to. In order to do so, special evaluation tables are prepared (appendixes 2 a, b, c). They represent mean values of physical development parameters (M) and values of standard deviation (σ). Each parameter is evaluated according to the value of standard deviation. Average values include those that are located in between ±1σ of mean value M. Evaluations “higher than average” and “lower than average” are gotten by all the parameters located from +1σ to +2σ and from -1σ to -2σ, respectively. Parameters located from -2σ and less get the evaluation “low” and parameters from +2σ and more get the evaluation “high”.

Based on results of physical development parameters evaluation an anthropometric profile can be build (Fig. 2).

	05.05.2014	05.05.2015
Weight, (kg)	85	77
Height standing (cm)	182	182
Height seated (cm)	94	94
Pause (cm)	100	96
Inhalation (cm)	104	102
Exhalation (cm)	96	92
Excursion (cm)	8	10
VC (cm^3)	4650	5200
Right hand (kg)	48	56
Left hand (kg)	46	52
Back dynamometry (kg)	130	140

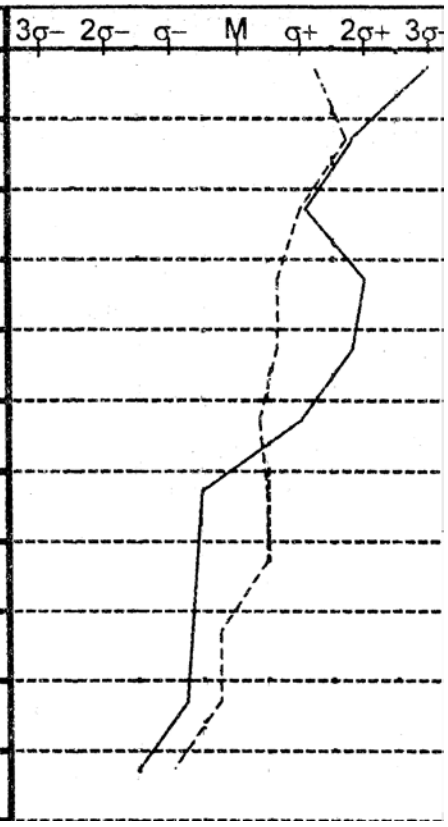


Fig. 2. Anthropometric profile
2014 _____
2015 ---------

The given profile gives a picture of physical development level of the examinee and allows to track its dynamics under the influence of various factors (age, physical exercises, etc.)

Indexes method is used for approximate evaluation of anthropometric parameters. The given method is based on the relation of two or more physical development parameters.

1. *Weight-height Ketle index* = weight (g) / height (cm).
   Average values:
   men – 350-400 g/cm;
   women – 325-375 g/cm.
2. *BMI index* (WHO, 1997) = weight (kg) / height (m^2).
   Below 18.5 kg/m^2 – low body weight;
   18.51-24.9 kg/m^2 – normal body weight;
   25-29.9 kg/m^2 – excess body weight;
   30 kg/m^2 and more – obesity;
   (30-34.9 – I degree, 35-39.9 – II degree, 40-44.9 –III degree, 45 and more – IV degree).
3. *Broca index* = weight (kg) / [height (cm) - 100] ×100%.

Optimal body weight equals to 90-100%.
Values that exceed 100% by:
19.9% – are determined as excess body weight;

20-29.9% – I degree of obesity;
30-49.9% – II degree of obesity;
50-99.9% – III degree of obesity;
100% and more - IV degree of obesity.

4. *Vital parameter* = VC (ml) / weight (kg).

Average values:
men – 65-70 ml/kg;
women – 55-60 ml/kg.

5. *Strength indexes:*

Hand grip (kg)/weight (kg)×100%

Average values:
men – 65-80%;
women – 48 -50%.

Back dynamometry (kg)/weight (kg)×100%.

Average values:
men – 200-220%;
women – 135-150%.

6. *Proportional constitution index* =
(height standing up – height seated)/height seated×100%.

Proportional constitution - 87-92%;
Short-legged – less than 87%;
Long-legged – more than 92%.

7. *WC/HC index*

Evaluation. Normal value of the WC/HC index for men is no more than **0.95** (according to some reports no more than 1.0)

Normal value of this index for women is no more than **0.8** (according to some reports no more than 0.85).

Dependence of a risk of cardiovascular diseases and diabetes mellitus on waist circumference (WHO, 1997)

Gender	**Increased risk of complications development**	**High risk of complications development**
Men	waist circumference > 94 cm	waist circumference > 102 cm
Women	waist circumference >80 cm	waist circumference > 88 cm

In order to evaluate acquired actual vital capacity (AVC) it is necessary to calculate proper vital capacity (PVC). It can be found using Anthony and Venrath tables (1962) taking into consideration gender, age and body weight (appendixes 3a, b_1, b_2, c, d),

where K is a coefficient that equals 2.2 for women and 2.6 for men.

The value of basal metabolism is determined using tables in which a height factor (B) and a weight factor (A) are found. The sum of A and B is a proper value of basal metabolism.

The other way of calculating PVC is Ludwig's formula:

[40 × height (cm) + 30 × weight (kg)] - 4400 – for men;

[40 × height (cm) + 10 × weight (kg)] - 3800 – for women.

If the relation of (AVC/PVC) × 100% = 100 ± 10%, actual VC corresponds to proper VC.

Health state evaluation

Given evaluation is performed by a therapist, a neurologist, an ophthalmologist, an otorhinolaryngologist, a surgeon, and a dentist (graph 20). Aside from the specialists mentioned above, medical examination can be also performed by a dermatologist and a gynecologist. All medical doctors record their medical decisions in a relevant graph on the second page of a medical supervision card of an athlete and sportsman.

Functional state evaluation

In order to evaluate functional state of an individual, the Martinet-Kushelevskiy test with standard load of 20 sit-ups is performed. Dynamic spirometry and Shtange-Serkin test are carried out additionally in sports practice (appendix 4).

Functional tests purpose:

- diagnosis of latent pathology and determination of its severity;
- selection of the amount and intensity of physical exercises and prescription of curative and restorative measures if some pathology was detected;
- control of adequacy and efficiency of physical exercises and curative and restorative measures.

Preparation order of patients to stress testing.

Alcohol and drugs should be excluded within 24 hours before examination. The patient should get a proper night sleep and have light breakfast with no tonic beverages in the morning. Stress testing is carried out 1.5-2 hours after meal. There should be no smoking within 1 hour before testing.

MARTINET-KUSHELEVSKIY TEST is recorded on the 4th page of the medical supervision card (graph 21).

Test goal: to determine the type of cardiovascular system reaction to standard load.

Performance technique: the patient sits down on a chair. A tonometer cuff is placed on the patient's left hand. Pulse is calculated every 10 seconds until three approximately equal values are acquired that are recorded in a relevant graph. After measuring blood pressure, the patient does 20 deep sit-ups with throwing hands out after 30 sec, the tonometer cuff remaining on the left hand. Then the examinee sits down and pulse is measured again for 10 sec, then 50 sec are used to measure blood pressure. First 10 sec of the second minute are used for pulse measurement. If it is close to initial value, it is measured every 10 sec until three same equal to initial values are acquired. Then blood pressure is measured again and the recovery time is recorded in the card. All parameters are recorded in relevant graphs.

Test evaluation is implemented by calculating increase in each parameter in % from the initial value and comparing them with normotonic reaction criteria. There are five possible cardiovascular system reaction types to standard load: normotonic, hypotonic (asthenic), hypertonic, dystonic, and step-like reaction (Fig. 3).

Normotonic reaction criteria: pulse (P) increases up to 80%, systolic blood pressure (sBP) increases from 15 to 30%, diastolic blood pressure (dBP) does not change or decreases to 35%, pulse pressure (PP) increases up to 80%, recovery time is 3 minutes.

Calculation of pulse increase in % (Δ P%) is made using the following formula:

$$\Delta P\% = (P_{after\ load.} - P_{initial}) / P_{initial} \times 100\%$$

Calculations of Δ sBP%, Δ dBP%, Δ PP% are carried out likewise.

One of the main features of the normotonic reaction is the correspondence of pulse increase percentage to pulse pressure increase.

Atypical (pathological) reactions or their elements may be detected in response to standard load.

Hypotonic reaction: P exceeds 80%, sBP increases no more than by 15% or sometimes decreases, dBP remains the same, PP increase falls behind P increase, recovery time is over 3 minutes.

Causes of the hypotonic reaction usually involve disorders of myocardial contraction function (myocardiodystrophy, myocarditis). This reaction type may be seen in anemia and asthenia patients.

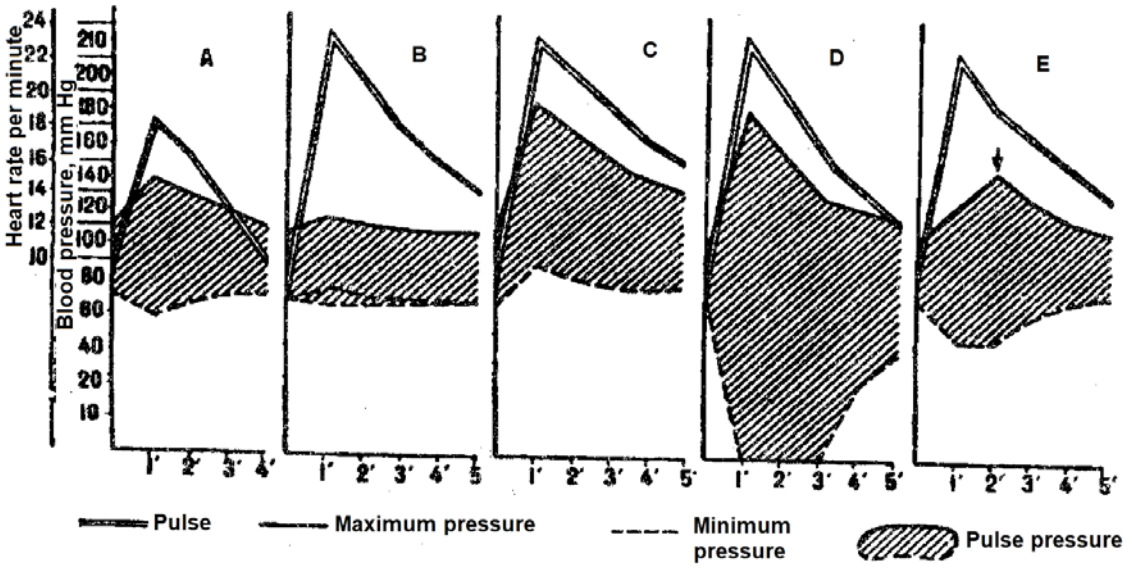


Fig. 3. Reaction types of pulse and blood pressure to standard load: A – normotonic, B – hypotonic (asthenic), C – hypertonic, D – dystonic, E – step-like reaction

Hypertonic reaction: P increases over 80%, sBP increases over 30%, dBP increases in relation to initial and PP increases over 80%, recovery time is more than 3 minutes.

Hypertonic reaction causes: hypertonic disease, symptomatic arterial hypertension.

Dystonic reaction: P increases over 80%, sBP increases over 30%, dBP decreases by more than 35% down to 0 (the “infinite tone” phenomenon occurs), recovery time is more than 3 minutes.

Causes of the given reaction include high speed of blood flow caused by hypersympaticotonia. This reaction type may also be seen in patients with thyroid hyperfunction.

Step-like reaction resembles hypotonic reaction in the 1st minute. Then P decrease is registered with a simultaneous increase in sBP and PP and dBP decrease in the 2nd minute; recovery time is over 3 minutes.

Inconsistency of P and PP increase in this reaction type are most frequently connected with disorders of myocardial contraction function.

After determining the type of cardiovascular system reaction to standard load, the graph "Medical decision" is completed (graph 22). Information about physical development level (mainly) is recorded. The "Health state" graph should reflect diagnosis if pathology was detected and a cardiovascular reaction type. If no pathology was detected, "healthy" is filled in as a medical decision. Then a medical group for physical education classes is determined based on medical examination results (appendix 5).

Medical groups for physical education classes

There are three medical groups: general, preparatory, and special. A special group consists of subgroups: physical education subgroup (A) and curative subgroup (B). Each medical group is characterized based on the amount and intensity of physical loads.

The amount of physical load is the use of the following physical exercises in class: gymnastic, playing, work-related, and sports-applied exercises (appendix 12).

Load intensity influences the intensity of metabolic processes and is in proportional dependence to the heart rate. There are maximum intensity loads that comply with 85-100% of maximum HR calculated using the following formula:

HR max = 220 - age (in years)

Performing exercises with this intensity activates anaerobic processes of energy provision in the body which causes extremely heavy exhaustion. Submaximum intensity loads represent 75-85% of maximum HR. It activates both aerobic and anaerobic energy provision processes and may be followed by heavy exhaustion. Moderate intensity loads are represented by 40-75% of maximum HR activating an aerobic regimen of energy provision with no signs of exhaustion. Low intensity loads are 40% or less of maximum HR.

A general group performs physical education program fully. All types of physical exercises are used during sessions. Individuals of this group should also do sports. Exercise performance intensity varies up to maximum. Sessions may be performed either in a group, in small groups, or individually. This group includes persons with average, above average and high level of physical development, with no or minor developmental disorders but with normotonic cardiovascular system reaction type to standard load.

A preparatory group performs physical education program to whatever extent assigned by a doctor who has knowledge in medical supervision and bases his/her prescription on results of primary medical examination and in some cases on results of thorough examination. All physical exercises are used during classes. Exercise performance intensity is submaximum. Expansion of the amount and intensity of

loads is assigned by the doctor who takes into consideration the results of additional or second medical examination. Exercise sessions may be performed in groups or individually. The preparatory group involves persons with below average physical development level with no health disorders and persons with average, above average and high physical development level with health problems. Cardiovascular system reaction type should be mainly normotonic.

A special group:

Subgroup A: this subgroup does not perform general physical education program. All physical exercises are used. Load intensity is mostly moderate. Exercises are performed in small groups or individually. Subgroup A involves persons with low physical development level with no health disorders and persons with average, above average and high physical development level with persistent health problems but without expressed dysfunctions of affected organs or systems. Cardiovascular system reaction type is mainly normotonic with elements of pathological reaction.

Subgroup B: main form of classes is medical gymnastics. Gymnastic exercises as well as elements of sports-applied exercises are mainly used in this subgroup. Load is strictly controlled and selected taking into consideration the results of thorough medical exam. Exercises are performed individually. This subgroup includes persons with persistent health disorders and expressed dysfunctions of affected organs or systems. Cardiovascular system reaction type may be either normotonic or pathological.

Transfer from one medical group to the other is conducted based on results of second and additional examinations.

Persons who suffered from a disease or trauma are temporary exempt from physical education classes for a certain period (appendixes 6, 7). However, physical exercises should not be fully excluded and should be performed in form of exercise therapy.

QUESTIONS FOR SELF-CONTROL

1. Goal and objectives of medical examination of persons engaged in physical training.
2. Methods of physical development level description.
3. Methods of physical development level evaluation.
4. Criteria of the flattened foot.
5. Locations of skin fold width measurement.
6. Technique of measuring height standing up.
7. Technique of measuring thoracic cage circumference.
8. Purpose of stress tests in clinical practice.
9. Goal of the Martinet test.
10. Martinet test evaluation.
11. Goal and evaluation of dynamic spirometry.
12. Goal and evaluation of the Shtange test.
13. Characteristics of the general medical group.
14. Characteristics of the preparatory medical group.
15. Characteristics of the special medical group A.

16. Characteristics of the special medical group B.

Test

Choose one or several correct answers.

1. MAIN FEATURES OF PHYSICAL DEVELOPMENT ARE:
   1) height
   2) weight
   3) thoracic circumference
   4) blood composition

2. METHODS OF PHYSICAL DEVELOPMENT LEVEL EVALUATION ARE:
   1) anthropometric standards
   2) indexes
   3) centiles
   4) somatic vegetative method

3. KETLE INDEX CONSIDERS:
   1) height
   2) pause
   3) thoracic circumference
   4) VC
   5) dynamometry

4. VC INDEX CONSIDERS:
   1) height
   2) weight
   3) pause
   4) thoracic circumference
   5) dynamometry

5. AVERAGE VALUES OF VC INDEX FOR WOMEN ARE THE FOLLOWING:
   1) 40-45
   2) 45-50
   3) 50-55
   4) 55-60

6. AVERAGE VALUES OF VC INDEX FOR MEN ARE FOLLOWING:
   1) 50-55
   2) 55-60
   3) 60-65
   4) 65-70

7. NORMAL BODY WEIGHT ACCORDING TO KETLE INDEX (WHO) IS:
   1) 25-27.9
   2) 22-24.9
   3) 18.6-24.9
   4) 27.9-29.9

8. OBESITY ACCORDING TO KETLE INDEX (WHO) IS:
   1) 25-27.9
   2) 22-24.9
   3) 18,6-24,9
   3) 25-29.9
   4) 30 -35

9. LOW BODY WEIGHT ACCORDING TO KETLE INDEX (WHO) IS:
   1) 25-27.9
   2) 22-24.9
   3) 18.6-24.9
   4) 25-29.9
   5) 18.5

10. HOW IS SKIN FOLD GRABBED ON THE ABDOMINAL WALL?
   1) vertically
   2) horizontally
   3) from outside in
   4) from inside out

11. WHAT FORMULA IS USED FOR CALCULATING PROPER VC FOR MEN?
   1) (40 • weight) + (30 • height) - 4400
   2) (40 • height) +(10 • weight) - 3800
   3) (40 • height) + (30 • weight) - 4400
   4) (40 • height) - (30 • weight) - 4400

12. WHICH FORMULA IS USED FOR CALCULATING PROPER VC FOR WOMEN?
   1) (40 • weight) + (30 • height) - 4400
   2) (40 • height) + (10 • weight) - 3800
   3) (40 • height) + (30 • weight) - 4400
   4) (40 • height) - (30 • weight) - 4400

13. LEVELS OF PHYSICAL DEVELOPMENT:
   1) good
   2) fair
   3) moderate
   4) poor
   5) weak

14. MEDICAL MEASURES OF MEDICAL SUPERVISION ARE:
   1) evaluation of physical development level
   2) medical and pedagogical supervision
   3) medical services at competitions
   4) medical sports consultations

15. WHEN MEASURING THORACIC CAGE CIRCUMFERENCE, THE MEASURING TAPE IS PLACED AT THE LEVEL OF … RIB
1) 2
2) 3
3) 4
4) 5

16. STRESS TESTS DETERMINE:
1) prognosis
2) latent pathology
3) physical development
4) treatment efficiency

17. CARDIOVASCULAR SYSTEM REACTION TYPE IS DETERMINED BY:
1) Ruffier test
2) Martinet test
3) Shtange-Serkin test
4) PWC_{170}

18. SHTANGE TEST ALLOWS TO DETERMINE:
1) hypoxia tolerance
2) physical preparedness
3) health state
4) cardiovascular system reaction type

19. DYNAMIC SPIROMETRY ALLOWS TO DETERMINE:
1) hypoxia tolerance
2) physical preparedness
3) health state
4) external respiration

20. GOAL OF MEDICAL EXAMINATION OF PERSONS ENGAGED IN PHYSICAL TRAINING IS:
1) determination of physical development level
2) evaluation of the functional state
3) determination of the health state
4) determination of a medical group

21. OBJECTIVE OF MEDICAL EXAMINATION OF PERSONS ENGAGED IN PHYSICAL TRAINING IS:
1) determination of motor density
2) evaluation of the functional state
3) performance of medical and pedagogical supervision
4) determination of a medical group

SITUATIONAL TASK 1

Male patient, 18 y.o., has no complaints. Life history: suffered community-acquired right side lower-lobe pneumonia 2 years ago. Underwent appendectomy 1 year ago. Postoperative period was with no complications. Athletic and sports anamnesis: sometimes plays football. Attended PE lessons with other classmates in school. Objectively: somatoscopy: flat back, O-shaped legs. Anthropometry: height – 180 cm, height seated – 94 cm, weight – 70 kg, thoracic cage circumference: pause – 93, inhale – 96, exhale – 91, spirometry – 4000 ml, dynamometry: right hand – 48 kg, left hand – 44 kg, back – 100 kg.

Medical decision: chronic sinusitis

Evaluation of the functional state. Martinet test:

Before load: pulse 13-14-13, BP 110 and 70,

After load: pulse 22, BP 123 and 65

Recovery time: 2 min 30 sec

Shtange test: 40 sec

1. *Evaluate physical development level*
2. *Evaluate the functional state*
3. *Determine the medical group*
4. *Determine orientation of physical exercise sessions*

SITUATIONAL TASK 2

Female patient, 21 y.o., has no complaints. Medical history: suffers chronic sinusitis and progressing myopia, has acute respiratory infections 4-5 times a year. Underwent trepanopunction of lobar sinus in 2014. Athletic and sports anamnesis: practiced dancing at the age of 10-11, played basketball at the age of 15-17. Objectively: scoliosis. Anthropometry: height – 181 cm, height seated – 94 cm, weight – 64 kg, thoracic cage circumference: pause – 90 cm, inhale – 93 cm, exhale – 81 cm. Spirometry – 3700 ml. Dynamometry: right hand – 39, left hand – 25, back was not performed.
Medical decision: progressing moderate degree myopia, chronic sinusitis.
Evaluation of the functional state:
Martinet test: before load – pulse 15-13-13, BP – 120/90, after load – pulse 20, BP – 130/90. Recovery time – 2 min 40 sec.
Shtange test – 60 sec.

1. *Evaluate physical development level*
2. *Evaluate the functional state*
3. *Determine the medical group*
4. *Determine orientation of physical exercise sessions.*

SITUATIONAL TASK 3

Female patient, 22 y.o., has no complaints. Medical history: suffers cystitis, II degree anemia, has acute respiratory infections 1-2 times a year. Underwent episiotomy in September of 2017. Athletic and sports anamnesis: played basketball while studying in school, did gymnastics in early childhood. Objectively: scoliosis. Anthropometry: height – 164 cm, height seated – 84 cm, weight – 59 kg, thoracic cage circumference: pause – 89, inhale – 90, exhale – 84. Spirometry – 2700 ml. Dynamometry: right hand – 29, left hand – 24, back – 25.
Medical decision: I degree myopia, II degree anemia, I degree scoliosis, cavity.
Evaluation of the functional state:
Martinet test: before load – pulse 12-13-12, BP – 110/70, after load – pulse 22, BP – 120/60. Recovery time – 2 min 50 sec.
Shtange test – 34 sec.

1. *Evaluate physical development level*
2. *Evaluate the functional state*
3. *Send to a specialist*
4. *Determine the medical group*
5. *Determine orientation of physical exercise sessions.*

SITUATIONAL TASK 4

Female patient, 24 y.o., has no complaints. Medical history: suffers acute respiratory infections 1-2 times a year. Had ankle joint sprain in 2010. Athletic and sports anamnesis: attended PE lessons with other classmates in school. Objectively: I degree scoliosis. Anthropometry: height – 161 cm, height seated – 84 cm, weight – 69 kg, thoracic cage circumference: pause – 95, inhale – 97, exhale – 93. Spirometry – 2700 ml. Dynamometry: right hand – 30, left hand – 29, back – 30.
Medical decision: cavity, I degree scoliosis.
Evaluation of the functional state:
Martinet test: before load – pulse 14-15-15, BP – 100/80, after load – pulse 17, BP – 120/80. Recovery time – 2 min 30 sec.
Shtange test – 60 sec.

1. *Evaluate physical development level*
2. *Evaluate the functional state*
3. *Determine the medical group*
4. *Determine orientation of physical exercise sessions.*

SITUATIONAL TASK 5

Female patient, 21 y.o., has no complaints. Medical history: suffers chronic pharyngitis, acute respiratory infections 5-6 times a year. Had pneumonia in 2012. Athletic and sports anamnesis: practiced dancing and running in school. Objectively: flattened foot. Anthropometry: height – 160 cm, height seated – 83 cm, weight – 54

kg, thoracic cage circumference: pause – 84, inhale – 88, exhale – 81. Spirometry – 2900 ml. Dynamometry: right hand – 30, left hand – 29, back – 44.
Medical decision: chronic pharyngitis, remission. Flat foot.
Evaluation of the functional state:
Martinet test: before load – pulse 12-12-12, BP – 90/60, after load – pulse 24, BP – 100/70. Recovery time – 2 min.
Shtange test – 35 sec.

1. *Evaluate physical development level*
2. *Evaluate the functional state*
3. *Determine the medical group*
4. *Send to a specialist*
5. *Determine orientation of physical exercise sessions.*

Topic 2. DETERMINATION OF PHYSICAL WORKING CAPACITY IN SPORTS AND CLINICAL PRACTICE

Goal: to learn principles of determination and evaluation of physical working capacity.

Questions for self-study:

1. Determination of physical working capacity and components which influence the level of physical working capacity.
2. Features of each component of physical working capacity.
3. Methods, techniques and load types for physical working capacity determination.
4. Indications, contraindications, performance technique, termination criteria and evaluation of maximal exercise tolerance test in clinical practice.
5. Indications, contraindications, performance technique, termination criteria and evaluation of submaximal clinical exercise tolerance test in clinical practice.
6. Indications, performance techniques and evaluation of Ruffier and PWC_{170} tests.

Theoretical part

Physical working capacity components

General physical working capacity is an important indicator of health and physical preparedness of an individual that is determined in departments of functional diagnostics. Physical working capacity (PWC) is an individual's potential ability to show maximum physical effort when performing static, dynamic, or mixed type of work. PWC is a complex term and is characterized by a number of components that are closely connected to each other (Fig. 4). Conditionally there are seven components of PWC: energy production, mental state, neuromuscular coordination, intramuscular coordination, intermuscular coordination, physical state, and health state.

Energy production. Bioenergetic capabilities of a human body are the most important factor limiting its PWC. Production of energy needed for muscle functioning can be implemented through aerobic and anaerobic paths. Traditionally there are three energy systems providing human PWC. The anaerobic alactic or phosphagen system is associated with processes of adenosine triphosphate (ATP) resynthesis using mostly energy of another high-energy phosphate compound – creatine phosphate (CP). The anaerobic glycolytic system ensures ATP and CP resynthesis using the reaction of anaerobic glycogen breakdown or glucose breakdown to lactic acid (LA).

The aerobic (oxidative) system is connected with a capability of performing work by oxidizing energy substrates – fatty acids, carbohydrates and proteins - with simultaneous increase in oxygen consumption, delivery, and assimilation in working muscles.

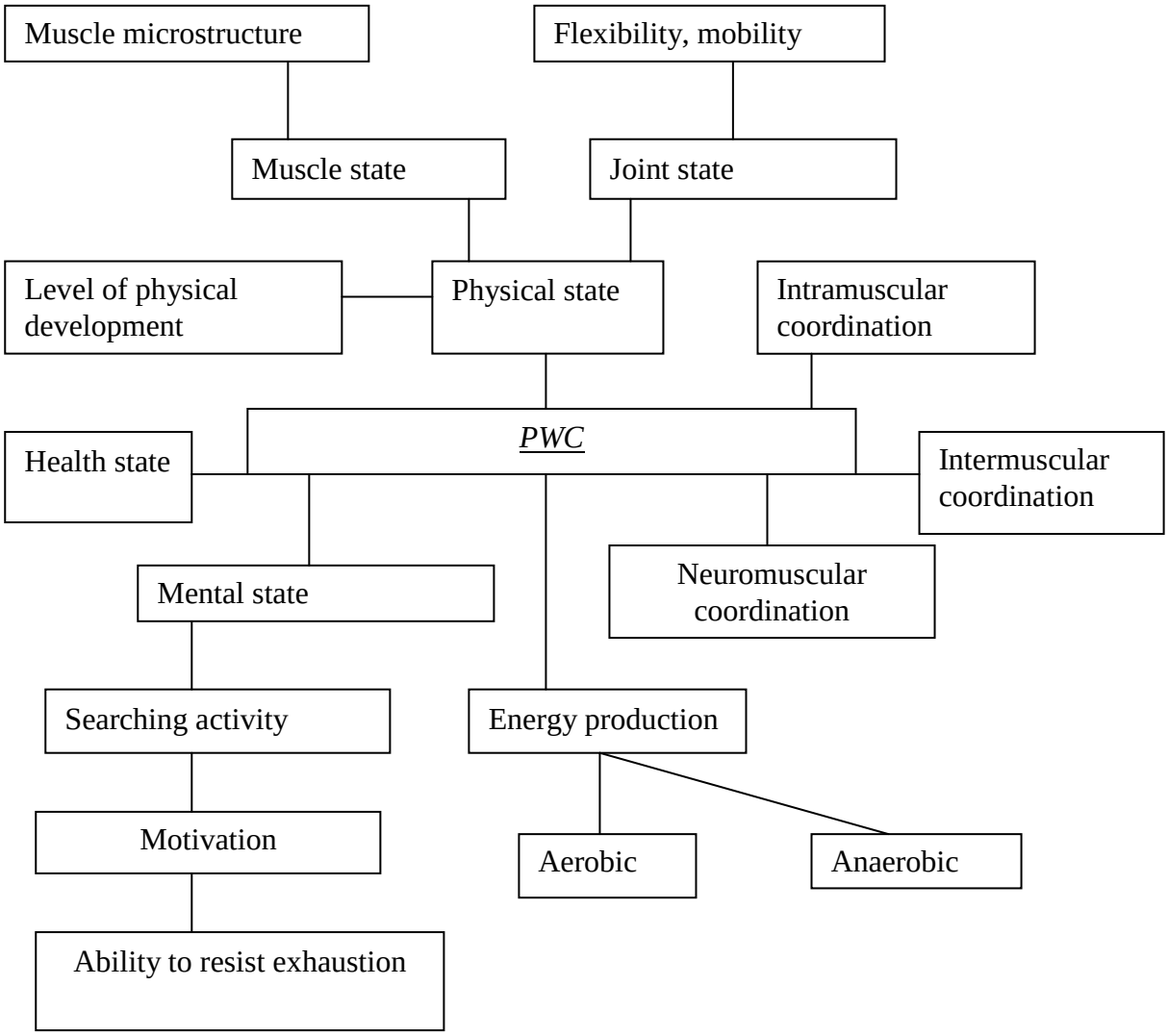


Fig.4. PWC components

Energy from the phosphagen system is used to provide maximum intensity muscle work for 15-20 seconds. Continuous muscle work during 30-40 and 250 seconds is provided by energy from anaerobic glycolysis. ATP molecules are formed 2.5 times faster in this system than in mitochondrial anaerobic oxidation, therefore the phosphagen system and anaerobic glycolysis provide the human with breakthrough muscle work of maximum intensity (sprint, weightlifting, diving, etc). More continuous muscle work requires lowering of its intensity and increase in oxidative phosphorylation that provides the main part of ATP resynthesis. Work duration in the aerobic regimen depends on energy system capacity.

Each energy system is characterized by such criteria as power, capacity and efficiency.

Power evaluates maximum energy per unit of time that can be provided by each of the energy systems. Maximum oxygen consumption (MOC) is a level of critical power for the aerobic system. Maximum increase in the level of lactic acid in blood is a power criterion for the glycolytic anaerobic system and speed of CP breakdown is a power criterion for the phosphagen system.

Capacity evaluates general quantity of performed work using the given component or general supplies of energy compounds available for use. It is time of maximum pH shift for the anaerobic system, or the size of alactic oxygen debt and creatine accumulation for the phosphagen system.

The efficiency criterion shows what amount of mechanical work can be done per each unit of spent energy: AT (anaerobic threshold) for oxidative phosphorylation, pH/W for glycolysis, CP/W and speed of alactic oxygen debt payment for the phosphagen system.

Energy production is based on genetics but changes in process of adaptation to motion activity.

Mental state. This component is characterized by searching activity, motivation, and ability to resist exhaustion.

Searching activity is a general nonspecific factor that determines body resistance to stress and harmful effects in different forms of behavior. A need of search is a need of constant change and is a driving force of each individual's self-development. Searching premises are genetically designed and their realization depends on conformity in life conditions and education especially in early childhood. Development of a need to search is an important objective of child education that helps maintain an individual in good health. Expression of searching activity depends on catecholamines level in the brain as well as on high activity of the sympathetic part of the vegetative nervous system that provides proper metabolism. Individuals with high searching activity tend to have high ability to motivation.

Motivation is a system of factors determining human's behavior (needs, goals, intentions, and other). Searching activity and motivation for movement are formed in the process of ontogenesis. Motivation changes significantly under the influence of external and internal stimuli. Formed motivation for action significantly increases human's ability to resist exhaustion.

Exhaustion is a functional state of a human that temporarily occurs under the impact of continuous and intensive work and leads to a decrease in efficiency of further activity.

Mechanisms of working capacity decrease are divided into central and peripheral ones.

Central mechanisms include changes in central nervous system activity when an individual is performing continuous and intensive physical load, resulting in changes of vegetative and endocrine systems activity that are manifested in a decrease in delivery speed of oxygen to working muscles and efficiency deterioration of energy exchange. A mental component of the central mechanism can be adjusted through the second signaling system by effects of strong external and internal stimuli.

Peripheral mechanisms (changes within working muscles) involve a decrease in phosphagen system supplies and lactic acid accumulation. Intercellular decrease in blood pH leads to deterioration of muscle contraction function. Moreover, glycolysis enzymatic activity decreases, which means that energy production speed lowers as well.

Exhaustion may occur in regard to neuromuscular coordination disorder which is one of the PWC components. This happens because neural stimulation of the axonal motor neuron transferring to the muscle fiber membrane is blocked due to decreased acetylcholine release from terminal branches of the motor axon (a presynaptic block) or (and) decreased speed of its destruction by acetylcholinesterase (a postsynaptic block).

Peripheral exhaustion mechanisms cannot be randomly eliminated. They require time for metabolism restoration.

Intramuscular coordination. When performing static or dynamic work of high intensity, untrained individual can use no more than 60% of his/her motor units (MU). Motor units consist of one motor neuron and a group of muscle fibers innervated by it that may include up to 2000 of them. Highly trained athletes of different sport specialties (where result depends on maximum effort applied) can simultaneously activate up to 85% of their MU and therefore work with more power than untrained individuals. Human's ability to simultaneously manage his/her MU and control the effort is called *intramuscular coordination*. This ability is needed for expressing speed-strength qualities. It is formed in process of learning and training.

Intermuscular coordination. Any movements performed by an individual during vocational or sports activities cannot be realized with a help of only one muscle. To meet each motor goal, a great variety of muscles are involved. Two types of motor functions are performed: movement itself and support of a necessary body pose. It is impossible to separate these functions from each other in natural conditions. For example, when performing walking movements, arms, legs, and the whole body must take a certain position. On the other hand, an individual performs necessary compensatory movements in response to any stimuli that can lead to pose violation. In any case, an optimal result is possible only when separate muscles or muscle group work is coordinated in space-time and dynamic-time relations. This collaboration of muscles that take part in movements is called *intermuscular coordination*. It is specific to certain types of movements and cannot be transferred from one movement to another.

Coherence of muscle work is of particular importance for intermuscular coordination. Muscles that directly perform movements (create draft force) are called agonists, and muscles that act in the opposite direction are called antagonists. For example, when bending femur in the hip joint, muscles of anterior surface work as agonists and muscles of posterior surface work as antagonists. "Explosion" of muscle activity occurs at the beginning of such rapidly performed movement because agonists contract and antagonists relax, which leads to femur movement acceleration. Then gradual deceleration of movement occurs and antagonist tension should stop femur movement at the end of the trajectory. The more muscles or their groups take part in movement, the harder movement is and the greater energy consumption is. As a result, intermuscular coordination plays an essential role in increasing movement efficiency and decreasing energy consumption. Ultimately, more advanced intermuscular coordination leads to increase in performed strength, speed, endurance and flexibility. It is formed in the process of learning and training.

Physical state. This component is characterized by the level of physical development and muscle and joint condition. There is no doubt that the level of physical development may influence the PWC level. Therefore, special attention is paid to harmonious physical development of above average and high level, when recruiting individuals in elite special divisions.

Strength and endurance are the main qualities of human's muscular system that determine his/her PWC. These qualities depend on muscle microstructure. There are three types of muscle fibers: fast, slow and intermediate. According to International Nomenclature, these muscle fibers are indicated as FG-type (Fast Glycolysis), SO-type (Slow Oxidative), and FOG-type, respectively.

The FG-type (fast muscle fibers) is characterized by a high level of glycogen and high activity of anaerobic enzymes that contribute to the usage of intramuscular energy substrates. These fibers are best suited for fast and strong but relatively short-term muscle contractions and "explosive" physical work of high power.

The SO-type (slow muscle fibers) is characterized by a well-developed capillary net with increased myoglobin concentration, presence of a great number of mitochondria, high activity of oxidative enzymes, and high concentration of oxidation substrates (triglycerides). This type of fibers is adapted for providing long-term but less powerful muscle contractions, which is typical for performing continuous work for endurance.

The FOG-type (intermediate muscle fibers) is adapted for rather intensive and continuous aerobic work with simultaneous strong glycolytic generation. However, their oxidative abilities are lower than those of SO-type fiber muscles. Muscle composition is genetically designed and does not change throughout lifetime. Structural changes may occur in all types of muscle fibers under the influence of training which means that the ability to perform physical work of different kinds can change as well.

Joint condition, their flexibility and mobility are important features of the musculoskeletal system. Insufficient mobility of joints restricts freedom of movement, increasing energy consumption, and manifests itself in decreased strength, endurance, reaction speed, and movement speed and frequently leads to severe injuries of muscles and joints.

Health state. Any deviations in health state may cause disorders in one or several components described above in one way or another. Therefore, they may significantly decrease general PWC.

Methods of physical working capacity determination

There are two methods of physical working capacity determination that are used in clinical and sports practice. These are direct and indirect methods.

The direct method implies pushing a patient to the point where he/she refuses to continue performing stress test. This method is more informative than the indirect method.

Indications for examination of working capacity using the direct method are the following:

- detection of early signs of ischemic heart disease;

- clarification of PWC condition of practically healthy individuals;
- medical examination of sportsmen;
- professional recruiting that requires full health and high PWC.

Contraindications for working capacity examination using the direct method:
- acute diseases (tonsillitis, SARS);
- exacerbation of chronic diseases;
- fever of any origin;
- individuals with reduced tolerance to physical load with threshold capacity of less than 125 W based on results of examinations carried out earlier;
- individuals incapable of climbing up on the 4^{th} floor without stopping;
- individuals with high degree of myopia;
- individuals with a tendency to fainting;
- individuals who suffered myocardial infarction;
- individuals with neurological symptoms in the brain.

Stress test determination criteria.

Causes of refusing to perform direct method examination are divided into subjective and objective ones.

Subjective causes include:
- headache;
- dizziness;
- pronounced shortness of breath (over 40 respiratory movements per minute);
- obvious exhaustion in working muscles;
- patient's unwillingness to continue the test;
- development of typical angina attack.

Objective causes are the following:
- reaching 100% of age-related heart rate (HR) that can be determined using table 1;
- electrocardiographic (ECG) criteria of myocardial ischemia;
- high gradation of ventricular rhythm disorders (frequent, polytopic extrasystole);
- increase in sBP over 250 mm Hg and in dBP over 120 mm Hg;
- cBP decrease.

Table 1

HR at different levels of physical load (K. Andersen at al.).

Percentage of maximum load	Age, years									
	20-29		30-39		40-49		50-59		60-69	
	m	f	m	f	m	f	m	f	m	f
	HR per minute									
75	160	166	155	149	151	153	144	144	139	140
100	195	198	187	189	178	179	170	172	162	163

Principles of PWC determination. In order to determine working capacity applying direct and indirect methods, cycle ergometry, treadmill, and step test are used. Cycle ergometer power load is dosed in watts (W) or kgm/min, their ratio being 1:6. It is necessary to use cycle ergometers in which power load does not depend on speed of pedal rotation. Treadmill power load can be changed through speed of treadmill movement and its angle rotation (%).

Two types of load are used to determine PWC. Those are continuous step-like increase and intermittent step-like increase with rest intervals between the steps (Fig. 5a and 5b, respectively)**.**

Power load of the initial step is 50 W, each following step increases by 50 W. Estimation of 1 W per kg of body weight is used in clinical practice when selecting power load for the first step.

a b

Fig. 5. Load types used for PWC determination by the direct method

Pedal rotation speed is set at 60±5 rotations per minute. Duration of pedaling for one step is 3-5 minutes. The second type of load implies making rest intervals that last as long as work in one step.

According to WHO recommendations, certain conditions should be met before starting PWC examination using the direct method:

- a patient must be informed about the performance technique of the given stress test. He/she should learn complications that may occur during the exam and sign a written consent to perform it;
- the exam room must be equipped with all necessary tools for emergency care provision;
- examination must be carried out by no less than three experienced examiners who can perform resuscitation.

Practical part

*Technical equipment***:** cycle ergometer or treadmill, tonometer, computer-aided electrocardiograph for ECG analysis, stopwatch, and gas-analyzer providing oxygen consumption and other external respiration parameters control. Equipment used in sports practice also includes devices for biochemical exam of blood acid-base condition, and LA for AT determination.

Stress test performance technique using the direct method. The patient sits on a cycle ergometer. The seat height is managed so that legs are straight or slightly bent

in the knee joint when the pedal is maximally distant from the seat. ECG electrodes, tonometer cuff and special facial mask are placed on the patient. Initial data is obtained and the results are recorded in a test protocol in the corresponding graph (appendix 10). Power load of the 1st step is set, pedaling time is determined and the patient is instructed to start pedaling. He/she reaches target pedaling speed. ECG and gas analyzer readings are constantly recorded, BP is measured every minute and all data is recorded in protocol graph *"1st step of load"*. When pedaling time of the 1st step ends, the power load of 2nd step is set and all the following actions are performed in the same way as in the 1st step. After that work is performed in the 3rd and following steps until termination criteria occur.

In order to avoid gravitational shock that may occur due to abrupt load termination, it is recommended to continue pedaling for 3-4 minutes with power load of 50% from the maximum (threshold) load.

When working on treadmill for PWC determination, it is recommended to use unmodified Bruce methodology (table 2).

The indirect method for PWC determination involves submaximal exercise tolerance test in clinical practice and PWC_{170} and Ruffier test in sports practice.

Submaximal exercise tolerance test

*Indications***:**

- atypical chest pain;
- non-specific ECG changes recorded at rest with no pain syndrome or with atypical pain;
- lipid metabolism disorders;
- determination of individual tolerance to physical load in patients with IHD;
- selection and evaluation of curative and restorative measures in patients with cardiovascular diseases including those who suffered myocardial infarction.

Absolute contraindications for stress testing:

- acute myocardial infarction;
- unstable angina not stabilized by preliminary pharmacotherapy;
- uncontrolled heart arrhythmia accompanied by symptoms or hemodynamic disorders;
- aortal stenosis with expressed symptoms;
- 2B and 3 stages of uncontrolled cardiac failure;
- acute pulmonary embolism or lung infarction with pronounced respiratory failure;
- acute myocarditis or pericarditis;
- acute aortic dissection.

Relative contraindications for stress testing:

- heart or vessel aneurysm;
- pronounced hypertonic disease;
- tachycardia of unknown etiology with a heart rate of 100+ per min;
- bundle branch block;
- serious heartbeat irregularities or syncopal events mentioned in medical history;

- moderately expressed aortic stenosis;
- hypertrophic cardiomyopathy and other forms with obstruction of left ventricular outflow tract;
- intellectual or physical disability.

Table 2

MET for treadmill and cycle ergometer stress test protocols (based on M.L. Pallock, modified)

Functional category	Clinical status				O_2 cost, $ml*kg^{-1}*min^{-1}$	MET	Cycle ergometer	Treadmill	
								Bruce	
								Stage 3 min	
							1W=6 kgm/min, if weights 70 kg – 1500 kgm/min	$m*hour^{-1}$	rotation angle %
Normal and I	Healthy, depending on age and activity	Sedentary healthy	Restricted	With IHD symptoms	56,0	16		5,5	20
					52,5	15		5,0	18
					49,0	14			
					45,5	13	1500	4,2	16
					42,0	12	1350		
					38,5	11	1200		
					35,0	10		3,4	14
					31,5	9	1050		
					28,0	8	900	2,5	12
					24,5	7	750		
II					21,0	6	600	1,7	10
					17,5	5	450		
III					14,0	4	300	1,7	5
					10,5	3	150		
					7,0	2		1,7	0
IV					3,5	1			

Termination criteria for submaximal clinical exercise tolerance test:

- reaching 75% of age-related HR (table 1);
- development of typical angina attack;
- emergence of threatening heartbeat irregularity;
- disorders of cardiac conduction system;
- symptoms of myocardial ischemia in ECG readings;
- increase in SBP above 220 mm Hg and DBP above 110 mm Hg, decrease in SBP by 20 mm Hg;
- dizziness, uncoordinated movements, headache;
- intermittent limping;
- shortness of breath above 30 per minute or asthma attack;
- patient's refusal to continue the test.

Technical equipment: cycle ergometer or treadmill, tonometer, computer-aided electrocardiograph, stopwatch.

Performance technique of this test does not significantly differ from that of the direct method of PWC examination. The only difference is the selection of 1st step power load that can be 10-25 W and depends on patient's clinical state.

Evaluation of stress test results. An ability to stand physical load is evaluated in MET (metabolic equivalent of a task or units that is a rough equivalent of oxygen consumption per minute while performing some physical activity compared to oxygen consumption per minute at rest). Relationship between power load (kgm/min) and MET is presented in Table 3.

Table 3

Relationship between power load and MET

kgm/min	150	300	450	600	750	900	1050	1200	1350	1500
MET	2-3	3-4	4-5	6-7	7-8	8-9	9-10	11-12	12-13	14-15

Advantage of using MET in protocols is that it allows to identify a certain functional category for the patient, evaluate the clinical state (table 2) and determine disease prognosis (Table 4).

Table 4

Main MET parameters

1 MET	Rest = 3.5 ml O_2×kg×min
< 5 MET	Poor prognosis
5 MET	Minimal activity in everyday life, usually in the 1st month after acute MI
10 MET	Fine prognosis both for conservative and surgical treatment
13 MET	Excellent prognosis, regardless of test results
20 MET	Sportsman

If a diagnostic stress test has a positive result, it is necessary to use the classification of IHD patients (table 5) to determine a functional class.

Table 5

Characteristics of functional classes of IHD patients (D.M. Aronov, B.A. Sidorenko, 1982)

Parameter	Functional class			
	I	II	III	IV
MET	7 or more	4.0-6.9	2.0-3.9	less than 2.0
DM (double multiplication), threshold (SBP*HR) 100	278 or more	218-277	151-217	150 or less
Threshold powerload	125 or more	75-100	50	25 or less

PWC_{170} test

PWC_{170} test was suggested by T. Sjostrand in 1947 and modified by V.L. Karpman. It is currently used to evaluate PWC in sportsmen and military personnel. This PWC test is expressed in values of the power load that increases HR up to 170 bpm. Selection of 170 HR value is determined by the fact that HR=160-180 bpm characterizes the range of optimal cardiorespiratory system functioning when working out, and, therefore, aerobic mechanisms of energy provision prevail. Sick and weak patients have the range of optimal cardiorespiratory system functioning that does not exceed 150 bpm; hence the test is performed as PWC_{150}.

Technical equipment: cycle ergometer or step with a height of 40 cm for men and 30 cm for women, tonometer, metronome.

Performance technique using cycle ergometer. The patient sits down on a cycle ergometer. A tonometer cuff is placed on his/her left arm, pulse is measured for 30 sec, BP is measured. It is important to obtain real pulse values at rest. Data is recorded in a test protocol in the graph "basic data" (appendix 10). Power load of the 1st step is set taking into consideration that the patient should get no less than 120 bpm at the end of 1st step work. The examiner marks the start time and gives a command to start pedaling at a speed of 60 rotations per minute. Thirty seconds before the end of 3rd and 5th minutes, pulse and BP are measured and data is recorded in the protocol. The patient stops and rests sitting on the cycle ergometer for 3 minutes. If pulse difference at the end of 3rd and 5th minute is ±5 beats, it speaks of reaching so-called "plateau" and the fact that aerobic mechanisms of energy provision prevail. While the patient is resting, the examiner selects power load of the 2nd step considering pulse increase after the 1st step. Power load should be of the value that will provide pulse of 170 bpm at the end of the 2nd step. In order to select power load of the 2nd step, estimation of W/pulse can be used, i.e. how many W fall on 1 pulse beat. When power load of the 2nd step is set, the examiner marks the time and gives a command to start pedaling at speed of 60 rotations per minute for 5

minutes. Measurement of cardiovascular system parameters is performed in the same way as in the 1st step. If pulse is less than 170 bpm at the end of the 5th minute, the following formula is used to determine PWC_{170}:

$$\mathbf{PWC_{170} = W_1 + (W_2 - W_1) \times \frac{170-P_1}{P_2-P_1},}$$

where
W_1 and W_2 are power loads of the 1st and 2nd steps,
P_1 and P_2 are pulse values at these steps, respectively.

Test evaluation is carried out considering relative and absolute values recalculated against body weight. Healthy untrained men have mean values of working capability of 850-1100 kgm/min and 14.4±2.7 kgm/min/kg, and healthy untrained women have working capability of 422-900 kgm/min and 10.2±1.6 kgm/min/kg, respectively. Sportsmen considering their specialty have mean values that are presented in appendix 8. Furthermore, test results can be evaluated using a 5-point scale; and one of the groups for a patient is determined. Individuals who are assigned to groups I and II need rehabilitation measures (appendix 9).

PWC_{170} performance technique using step. The climbing pace is set using a metronome which is 80 steps per minute in the 1st stage. The patient climbs up and down the step during 3 minutes. Pulse is measured 10 seconds before 3rd minute is over. Climbing pace of the 2nd stage is increased to 120 steps per minute, the patient continues to climb up and down the step for 3 minutes. Pulse is measured again 10 seconds before the 3rd minute is over and the test ends.

A specially developed table (appendix 11) may be used for test evaluation. Horizontal axes of the table represent pulse values that are acquired at the end of the first 3 minutes (1st stage) and vertical axes represent pulse values that are acquired at the end of the second 3 minutes (2nd stage). The point of axes intersection is the relative value of PWC_{170}.

Ruffier test

Ruffier test is carried out in medical exercise dispensaries when performing mass medical examination of sportsmen and athletes.

Technical equipment: stopwatch, metronome.

Performance technique. There are two ways of performing this test.

Adults. The patient takes a sitting position. The examiner measures pulse for 15 seconds until true values (P_1) are obtained. Then the patient stands up and does 30 sit-ups in 30 seconds. When sit-ups are done, the patient sits down and the examiner instantly measures his/her pulse for 15 seconds (P_2). Then the examiner measures pulse again in last 15 seconds of the 1st minute of resting period (P_3). Evaluation of working capability is performed with a help of the index calculated using the following formula:

$$\text{Ruffier Index} = \frac{4\,(P_1 + P_2 + P_3) - 200}{10}$$

Test evaluation:
0-2.9 – excellent,

3-5.9 – good,
6-7.9 – fair,
8 and more – poor.

Children. When performing this test, pulse 1 is measured in the initial position of laying down and 30 sit-ups are done in 45 seconds. Quality evaluation is the same as described above, when calculating the Ruffier-Dickson index.

$$\text{Ruffier-Dickson Index} = \frac{(P_2 - 70) + (P_3 - P_1)}{10}$$

QUESTIONS FOR SELF-CONTROL

1. Definition of PWC
2. PWC components
3. PWC determination methods
4. PWC determination methodologies
5. Load types for testing
6. W to kgm/min relation
7. Goal of maximal exercise tolerance stress test in clinical practice
8. Goal of submaximal exercise tolerance stress test
9. Performance technique of maximal exercise tolerance test
10. Performance technique of submaximal exercise tolerance test
11. Contraindications to submaximal exercise tolerance stress test
12. Goal of the Ruffier test
13. Performance technique and evaluation of the Ruffier test
14. Goal of PWC_{170}
15. Performance technique and evaluation of PWC_{170}

Test

Choose one correct answer.

1. IN ORDER TO EFFECTIVELY IMPROVE STRENGTH, IT IS NECCESARY TO PERFORM EXERCISES THAT DEVELOP:

1) endurance
2) aerobic production
3) coordination
3) flexibility

2. SPEED QUALITIES ARE IMPROVED THROUGH EXERCISES THAT DEVELOP:
1) endurance
2) flexibility
3) strength

3. ENDURANCE IS IMPOVED THROUGH EXERCISES THAT DEVELOP:
1) flexibility
2) strength
3) speed

4. MOVEMENT COORDINATION IS IMPROVED THROUGH EXERCISES THAT DEVELOP:
1) strength
2) endurance
3) speed
4) flexibility

5. WHAT METHOD IS USED TO DETERMINE PWC?
1) indexes method
2) direct method
3) nomogram method

6. THRESHOLD POWER LOAD (W) FOR IV FUNCTIONAL IHD CLASS PATIENTS IS:
1) 50
2) 25
3) 35
4) 75

7. SIGNS OF CORONARY INSUFFICIENCY IN III FUNCTIONAL CLASS IHD PATIENTS OCCUR AT THE POWER LOAD (W) OF
1) 10
2) 25
3) 50
4) 75

8. THRESHOLD POWER LOAD (W) FOR II FUCNTIONAL CLASS IHD PATIENTS IS:
1) 50
2) 100
3) 125
4) 150

9. MINIMUM THRESHOLD LOAD (W) FOR II FUCNTIONAL CLASS IHD PATIENTS IS:
1) 75
2) 100
3) 125

10. MINIMUM THRESHOLD LOAD (W) FOR I FUCNTIONAL CLASS IHD PATIENTS IS:
1) 75
2) 100
3) 125
4) 150

11. WHAT TEST IS USED TO DETERMINE FUNCTIONAL CLASS OF IHD PATIENTS?
1) Ruffier test
2) maximal clinical exercise tolerance stress test
3) submaximal clinical exercise tolerance stress test
4) PWC_{170}

12. DOUBLE MULTIPLICATION (DM) CHARACTERIZES:
1) maximum oxygen consumption
2) myocardial oxygen demand
3) coronary blood flow
4) oxygen delivery to myocardium

13. DM IS A MULTIPLICATION OF:
1) pulse and blood pressure
2) pulse pressure and pulse
3) pulse and systolic blood pressure
4) stroke volume and HR

14. MAXIMUM THRESHOLD OF DM FOR IV FUNCTIONAL CLASS IHD PATIENTS IS:
1) 100
2) 150
3) 217
4) 278

15. MAXIMUM THRESHOLD OF DM FOR III FUNCTIONAL CLASS IHD PATIENTS IS:
1) 150
2) 151
3) 217
4) 225

16. MINIMUM THRESHOLD OF DM FOR III FUCNTIONAL CLASS IHD PATIENTS IS:
1) 150
2) 151
3) 217
4) 225

17. MAXIMUM THRESHOLD OF DM FOR II FUCNTIONAL CLASS IHD PATIENTS IS:
1) 100
2) 150
3) 217
4) 277

18. THE RELATION OF W TO KGM/MIN IS:
1) 1:1
2) 6:1
3) 1:6

19. THE TARGET MET OF IHD PATIENTS WHO UNDERWENT SURGICAL INTERVENTION IS:
1) 5
2) 4
3)10
4) 8

20. IHD PATIENTS HAVE POOR PROGNOSIS IF THEIR THRESHOLD MET IS:
1) 4
2) 5
3) 7
4) 8

21. RUFFIER TEST DETERMINES THE LEVEL OF:
1) physical development
2) fitness
3) PWC
4) health

SITUATIONAL TASK 1
Male patient, 40 y.o., suffered myocardial infarction 2 weeks ago. Pulse at rest is 70 bpm, BP=110/80 mm Hg.
Test results:

Step	Step time	Load (W)	MET	HR	BP	DM
1	5	25	2.2	107	130/80	139
2	5	50	3.4	121	140/80	169
3	3	75	4.6	136	150/90	204

Termination cause: ECG criteria of myocardial ischemia

1. *Determine methodology*
2. *Determine the functional class and prognosis*
3. *Determine exercise types and training HR in % of heart rate reserve.*

SITUATIONAL TASK 2

Male patient, 32 y.o., suffered myocardial infarction 2 weeks ago. Pulse at rest is 70 bpm, BP=110/80 mm Hg. Test results:

Step	Step time	Load (W)	MET	HR	BP	DM
1	5	25	2.2	107	130/80	139
2	5	50	3.4	121	140/80	169
3	5	75	4.6	136	150/90	204
4	4	100	5.8	153	170/90	260

Termination cause: ECG criteria of myocardial ischemia

1. *Determine methodology*
2. *Determine the functional class and prognosis*
3. *Determine exercise types and training HR in % of heart rate reserve.*

SITUATIONAL TASK 3

Male patient, 60 y.o. with the following diagnosis: ischemic heart disease, exertional angina. Pulse at rest is 70 bpm, BP=110/80 mm Hg. Test results:

Step	Step time	Load (W)	MET	HR	BP	DM
1	5	25	2.2	107	130/80	139
2	4	50	3.4	121	140/80	169

Termination cause: angina attack

1. *Determine methodology*
2. *Determine the functional class and prognosis*
3. *Determine exercise types and training HR in % of heart rate reserve.*

SITUATIONAL TASK 4

Male patient, 30 y.o., suffered myocardial infarction 1 year ago. Pulse at rest is 70 bpm, BP=110/80 mm Hg. Test results:

Step	Step time	Load (W)	MET	HR	BP	DM
1	5	25	2.2	107	130/80	139
2	5	50	3.4	121	140/80	169
3	5	75	4.6	136	150/90	204
4	5	100	5.8	153	170/90	260
5	4	125	7.6	160	180/90	288

Termination cause: ECG criteria of myocardial ischemia

1. *Determine methodology*
2. *Determine the functional class and prognosis*
3. *Determine exercise types and training HR in % of heart rate reserve.*

SITUATIONAL TASK 5

Male patient, 60 y.o., with ischemic heart disease and exertional angina. Pulse at rest is 70 bpm, BP=110/80 mm Hg. Test results:

Step	Step time	Load (W)	MET	HR	BP	DM
1	5	10	1	90	130/80	117
2	4	20	2	105	140/80	147

Termination cause: angina attack

1. *Determine methodology*
2. *Determine the functional class and prognosis*
3. *Determine exercise types and training HR in % of heart rate reserve.*

Topic 3. MEDICAL AND PEDAGOGICAL SUPERVISION (MPS) IN CLINICAL PRACTICE

Goal: to understand the principles of optimal physical load selection in clinical practice.

Questions for self-study:

1. Goal and objectives of MPS
2. Sanitary and hygienic norms for places of physical exercise sessions performance
3. The structure of a physical exercise session
4. Adequacy and efficiency evaluation criteria of a physical exercise session
5. Determination and evaluation of session motor density

Theoretical part

Physical exercise sessions must solve preventive, curative, and raining problems. To do so, special and general developmental exercises should be selected, provided they are of adequate tolerance. Consequently, MPS for individuals engaged in physical training is performed in sports and clinical practice.

MPS is a series of examinations performed in order to optimize a motor activity regimen based on evaluation of physical exercise effect on the human body.

MPS is essential in sports practice when it is aimed at optimizing the training process, determining sportsmen' level of training and evaluating the efficiency of applied training methodology. This measure of medical supervision is particularly relevant during physical exercise sessions of persons with various health disorders.

A person suffering from some disease is qualitatively different from a healthy one. Special health state of an individual during disease is governed by special features of the disease, a degree of functional disorder of the affected system, and the presence of *limiting and risk factors* in the patient. These factors restrict the use of physical exercises in the amount and intensity that negatively affect time and efficiency of treatment.

Limiting factors may be special features of physical, mental, or physiological state. Some accompanying diseases such as diabetes mellitus, III-IV degree obesity, hernias, injuries or surgery complications, as well as absence of sports or physical education anamnesis may often serve as limiting factors.

Risk factors are special features of the pathological state that may result in injuries if they are not taken into consideration when planning load amount and intensity. These factors may include osteoporosis, uncontrolled hypertension, ischemic heart disease, and decompensated conditions.

It is quite common when risk factors of one disease are simultaneously limiting factors for the other disease and vice versa; i.e. no strict distinction can be drawn between them. However, detection of either of them has one goal - to correct load amount and intensity.

MPS in clinical practice implies using two control methods – *operative and integrative ones*.

Operative control methods include methods that give objective information on the reaction of the cardiorespiratory system and the general condition of patients when performing various dosed physical loads. This examination in clinical practice is performed by an exercise therapy (ET) specialist together with an instructor when delivering physical exercise sessions with patients.

Integrative methods allow to give an objective complex evaluation of the clinical and functional state of patients, learn their dynamic changes under the influence of various curative and restorative measures for a longer supervision time.

MPS goal is to select optimal physical load for the patient that allows to solve certain preventive, curative and training problems for persons engaged in physical training.

MPS objectives include evaluation of:

- sanitary and hygienic conditions of places for physical exercise sessions;
- observation of the structure of the procedure and performance principles;
- adequacy of the applied system of physical exercises;
- session motor density;
- session efficiency.

Practical part

Evaluation of sanitary and hygienic conditions of ET room

In order to evaluate sanitary and hygienic conditions of session performance, it is necessary to know accepted hygienic norms and monitor their implementation. An ET specialist controls an ET room, sports equipment (technical condition of objects, apparatus, and exercise equipment), patients' clothes and shoes. Detected inconsistencies in sanitary and hygienic condition must be thoroughly recorded and taken into account. The better the conditions are, the more effective physical exercise sessions are. Failure to follow sanitary and hygienic conditions may lead to inadequate patient's reaction to performed physical load and adversely affect treatment results.

According to sanitary and epidemiological rules and norms 2.1.3.1375-03 (with changes of April 25, 2007), the following terms must be complied with in ET rooms:

- individual session room area must be no less than 12 m^2 and a session room for small groups (up to 4 patients) must be no less than 20 $m^{2;}$
- total area of the ET room should provide 4 m^2 per one patient;
- area for exercise sessions using exercise equipment must be no less than 20 m^2 or 4 m^2 per one person;
- ET room walls are recommended to be painted in silica paint (accompanied by oil paint if necessary). Whitewash or water emulsion paint may be used to paint ceilings;
- floors must obtain high heat insulation properties and must be covered with linoleum, with its sides being hidden under the baseboard and firmly enshrined between a wall and a ceiling. Seams of linoleum that adjust to each other must be thoroughly soldered;
- air temperature must be 18ºC;

- relative air humidity should be 15-75%, or 40-60% when using air conditioner;

- air velocity should be no more than 0.2 m/sec;

- mechanical ventilation should be 50 m^3 per hour per one patient. If natural ventilation is used, multiplicity of air exchange equals 2;

- room should be illuminated using luminescent lamps (200 lx) and incandescent lamps (100 lx).

Wet cleaning of the room (washing floors, dusting furniture, window sills and equipment) must be done no less than 2 times a day; after each session of patients with chronic lung diseases disinfectant solutions must be used for cleaning. The ET room should have medications for emergency care.

ET rooms are equipped with objects (gymnastic sticks, hoops, skipping ropes, expanders of different modifications, balls, fitballs, neuroballs, medicine balls, roller massagers, dumbbells, positioning couches, and individual gymnastics mats) and sports apparatus (climbing frame, parallel bars, rope, crossbar, and gymnastic rings). One of the walls should have a wall-wide mirror.

According to the order of the Ministry of Health and Social Development No.753, of December 1, 2005, the ET room must be set with medical equipment presented in Table 6.

Table 6

ET room equipment

№	Name of medical equipment	Quantity, pieces (by number of visits)		
		under 250	250-500	over 500
1.	Vibration massager	1	2	3
2.	Cycle ergometer	1	2	2
3.	Medical scales with height rod	1	1	1
4.	Hand grip	1	1	1
5.	Back dynamometer	1	1	1
6.	Blood pressure meter	1	2	2
7.	Metronome	1	1	1
8.	Weight pulley system machines	1	1	1
9.	Mechanic apparatus for joint-muscular pathology treatment	1	1	1
10.	Bactericidal irradiator	1	1	1
11.	Pulse-tachometer	1	2	2
12.	Spirometer	1	1	1
13	Protractor for determination of limb and finger joints mobility	1	1	1
14.	Autogravitational traction device	1	1	1

Evaluation of the structure of a physical exercise session

Medical gymnastics is one of ET forms in clinical practice that can be used in different medical and preventive institutions to solve curative and preventive problems. Medical gymnastics is widespread due to its accessibility, wide variety of physical exercises, a possibility to be used at any age and for almost any disease in different conditions, i.e. in patient's bed, ward, ET room, outdoors, or in water.

Medical gymnastics is variable in its content and amount. Its kind (duration, exercise type, and intensity) changes according to patient's condition, abilities, functional disorders, and features of the disease course. The most optimal kind of medical gymnastics should be selected for each patient (appendix 12). Gymnastic physical exercises are mainly used when planning a medical gymnastics complex. However, playing, work-related, and sports-applied physical exercises can be selected according to certain therapeutic objectives. Session duration depends on disease and motor activity regimen (appendix 13).

With respect to periods of the ET session (indicative, training, and supporting), the duration of medical gymnastics can be 30, 45, or 60 minutes, respectively.

A physical exercise session consists of three parts: preparatory (warm-up), main, and final ones. Duration of the main part accounts for 2/3 (65-70%) of the whole procedure time. The remaining time is divided between preparatory (20-25%) and final parts (5-15%). Duration of separate parts depends on physical capabilities of the patient. Preparatory and final parts may be longer at first, and then become shorter when all the necessary motor skills are mastered and patient's clinical and functional states are improved.

Patient's individual features (gender and age), sports anamnesis, physical capabilities and deviations in the functional state, the nature of the pathological process, and the presence of limiting and risk factors should be taken into consideration when selecting exercises.

Successful procedure performance depends greatly on medical staff, with them creating positive motivation for the patient to perform physical exercises. Patient's conscious attitude to physical exercise sessions is one of the main pedagogical principles. The doctor in charge should familiarize the patient with the results of performed clinical and functional examinations and draw special attention to detected deviations that may be either a cause of disease or its consequence. It is particularly important to inform the patient about those physical exercises that may eliminate indicated deviations and form a will to attend medical gymnastics sessions.

Medical gymnastics in its content corresponds to all main principles of a physical exercise session.

Preparatory part. The goal of this part is to prepare cardiorespiratory and musculoskeletal systems to physical loads in the main part. Exercises that have general impact on the human's body (walking, running and their varieties) are used at the beginning of a warm-up, then exercises for minor, medium, and major muscles of upper limbs as well as exercises for shoulder girdle, neck, trunk, and lower limbs are used. At the end of the warm-up stretching exercises are performed with a focus on muscles that will be mostly involved in performing exercises in the main part.

Main part. The goal of this part is to restore functions of an affected organ or system or to form compensations if the function is partially or completely lost.

Main therapeutic problems that emerge following the results of clinical and functional examinations are solved in this part of the session. Special and general physical exercises are used for this purpose, with generally accepted pedagogical principles (accessibility, visibility, gradualism, order, comprehensiveness, and positive emotional background) taken into consideration. It is important to competently use main methodological techniques of load dosage (the pace of exercise performance, initial position, amount of muscle groups, type of muscle contraction, amount of free will respirations, number of repetitions, and use of certain objects, equipment and machines).

Adhering to the principle of accessibility, the instructor must select exercises that are suitable for the patient's motor status and physical capabilities. Patients with low motor skills should be offered simple and easily reproduced exercises.

The principle of visibility also plays a great part when teaching physical exercises to patients. Visibility is demonstration of proper exercise performance. It is common that patients can understand and perform only basic movements based solely on verbal explanation. They cannot properly perform more complicated exercises without demonstration. Therefore, verbal explanation of a movement or exercise must be accompanied with demonstration. A patient listens to the explanation, watches proper exercise performance done by the instructor and then repeats it.

Violation of the gradualism principle during the physical exercise session in clinical practice may lead to adverse consequences and deterioration of patient's condition. Respect for the principle of gradualism is important especially when physical load increases in amount and intensity. When the procedure is performed, pedagogical rules should be applied, i.e. from simple to complicated, from easy to difficult, from known to unknown.

The principle of order allows to increase the duration of the physical exercise session. Consistent alteration of different muscle groups gives an opportunity to increase the amount and intensity of physical load, if necessary, without major exhaustion.

Respecting comprehensiveness principle, physical exercise sessions must be aimed at solving specific problems as well as having general impact on all body functions and features. That is why special physical exercises should be performed along with general developmental exercises.

Final part. The goal of this part is to calm down all systems of the body bringing them close to the initial state.

In order to reach this goal, relaxing and stretching exercises for the musculoskeletal system as well as controlled breathing exercises are used to improve and maintain main properties of joints, such as flexibility and mobility, at a good level.

Adequacy evaluation of physical exercises

An important section of MPS is evaluation of alignment of physical exercises applied by the instructor with therapeutic objectives and patient's capabilities. Determination of the influence of once performed physical exercise session on the patient is a specific ET technique that evaluates adequacy and efficiency of the medical procedure. Incorrect methodology of session performance, use of physical exercises aimed at treating certain disease with no consideration of functional state aspects, limiting and risk factors will not provide an expected curative effect and may even lead to deterioration of patient's condition.

Before the ET specialist starts MPS, he/she makes sure there is an available plan of the future session and checks if it is prepared according to therapeutic objectives. Subjective and objective criteria of patient's state evaluation during the procedure are determined at the beginning of the session. A supervision protocol (appendix 14) is prepared as well. The given criteria are determined based on clinical signs of the main and accompanying diseases. The patient should know what subjective criteria he/she must pay attention to during the physical exercise session and therefore inform the ET specialist if any of them are present. The doctor marks exercises that cause uncomfortable feelings in the patient and measures objective parameters including pulse. Pulse measurement is performed within 6 or 10-second time interval. Moreover, objective parameters are measured before, in the middle, and after the warm-up, 4-5 times in the main part and once at the end of the session. All data is required to draw a physiological curve in the protocol that is used to evaluate load adequacy, its intensity and session energy cost. It is preferable that a patient learns the technique of pulse measurement for self-control during individual physical exercises sessions.

Apart from objective parameters inherent to certain disease, load tolerance control must be performed based on exhaustion signs. Light skin flush and moderate skin moisture are permissible during the session, if there are no complaints present. Movements should be confident, mood should be lively and the patient should have the desire to continue exercising sessions at the end of the procedure.

Selection of optimal load intensity is significant for load adequacy and is determined based on stress tests results.

Physical exercise sessions are usually performed using low or average load intensity estimated in % of heart rate reserve (HRR) (Karvonen, 1957).

HRR = HR max (threshold) – HR at rest

Threshold HR is determined based on results of maximal or submaximal exercise tolerance stress tests and corresponds to the value at which PWC examination was terminated. When working with patients who suffered myocardial infarction at the inpatient stage of medical rehabilitation, maximum heart rate is estimated using the following formula:

HR max = 190 - age (in years)

Load intensity estimated in % of heart rate reserve is selected considering motor activity regimen (table 7).

Table 7

HR determination depending on motor activity regimen and HRR (based on V.G. Postolovskiy, 2001)

Regimen	HR
Complete bed-rest	10 – 20% HRR
Expanded bed-rest	20 – 30% HRR
Ward	30 – 40% HRR
General	40 – 50% HRR

However, the main criterion that is used to evaluate load tolerance in clinical practice is subjective feelings of a patient, for instance the feeling of experienced effort based on Borg scale (table 8). Patients must not experience hard effort when exercising (scale 15).

Table 8

Original Borg scale	Feeling of experienced effort
6	none
7 8	extremely light
9 10	very light
11 12	light
13 14	moderate
15 16	hard
17 18	very hard
19	extremely hard
20	maximum

Analyzing the physiological curve during the whole procedure, indicative energy cost of the physical exercise session can be determined using table 9.

Table 9

Energy consumption (EC) (kcal/min) depending on pulse rate (A. Buskirik, 1960)

HR	EC	HR	EC	HR	EC	HR	EC	HR	EC
69	0,60	86	3.22	107	5.85	128	8.47	149	11.10
66	0.72	87	3.35	108	5.97	129	8.60	150	11.22
67	0.85	88	3.47	109	6.10	130	8.72	151	11.35
68	0.97	89	3.60	110	6.22	131	8.85	152	11.47
69	1.10	90	3.72	111	6.35	132	8.97	153	11.60
70	1.22	91	3.85	112	6.47	133	9.10	154	11.72
71	1.35	92	3.97	113	6.60	134	9.22	155	11.85
72	1.47	93	4,10	114	6.72	135	9.35	156	11.97
73	1.60	94	4.22	115	6.85	136	9.47	157	12.10
74	1.72	95	4.35	116	6.97	137	9.60	158	12.22
75	1.85	96	4.47	117	7.10	138	9.72	159	12.35
76	1.97	97	4.60	118	7.22	139	9.85	160	12.47
77	2.10	98	4.72	119	7.47	140	9.97	161	12.60
78	2.22	99	4.85	120	7.60	141	10,10	162	12.72
79	2.35	100	4.97	121	7.72	142	10.22	163	12.85
80	2.47	101	5.10	122	7.85	143	10.35	164	12.97
81	2.60	102	5.22	123	7.97	144	10.47	165	13.10
82	2.72	103	5.35	124	8.10	145	10.60	166	13.22
83	2.85	104	5.47	125	8.22	146	10.72	167	13.35
84	2.97	105	5.60	126	8.22	147	10.85	168	13.47
85	3.10	106	5.72	127	8.35	14a	10.97	169	13.70

Evaluation of session motor density

Session density (motor density) is a relation of time spent on exercise performance to the total time of the session (in %). With respect to ET course periods, motor density must increase. The indicative period involves explanation, demonstration and teaching a patient how to perform exercises. Rest between exercises may be passive, hence density is 60-70%. Session density must be brought up to 100% properly, using main techniques of load dosage in the process of teaching motor skills and transferring the patient to the training and supporting regimen. Rest between exercises changes from passive to active and may be presented by walking, stretching and breathing exercises. Decrease in session density based on inadequate body reaction to performed load leads in turn to decreased procedure efficiency.

Evaluation of exercise session efficiency

Efficiency of ET and other methods of treatment applied for a certain patient depends mostly on knowledge and skills of the doctor that allow him/her to promptly prescribe a full complex of curative and restorative measures.

In many patients with central and peripheral nervous system disorders and heart or musculoskeletal system pathology, hypodynamia or adynamia accompany

the main disease. Hypokinesia (akinesia) may cause local or general adverse consequences that will exacerbate the disease course and decrease PWC, and, therefore, deteriorate treatment prognosis. Moreover, feeling of his/her own helplessness affects patient's mental state; depression develops, hope for curation disappears, and prognosis may become poor. Therefore, the doctor in charge must plan curative and rehabilitation measures in time, create motivation for curation, and explain the significance of physical exercise sessions to the patient. Patient's active participation in his/her own health restoration is one of the main positive effects of ET. Optimal load and positive emotions when exercising distract the patient from thoughts about his/her disease, and the acquired result gives self-confidence and belief in convalescence. In order to support this belief, it is necessary to draw patient's attention to even minor positive changes in his/her condition using objective parameters in each session.

Parameters of *integrative* control, that indicate functional state dynamics of all systems and organs following curative and restorative measures, through stress tests and a number of clinical examinations can be used in order to build strong motivation for the patient. Selection of certain examination methods depends on therapeutic objectives.

For example, anthropometric parameters (weight, vital lung capacity, thoracic cage excursion, and dynamometry) and indexes can be used for dynamic control of efficiency of performed curative and restorative measures when physical development deviations are indicated. Tests (Martinet-Kushelevskiy test, dynamic spirometry, Shtange-Serkin test, orthostatic test, Genchi, and Shtange tests) are used to evaluate the functional state.

Relevant stress tests (including cycle ergometry and treadmill test) are selected to evaluate efficiency of measures aimed at increasing general PWC with respect to patient's clinical status.

Electromyography, dynamometry, and angle measurement (physiological joint parameters of upper and lower limb movements are presented in appendix 15) are performed in patients with musculoskeletal system diseases and injuries.

Division of operative and integrative control methods is relatively conditional. These two groups of methods complement each other and thereby give the doctor an opportunity to acquire a holistic view of the patient, his/her special features, and adaptation to various physical loads. All this allows to select optimal tactics of patient's management for complex use of curative and restorative measures.

It is necessary to evaluate treatment efficiency in clinical practice when transferring a patient from one motor activity regimen to another. Integrative control must be performed no less than once a week in the general regimen and before the patient is discharged from hospital. Following the results of final clinical and functional examinations, the doctor in charge gives recommendations on further treatment and physical exercises.

QUESTIONS FOR SELF-CONTROL

1. MPS goal.
2. MPS objectives.
3. Methods of medical supervision in clinical and sports practice.
4. Significance of medical supervision methods.
5. Goal of each part of a physical exercises session.
6. Principles of preparatory part performance.
7. Principles of main part performance.
8. Principles of final part performance.
9. Significance of a physiological load curve.
10. Significance of the Borg scale.
11. Heart rate reserve estimation.
12. Estimation and evaluation of motor density.
13. Basic sanitary and hygienic requirements to facilities for physical exercise performance.

Test

Choose one or several correct answers.

1. BORG SCALE ALLOWS TO DOSE:
1) duration of one exercise class
2) load intensity
3) motor density
4) energy expenditure

2. BORG SCALE IS BASED ON:
1) pulse numbers
2) BP numbers
3) LA concentration
4) subjective feelings

3. CLASSIC BORG SCALE HAS … CATEGORIES
1)5
2)10
3)12
4)15
5)16

4. IN ORDER TO DETERMINE LOAD INTENSITY THE FOLLOWIG IS USED:
1) MOC
2) maximum HR
3) HRR
4) double multiplication

5. ESTIMATION OF HRR USES THE FOLLOWING FORMULA:
1) 220 - age
2) sBP * BP * HR/100
3) maximum HR – HR at rest
4) stroke volume * HR
5) dBP + sBP – dBP/3

6. METHODS OF MEDICAL SUPERVISION ARE:
1) direct
2) indirect
3) operative
4) method of standards

7. METHODS OF MEDICAL SUPERVISION ARE:
1) direct
2) indirect
3) integrative
4) method of standards

8. ROOM AREA (SQ. M.) FOR INDIVIDUAL CLASSES MUST BE NO LESS THAN:
1) 4
2) 8
3) 12
4) 20

9. ROOM AREA (SQ. M.) FOR CLASSES IN SMALL GROUPS MUST BE NO LESS THAN:
1) 4
2) 8
3) 12
4) 20

10. GENERAL ET ROOM AREA IS DETERMINED TAKING IN CONSIDERATION SQ. M. PER PERSON:
1) 20
2) 4
3) 8
4) 12

11. ROOM AREA (SQ. M.) FOR EXERCISES USING SPORTS EQUIPMENT MUST BE NO LESS THAN:
1) 20
2) 4

3) 8
4) 12

12. ROOM AREA FOR EXERCISES USING SPORTS EQUIPMENT IS DETERMINED CONSIDERING SQ. M. PER ONE SPOT:
1) 20
2) 4
3) 8
4) 12

13. MPS OBJECTIVES INCLUDE EVALUATION OF:
1) physical working capacity level
2) sanitary and hygienic conditions
3) class structure
4) motor density

14. MPS OBJECTIVES INCLUDE EVALUATION OF:
1) class efficiency
2) load adequacy
3) health state

15. PHYSIOLOGICAL CURVE ALLOWS TO EVALUATE:
1) load adequacy
2) procedure efficiency
3) class structure
4) motor density

16. IN ORDER TO EVALUATE LOAD ADEQUACY, THE ANALYSIS OF … IS CARRIED OUT:
1) class structure
2) procedure density
3) physiological curve
4) physical working capacity

17. MSS COTROL METHODS INCLUDE:
1) indexes method
2) operative method
3) direct method
4) indirect method

18. COMPILATION OF A PHYSIOLOGICAL LOAD CURVE IS A:
1) indexes method
2) nomogram method
3) integrative method
4) operative method

19. MSS GOAL IS DETERMINATION OF:
1) physical load tolerance
2) class structure
3) optimal physical load
4) class density
5) procedure efficiency

20. OPTIMAL MOTOR DENSITY OF EXERCISE CLASS REPRESENTS …%:
1) 50
2) 75
3) 100
4) 80

ANSWER STANDARDS

Answer standards for “Medical examination of persons engaged in physical training” theme.

Question	Answer	Question	Answer	Question	Answer
1	1,2,3	8	4	15	3
2	1,2,3	9	5	16	1,2,4
3	1	10	1	17	2
4	2	11	1	18	1,2,3
5	4	12	2	19	2,3,4
6	4	13	3	20	4
7	3	14	2,3,4	21	2

Answers to situational tasks

Task 1

1. The level of physical development is mainly average with elements of above average in height and below average in spirometry, excursion and back dynamometry (disharmonic development).
2. The type of cardiovascular system reaction to standard physical load is mainly normotonic with elements of asthenic reaction in pulse and sBP. Hypoxia tolerance is fair.
3. Preparatory medical group.
4. Exercises for external respiration and muscle strength improvement, the ones for hypoxia tolerance increase and spine flexibility development.

Task 2

1. The level of physical development is mostly average with elements of above average in height and below average in dynamometry (disharmonic development).
2. The type of cardiovascular system reaction to standard load is mainly normotonic with elements of hypertonic reaction in dBP. Hypoxia tolerance is good.
3. Special medical group, subgroup A.
4. Use exercises for external respiration and muscle strength improvement.

Task 3

1. The level of physical development is mostly average with elements of below average in spirometry and dynamometry (disharmonic development).
2. The type of cardiovascular system reaction to standard load is mainly normotonic with elements of hypotonic reaction in pulse and sBP. Hypoxia tolerance is fair.
3. Special medical group, subgroup A.
4. Hematologist consultation is required.

Task 4

1. The level of physical development is mostly average with elements of below average in spirometry, excursion, and back dynamometry, and above average in weight and thoracic circumference (disharmonic development).
2. The type of cardiovascular system reaction to standard load is normotonic. Hypoxia tolerance is good.
3. General medical group.
4. Use exercises for external respiration and muscle strength improvement. Weight control.

Task 5

1. The level of physical development is mainly average with elements of below average in spirometry and back dynamometry.
2. The type of cardiovascular system reaction to standard load is mainly hypotonic. Hypoxia tolerance is fair.
3. Preparatory medical group.
4. The examinee should be sent for x-ray exam
5. Use exercises for external respiration and muscle strength development.

Answer standards for “Determination of physical working capacity in sports and clinical practice” theme

Question	Answer	Question	Answer	Question	Answer
1	3	8	2	15	3
2	2	9	1	16	2
3	1	10	3	17	4
4	4	11	3	18	3
5	2	12	2	19	3
6	2	13	3	20	1
7	4	14	2	21	3

Answers to situational tasks

Task 1

1. Cycle ergometry.
2. II functional class. Poor prognosis.
3. Sports-applied exercises. Walking, exercises using a cycle ergometer. Training pulse is 99-113.

Task 2

1. Cycle ergometry.
2. II functional class. Fair prognosis.
3. Sports-applied and gymnastic exercises. Walking and exercises using a cycle ergometer. Training pulse is 107-124.

Task 3

1. Cycle ergometry.
2. III functional state. Poor prognosis.
3. Cycle ergometer training. Training pulse 93-103.

Task 4

1. Cycle ergometry.
2. I functional class. Fair prognosis.
3. Sports-applied, gymnastic, and work-related exercises. Walking, exercises using a cycle ergometer. Training pulse 110-128.

Task 5

1. Cycle ergometry.
2. IV functional class. Poor prognosis.
3. Gymnastic exercises. Training pulse is no more than 85.

Answer standards for “Medical supervision (MS) in clinical practice” theme

Question	Answer	Question	Answer	Question	Answer
1	2	8	3	15	1
2	4	9	4	16	3
3	4	10	2	17	2
4	1,2,3	11	1	18	4
5	3	12	2	19	3
6	3	13	2,3,4	20	3
7	3	14	1,2		

LIST OF RECOMMENDED LITERATURE

1. The Olympic Textbook on Medicine in Sport / edited by Martin Schwellnus. – (Encyclopaedia of Sports Medicine; v.14), 2008. – 624 p.

2. The ESC Textbook of Cardiovascular Medicine (2 ed.) / edited by John Camm, Thomas F. Lüscher, and Patrick W. Serruys. – European Society of Cardiology, 2018. – 3408 p.

APPENDIXES

Appendix 1a

USSR Ministry of Health

MEDICAL DOCUMENTATION
Form 061-y
USSR Ministry of Health
Confirmed by
04 10. 80. № 1030

MEDICAL SUPERVISION CARD of athlete and sportsman

Date of completion year/month/day

Organisation name

Sports specialty

1 First and last name

2 Birth date 3 Gender

4 Home address

Phone number

5 Place of work

6 Occupation, position

7 Education 8 Living conditions

9 Diet

10 Suffered: a) diseases

b) injuries

c) surgeries

11 Alcohol consumption : occasional, a little, a lot often, none (underline)

Smoking: since cigarettes/day

non-smoker (underline)

12 Predominant sports specialty

13 For how long

14 Other sports specialties

15 Participation in competitions (sport)

16 Sports category

date of getting each category

in what sport

evaluation of kids and teenagers up to 17 y.o. incl.

17. Anthropometric parameters

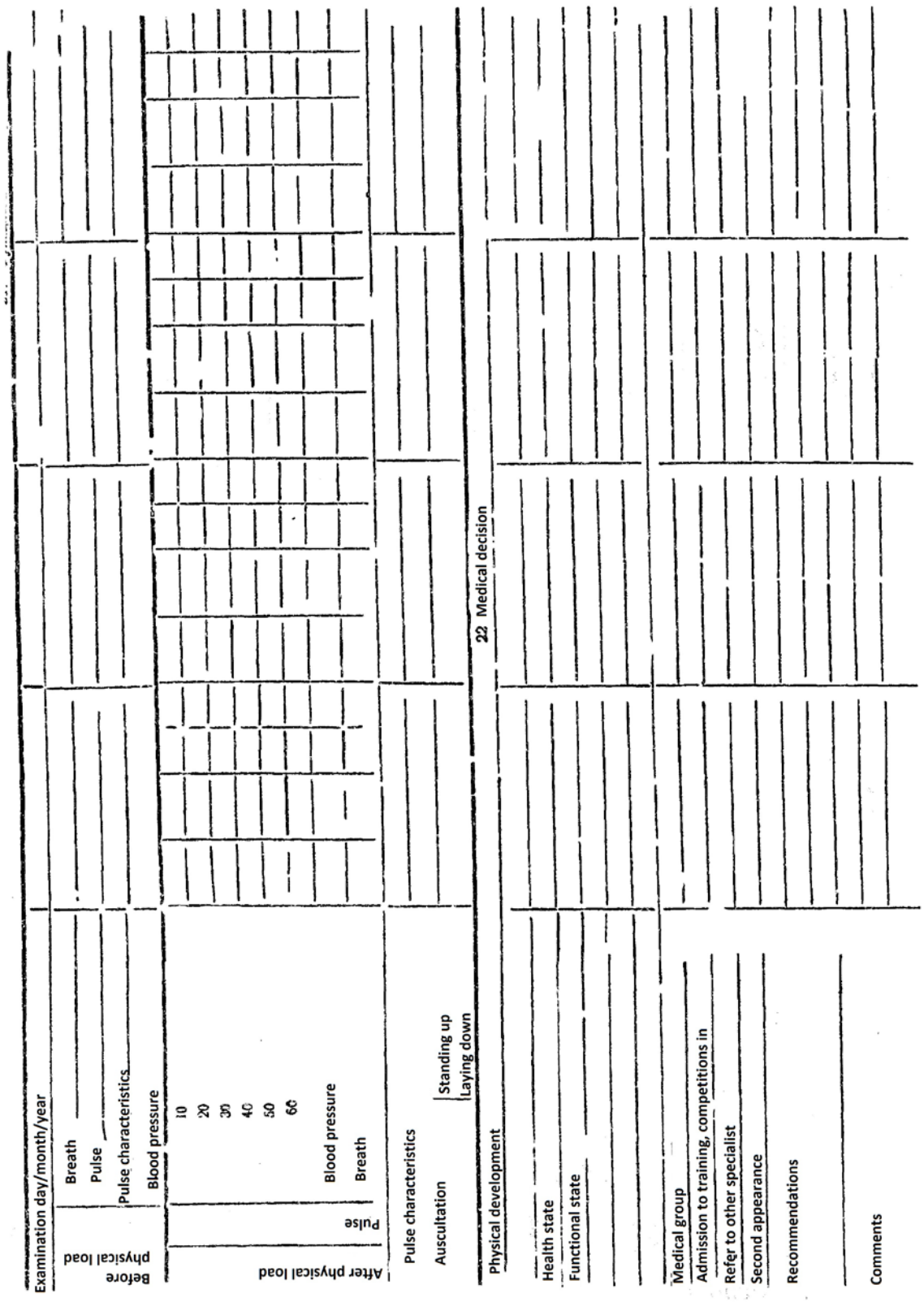
		First exam - Exam date	age	evalua-tion	Second exam Exam date	age	evalua-tion	Third exam Exam date	age	evalua-tion	Fourth exam Exam date	age	evalua-tion
Weight													
Height standing													
thoracic cage	inhalation												
	exhalation												
	pause												
circumference	excursion												
Spirometry													
Dynamometry	right hand												
	left hand												
	back												

18. External examination data

Skin													
Visible mucous membranes													
Lymphatic system													
Fat deposition													
Muscules													
Hernia gate state													
Thoracic cage													
Back													
Foot													
Legs													

	First examination Examination date	Second examination Examination date
Brief information about training sessions and sports competitions		
20. Examination information		
Complaints		
Respiration system: upper airways, lungs (auscultation)		
Cardiovascular system: heart (borders, transversal size, auscultation)		
Gastrointestinal system: tongue, stomach (palpation)		
Genitourinary system		
Endocrine system		
Nervous system		
Examination by medical specialists:		
Ophtalmologist		
Otorhinolaryngologist		
Surgeon		
Trauma surgeon		
Dentist		
Other specialists		

Appendix 1c


Examination day/month/year
Before physical load
Breath
Pulse
Pulse characteristics
Blood pressure
After physical load
10
20
30
40
50
60
Pulse
Blood pressure
Breath
Pulse characteristics
Auscultation
Standing up
Laying down
22 Medical decision
Physical development
Health state
Functional state
Medical group
Admission to training, competitions in
Refer to other specialist
Second appearance
Recommendations
Comments

Appendix 2a

Age, years	Children physical development parameters (boys,M±σ)							
	Height standing up (cm)	Height seated (cm)	Weight (kg)	Thoracic cage circumference	Excursion (cm)	VC (cm^3)	Dynamometry (kg)	
							right hand	left hand	back
Newborn	53,50±2,60		3562±456,00	34,40±1,70					
1	75,71±2,90		10,74±0,85	49,74±2,90					
2	86,60±3,86		12,80±1,41	51,39±3,23					
3	95,35±3,81		15,03±1,57	52,52±2,88					
4	102,28±3,57		16,96±1,71	55,01±2,94					
5	109,81±5,22		19,34±3,32	56,93±3,06					
6	114,61±5,64		21,37±4,19	59,05±3,06					
7	123,77±3,84	67,42±2,18	24,07±2,07	61,87±2,68	5,55±1,34	1494,29±275,62	12,70±2,70	12,60±3,18	
8	127,09±3,91	68,67±2,86	25,72±2,40	62,84±2,54	5,34±1,26	1591,89±232,93	15,24±3,52	14,51±3,28	
9	133,11±5,91	70,55±2,62	28,40±2,78	63,67±3,19	5,85±1,30	1809,76±293,68	14,97±4,58	14,43±4,41	49,63±10,97
10	136,59±5,64	72,21±2,79	31,35±3,61	66,65±3,20	6,09±1,26	1980,50±290,92	17,41±4,80	15,76±4,57	61,75±10,28
11	141,36±4,91	74,29±3,0	34,47±4,10	68,73±3,45	6,39±1,44	2066,05±341,59	19,02±5,45	16,02±4,29	66,02±14,29
12	146,10±5,49	76,32±3,01	37,96±4,59	70,81±3,80	6,40±1,46	2020,30±443,40	23,99±6,11	22,04±5,97	71,48±14,18
13	151,81±6,44	78,35±3,42	41,22±5,10	73,23±3,84	6,77±1,58	2218,86±508,86	28,74±6,85	26,35±5,80	78,08±13,71
14	157,19±7,52	81,51±4,21	47,48±7,11	76,94±4,88	7,17±1,57	2657,59±652,29	34,42±7,78	34,01±6,71	89,04±19,03
15	164,69±6,80	85,19±3,86	53,58±6,53	81,23±4,45	7,61±1,54	3186,14±731,20	42,95±9,78	39,30±9,27	107,40±21,06
16	170,18±5,98	88,49±4,20	60,72±7,06	85,18±4,94	7,80±1,83	3970,18±586,10	50,73±11,19	46,68±10,35	128,74±25,02
17	170,95±5,54	89,11±4,02	63,17±6,26	87,98±4,26	7,80±1,83	4237,90±530,46	54,75±10,37	50,31±10,40	138,25±23,36

Appendix 2b

Children physical development parameters (girls, M±σ)								
Age, years	Height standing up (cm)	Height seated (cm)	Weight (kg)	Thoracic cage circumference (cm)	Excursion (cm)	VC (cm^3)	Dynamometry (kg)	
							right hand	left hand	back
Newborn	53,4±2,9		3436,0±390,0	34,00±1,60					
1	74,64+2,9		10,17±0,9	48,27±2,92					
2	86,20+4,66		12,30±1,45	51,43±4,87					
3	94,68+4,06		14,58±1,48	52,06±2,58					
4	103,13+4,45		16,86±1,81	54,44±2,55					
5	110,93+3,82		19,56±2,05	56,63±2,64					
6	115,59+5,08		20,98±2,67	57,58±3,88					
7	124,37+3,64	67,9±3,9	24,71±2,88	60,80±2,82	4,5±1,0	1397,8±227,0			
8	127,07±4,59	68,6±2,6	26,05±3,37	61,50±3,67	4,9±1,1	1411,8±218,1			
9	132,24±4,73	70,5±2,6	28,53±2,85	63,11±2,90	5,4±1,1	1616,3±316,6	13,0±4,1	11,7±3,5	41,7±9,4
10	136,50±4,90	72,2±2,7	30,69±3,58	64,70±3,41	5,8±1,1	1793,4±287,2	14,4±3,6	13,2±3,5	43,7±11,3
11	141,24±5,54	74,6±2,9	34,31±5,01	67,55±4,63	5,9±1,3	1824,0±361,5	16,8±4,5	16,3±3,9	47,9±12,9
12	149,83±5,74	79,0±3,7	40,16±4,73	72,07±4,40	6,5±1,4	1942,6±579,3	18,6±5,2	18,1±5,7	55,0±15,1
13	154,17±5,40	81,8±3,6	44,21±5,46	74,36±4,48	6,4±1,5	2260,3±678,1	22,7±4,6	20,7±4,9	57,0±17,2
14	157,02±4,60	83,4±3,4	47,262±4,92	77,03±4,64	6,8±1,41	2554,7±649,6	26,1±7,5	23,8±6,6	55,8±15,7
15	160,10±4,40	85,6±2,9	53,00±6,39	79,63±4,11	6,8±1,5	2864,7±989,3	28,3±6,3	23,8±6,9	55,1±12,0
16	160,38±4,92	86,6±2,8	56,52±6,02	82,06±3,93	6,7±1,4	2912,0±569,5	31,7±7,1	28,3±6,7	59,3±15,9
17	160,74±4,97	86,8±2,8	57,62±6,09	82,01±4,05	6,8±1,4	2909,5±660,2	32,2±7,9	29,3±7,3	62,7±17,1

Appendix 2c

Parameters of physical development of men and women aged 20 and older

Parameters of physical development		Men	Women
		M ± σ	**M ± σ**
Height standing (cm)		171.4±5.42	160.0±5.02
Height seated (cm)		90.6±2.92	85.7±2.76
Weight (kg)		67.6±6.2	59.0±5.62
Thoracic circumference	**Pause**	92.9±4.12	83.8±3.84
	Inhalation	98.9±4.74	88.7±3.99
	Exhalation	89.6±4.5	81.5±3.78
	Excursion	8.2±1.97	7.5±1.7
Spirometry (cm^3)		4772±622.5	3397±407.5
Dynamometry (kg)	**Right hand grip**	53.6±8.25	35.6±5.51
	Left hand grip	48.8±7.89	30.3±5.4
	Back dynamometry	148.8±24.08	81.7±21.55

Appendix 3a

Basal metabolism in calories estimated based on body weight, men (Anthony-Venrath, 1962)

kg	kcal	kg	kcal	kg	kcal	kg	kcal
45	685	65	960	85	1235	105	1510
46	699	66	974	86	1249	106	1524
47	713	67	988	87	1293	107	1538
48	727	68	1012	88	1277	108	1552
49	740	69	1015	89	1290	109	1565
50	754	70	1029	90	1304	110	1579
51	768	71	1043	91	1318	111	1593
52	782	72	1057	92	1332	112	1607
53	795	73	1070	93	1345	113	1620
54	809	74	1084	94	1359	114	1634
55	823	75	1098	95	1373	115	1648
56	837	76	1112	96	1387	116	1662
57	850	77	1125	97	1400	117	1675
58	864	78	1139	98	1414	118	1688
59	878	79	1153	99	1428	119	1703
60	892	80	1167	100	1442	120	1717
61	905	81	1180	101	1455	121	1730
62	918	82	1194	102	1469	122	1744
63	933	83	1208	103	1483	123	1758
64	947	84	1222	104	1497	124	1772

Basal metabolism in kilocalories estimated based on body weight, women (Anthony-Venrath, 1962)

kg	kcal	kg	kcal	kg	kcal	kg	kcal
45	1085	65	1277	85	1468	105	1659
46	1095	66	1286	86	1478	106	1669
47	1105	67	1296	87	1487	107	1687
48	1114	68	1305	88	1497	108	1688
49	1124	69	1315	89	1506	109	1698
50	1133	70	1325	90	1516	110	1707
51	1143	71	1334	91	1525	111	1717
52	1152	72	1344	92	1535	112	1726
53	1162	73	1353	93	1544	113	1736
54	1172	74	1363	94	1554	114	1745
55	1181	75	1372	95	1564	115	1755
56	1191	76	1382	96	1573	116	1764
57	1200	77	1391	97	1583	117	1774
58	1210	78	1401	98	1592	118	1784
59	1219	79	1411	99	1602	119	1793
60	1229	80	1420	100	1611	120	1803
61	1238	81	1430	101	1621	121	1812
62	1248	82	1439	102	1631	122	1822
63	1258	83	1449	103	1640	123	1831
64	1267	84	1458	104	1650	124	1841

Basal metabolism (in calories) estimated based on age and height (men) (Anthony, Venrath, 1962)

Height, cm	Age, years																										
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
151	663	638	614	600	587	573	560	547	533	520	506	493	479	466	452	439	425	412	397	384	370	357	343	330	316	303	289	276
153	683	656	624	611	597	584	570	557	543	530	516	503	489	476	462	449	435	422	407	394	380	367	353	340	326	313	299	289
155	703	670	634	621	607	594	580	567	553	540	526	513	499	486	472	459	445	431	417	404	390	377	363	350	336	323	309	296
157	721	686	644	631	617	604	590	577	563	550	536	509	496	482	482	469	455	442	428	415	400	387	373	360	346	333	319	306
159	735	700	654	641	627	614	600	587	573	560	546	533	519	506	492	479	465	452	438	425	410	397	383	370	356	343	329	316
161	751	716	664	651	637	624	610	597	583	570	556	543	529	516	502	489	475	462	448	435	420	407	393	380	366	353	339	328
163	765	730	674	661	647	634	620	607	593	580	566	553	539	526	512	499	485	472	458	445	431	417	403	390	376	363	349	336
165	781	746	684	671	657	644	630	617	603	590	576	563	549	536	522	509	495	482	468	455	440	427	413	400	386	373	359	346
167	795	760	694	681	667	654	640	627	613	600	586	573	559	546	532	519	505	492	478	465	451	438	423	410	396	383	369	356
169	808	773	704	691	677	664	650	637	623	610	596	583	569	556	542	529	515	502	488	475	461	448	433	420	406	393	379	366
171	818	783	714	701	687	674	660	647	633	620	606	593	579	566	552	539	525	512	498	485	471	458	444	431	416	403	389	376
173	828	793	724	711	697	684	670	657	643	630	616	603	589	576	562	549	535	522	508	495	481	468	454	441	426	413	399	386
175	838	803	734	721	707	694	680	667	653	640	626	613	599	586	572	559	545	532	518	505	491	478	464	451	437	424	409	396
177	848	813	744	731	717	704	690	677	663	650	636	623	609	596	582	569	555	542	528	515	501	488	474	461	447	434	419	406
179	858	823	754	741	727	714	700	687	673	660	646	633	619	606	592	579	565	552	538	525	511	498	484	471	457	444	429	416
181	868	833	764	751	737	724	710	697	683	670	656	643	629	616	602	589	575	562	548	535	521	508	494	481	467	454	439	426
183	878	843	774	761	747	734	720	707	693	680	666	653	639	626	612	599	585	572	558	545	531	518	504	491	477	464	450	437
185	888	853	784	771	757	744	730	717	703	690	676	663	649	636	622	609	595	582	568	555	541	528	514	501	487	474	460	447
187	898	863	794	781	767	754	740	727	713	700	686	673	659	646	632	619	605	592	578	565	551	538	524	511	497	484	470	457
189	908	873	804	791	777	764	750	737	723	710	696	683	669	656	642	629	615	602	588	575	561	548	534	521	507	494	480	467
191	918	883	814	801	787	774	760	747	733	720	706	693	679	666	652	639	625	612	598	585	571	558	544	531	517	504	490	477
193	928	893	824	811	797	784	770	757	743	730	716	703	689	676	662	649	635	622	608	595	581	568	554	541	527	514	500	487
195	938	903	834	821	807	794	780	767	753	740	726	713	699	686	672	659	645	632	618	605	591	578	564	551	537	524	510	49
197	948	913	844	831	817	804	790	777	763	750	736	723	709	696	682	669	655	642	628	615	601	588	574	561	547	534	520	507
199	958	923	854	841	827	814	800	787	773	760	746	733	719	706	692	679	665	652	638	625	611	598	584	571	557	544	530	517

Basal metabolism (in calories) estimated based on age and height (women) (Anthony, Venrath, 1962)

Height, cm	Age, years																														
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
151	198	189	181	171	162	153	144	134	125	115	106	97	88	78	69	60	50	40	31	22	13	4	-6	-15	-25	-34	-43	-53
153	204	195	185	175	166	156	148	138	129	119	110	100	92	82	73	63	54	44	35	26	17	8	-2	-11	-21	-30	-39	-49
155	210	201	189	179	170	160	151	141	132	122	114	104	95	85	76	67	58	49	39	30	20	12	1	-7	-17	-26	-36	-45
157	218	209	193	183	174	165	155	145	136	128	118	108	99	90	80	71	62	52	43	34	24	16	5	-3	-13	-22	-32	-41
159	226	217	196	187	177	167	158	148	140	130	121	111	102	92	84	74	65	55	46	38	28	20	9	1	-10	-18	-29	-37
161	233	224	200	191	181	171	162	152	144	134	125	115	106	97	88	78	69	60	50	42	32	24	13	5	-6	-14	-25	-33
163	240	231	203	195	185	175	166	156	147	137	128	119	110	100	91	81	72	63	54	45	35	27	16	9	-2	-10	-21	-29
165	248	239	207	199	189	180	170	160	151	141	132	123	114	104	95	85	76	67	58	48	39	30	20	12	2	-6	-17	-25
167	251	243	211	203	192	183	173	164	155	145	136	126	117	107	98	89	80	70	61	52	42	34	24	15	5	-2	-14	-21
169	259	250	215	206	196	186	177	167	159	149	140	130	121	111	102	93	84	74	65	56	46	38	28	19	9	2	-10	-17
171	265	257	218	210	199	190	181	171	162	152	143	134	125	115	106	96	87	77	68	60	50	42	31	21	12	4	-6	-13
173	270	261	222	213	203	194	185	175	166	156	147	138	129	110	110	100	91	81	72	63	54	45	35	25	16	6	-2	-10
175	276	267	225	217	207	197	188	179	169	160	151	141	132	123	113	104	95	85	76	67	57	48	38	29	20	10	1	-6
177	282	273	229	221	211	201	192	182	173	164	155	145	136	126	117	108	99	90	80	71	61	52	42	32	24	14	5	-2
179	288	279	233	223	214	204	195	186	177	167	158	148	139	130	121	111	102	92	83	75	65	56	46	36	27	18	8	0
181	295	286	237	227	218	208	199	190	181	171	162	152	143	134	125	115	106	97	87	79	69	60	50	40	31	22	12	2
183	302	292	240	231	222	212	203	193	184	174	165	156	147	137	128	118	109	100	91	83	72	64	53	44	35	26	16	6
185	310	299	244	235	226	216	207	197	188	179	169	160	151	141	132	122	113	104	95	87	76	67	57	48	39	30	20	10
187	312	302	248	238	229	219	210	201	192	182	173	163	154	145	135	126	117	107	98	91	79	70	61	52	42	33	23	14
189	317	307	252	242	233	223	214	205	196	186	177	167	157	148	139	130	121	111	102	94	83	74	65	56	46	37	27	18
191	321	311	255	245	236	227	218	208	199	190	180	171	162	152	143	133	124	114	105	96	87	78	68	60	49	41	31	22
193	326	316	259	250	240	231	222	212	203	193	184	175	166	156	147	137	128	118	109	100	91	82	72	63	53	44	35	25
195	330	326	262	253	244	234	225	215	206	197	188	178	169	160	150	141	132	122	113	104	94	86	75	67	57	47	38	29
197			266	257	248	238	229	219	210	201	192	182	173	162	154	145	136	126	117	108	98	90	79	71	61	52	42	33
199			270	260	251	241	232	223	214	204	195	185	175	167	158	148	139	130	120	112	102	93	83	74	64	55	45	36

Appendix 3c

Basal metabolism in kilocalories estimated based on age and height, boys (Anthony-Venrath, 1962)

Height, cm	Age, years						
	10	11	12	13	14	15	16
76	55	30					
80	95	70	50				
84	135	110	85	60			
88	180	160	130	100			
92	235	220	180	140	120	100	
96	290	280	230	180	160	140	126
100	340	330	280	230	205	180	166
104	395	390	330	280	250	220	210
108	450	450	390	330	300	260	245
112	500	500	440	380	340	300	287
116	550	550	490	430	385	340	327
120	600	600	540	480	430	380	368
124	645	650	590	530	470	420	417
128	695	700	640	580	520	460	448
132	745	750	690	630	570	500	486
136	790	800	740	680	620	540	526
140	835	840	780	720	650	580	565
144	885	890	825	760	690	620	607
148	935	950	885	820	740	660	647
152	975	990	925	860	780	700	685
156	1020	1030	960	890	815	740	725
160	1040	1060	990	920	850	780	761
164	1080	1100	1040	960	885	810	794
168	1120	1140	1070	1000	920	840	820
172	1180	1190	1110	1020	940	860	840
176		1230	1140	1040	960	880	860
180			1170	1060	980	900	880
184					1000	920	903
188						940	920

Appendix 3d

Basal metabolism in kilocalories estimated based on age and height, girls (Anthony-Venrath, 1962)

Height, cm	Age, years						
	10	11	12	13	14	15	16
68	-95						
72	-84	-89					
76	-68	-73	-75				
80	-52	-57	-60	-66			
84	-31	-31	-41	-50	-55		
88	-9	-5	-17	-34	-39	-43	
92	9	19	0	-14	-22	-27	-32
96	22	27	13	-2	-5	-11	-17
100	38	43	31	14	10	5	0
104	58	62	45	30	25	21	16
108	80	85	65	56	47	37	32
112	96	01	87	72	62	53	48
116	112	117	107	98	84	69	64
120	133	143	129	114	97	80	77
124	148	159	145	130	115	101	101
128	167	175	161	146	132	117	112
132	186	191	177	162	148	133	128
136	202	207	192	178	159	140	140
140	219	228	211	194	180	165	160
144	244	241	230	210	195	181	176
148	260	265	250	236	220	197	192
152	277	281	267	252	232	212	206
156	292	297	279	260	243	227	221
160	298	303	289	274	258	242	235
164	311	313	301	290	274	257	250
168	335	325	315	306	288	271	263
172		331	324	318	301	285	276
176				328	314	299	289
180					323	313	302
184						327	315

Appendix 4

Dynamic spirometry

Test goal is to evaluate external breath adaptation to standard physical workload.

Performance technique. Vital capacity is measured at rest. Then the examinee performs standard workload in a form of 20 sit-ups in 30 seconds. VC is measured again immediately after that. Measurement is repeated at the end of the 1st minute of the recovery period, if necessary.

Test evaluation:

1. VC increases and doesn't change or decreases by 100 ml if external breathing adaptation to standard physical workload is good.
2. If VC decreases by more than 100 ml, the measurement should be repeated in 1 minute. If VC returns to its baseline, the result is evaluated as fair, if it doesn't return, VC is counted as poor.

Shtange-Serkin test

Test goal is to evaluate the body's adaptation to hypoxia.

Performance technique. The test is performed in three phases.

1. The examinee in seated position is asked to inhale submaximally holding nose. The time of breath holding is estimated using stopwatch (Shtange test). Serkin test is performed if Shtange test has a good result.
2. The examinee does 20 deep sit-ups, throwing hands out. Then one takes initial position and holds his/her breath, having inhaled beforehand. The time of breath holding is estimated using the stopwatch.
3. The breath is held again in 1 minute and the time is marked using the stopwatch.

Test evaluation

1st phase – adaptation is considered good if the time of breath holding is 50 sec or more, fair if it is 30-49.9 sec, and poor if it is less than 30 sec;

2nd phase – adaptation is considered good if the time of breath holding is 50% or more of initial time, fair if it is 35-49%, and poor if it is less than 35%;

3rd phase – adaptation is considered good if the time of breath holding is 100% of initial time, fair if it is 70-99%, and poor if it is less than 70%.

The medical decision is formed based on the results of all three phases.

Indicative results of Shtange and Genchi tests in children aged 5-16

Age, years	Boys		Girls	
	Shtange test	Genchi test	Shtange test	Genchi test
5	24 sec	12 sec	22 sec	12 sec
6	30 sec	14 sec	26 sec	14 sec
7	36 sec	14 sec	30 sec	15 sec
8	40 sec	18 sec	36 sec	17 sec
9	44 sec	19 sec	40 sec	18 sec
10	50 sec	22 sec	50 sec	21 sec
11	51 sec	24 sec	44 sec	20 sec
12	60 sec	22 sec	48 sec	22 sec
13	61 sec	24 sec	50 sec	19 sec
14	64 sec	25 sec	54 sec	24 sec
15	68 sec	27 sec	60 sec	26 sec
16	71 sec	29 sec	64 sec	28 sec

Genchi test is holding breath on the exhale.

Appendix 5

Approximate assignment to medical groups for completion of the physical education program

Diagnosis	Medical group		
	General	Preparatory	Special
Pneumonia (bronchitis)*	-	-	+ (dispensary supervision)
Chronic bronchitis*	-	-	+
Bronchial asthma*	-	+ (if in steady remission)	+
Lung tuberculosis*	-	+(if taken off dispensary list)	+
Previous myocarditis*	-	-	+
Congenital heart valve defects*	-	-	+
Acquired heart valve defects	-	-	+
After surgical treatment of heart defects	-	-	+
Tonsillocardiac syndrome*	-	-	+
Chronic gastritis, enteritis, colitis	+	-	-
Stomach and duodenal ulcer disease	-	+ (if in steady remission)	+
Splanchnoptosis	-	-	+
Chronic nephritis, pyelonephritis	-	-	+
Diabetes milletus	-	-	+
Obesity	-	+ 1st degree	+
Hernia repair surgery, appendectomy, musculoskeletal system fractures	-	-	+
Scoliosis: I degree	+	-	-
Scoliosis: II, III, IV degrees	-	-	+
Paralysis, paresis, hyperkinesis	-	-	+
Compensated chronic tonsillitis	+		
Decompensated chronic tonsilitis	-	-	+
Sinusitis	-	-	+
Refraction anomalies (myopia, hyperopia)	< 3,0 D	< 6,0 D	> 6,0 D
Varicose vein disease of lower extremities	-	-	+

** Individuals with assigned pathology can be assigned to another medical group considering the results of additional and updated thorough examination.*

Appendix 6

Start of physical education classes after injuries

	Injury	Time interval, days
1.	Bone fractures of lower extremities: - ankles - tibias - femurs	 40-60 days after immobilization bandage is removed; 90-120th day -″- 5-6th month -″-
2.	Feet – with bone fragments fixation not disturbing arches and spring function	2-3 months after a plaster cast is removed
3.	Feet – with bone fragments fixation disturbing arches and spring function	4-6th month -″-
4.	Bone fractures of upper extremities: - clavicles - forearms - humerus - wrist and fingers	 45-60 days after fracture 45-60 days after immobilization removal 60-90 days 30-45 days after fracture
5.	Compression fractures to thoracic and lumbar spine regions	10-12 months after fracture
6.	Sprain of ankle joint ligaments: 1 degree – with ligament microtears 2 degree – with expressed ligament impairments 3 degree – with ligament separation from bone	 7-10 days after injury 14-21st day -″-
7.	Sprains and contusions of knee joint: - no hemarthrosis and ligament impairments - with minor hemorrhage in joint, with minor ligament impairment - with hemarthrosis and ligament impairment	 10-14 days after injury 14-28th day -″- not earlier than 45th day -″-
8.	Period after meniscectomy in knee joint	90-180 days after surgery
9.	Elbow and shoulder joint dislocation	30-60 days after dislocation
10.	Wrist joint dislocation	7-30 days after dislocation

Appendix 7

Start of physical education classes after suffering acute infectious diseases

Diagnosis		Time interval, days
1.	Acute tonsillitis (catarrhal, follicular, lacunar)	6-7
2.	Purulent acute tonsillitis	14-15
3.	Acute appendicitis	7-10
4.	Period after uncomplicated appendectomy	30-35
5.	Acute bronchitis	7-12
6.	Varicella (chicken pox)	7-8
7.	Acute inflammation of paranasal sinuses	10-12
8.	Pneumonia	14-18
9.	Gastroenteritis and other acute GIT disorders	2-3
10.	Influenza – catarrhal, gastrointestinal, and nervous forms:	
10.1	A) slight and moderate degree of severity: high temperature no more than for 4 days, absence of expressed local changes	4-5
10.2	B) more severe forms (high temperature for more than 5 days, disorders of various organs, sharply expressed symptoms of general intoxication)	10-12
11.	Dysentery	14-16
12.	Diphtheria	30-35
13.	Measles	14-16
14.	Malaria	6-7
15.	Acute nephritis	50-60
16.	Acute and subacute skin and mucous membrane diseases (contagious and non-contagious) not causing sharp pain or motion limitation (scabies or dermatophytosis)	5-6
17.	Acute heart expansion (due to sports or other exertion)	30-45
18.	Acute otitis	14-16
19.	Dry pleurisy	14-16
20.	Pleurisy with effusion	40-50
21.	Acute rheumatism	6-8
22.	Scarlet fever	30-40
23.	Hepatitis	60-70
24.	Acute myocarditis	8-9
25.	Tonsillectomy	8-9
26.	Adenectomy	4-5
27.	Peritonsillar abscess drainage	5-6
28.	Nasal septum resection	5-7
29.	Radical surgery on temporal bone	80-90
30.	Hernia repair surgery	30-45
31.	Brain concussion	20-25

Appendix 8

Physical working capacity of various sportsmen, men

Sport	PWC_{170} ($x \pm \sigma$)	
	kgm/min	kgm/min/kg
Athletics	1571±377	14.6±3.6
Diving	1198±243	17.8±2.1
Weightlifting	1135±20	15.3±2.3
Equestrian sport	1115±161	15.6±1.6
Artistic gymnastics	1044±150	16.5±2.0
Water polo	1865±302	22.4±3.6
Basketball	1705±280	19.3±2.7
Figure skating	1672±379	24.5±3.0
Soccer	1618±296	21.6±2.8
Hockey	1428±217	20.1±2.7
Wrestling	1370±310	18.6±2.8
Boxing	1360±335	20.2±2.4
Tennis	1260±286	18.4±3.2
Biathlon	1930±117	27.7±1.9
Ski race	1760±305	25.7±4.6
Speed skating	1710±284	24.0±3.5
Modern pentathlon	1709±242	23.5±3.0
Track and field (average spacing)	1676±190	24.1±4.9
Cycling	1676±296	22.7±2.8
Rowing	1651±235	19.0±3.0
Swimming	1642±217	22.9±3.0
Track and field (power walking, marathon running)	1605±239	23.1±3.6

Physical working capacity of various sportsmen, women

Sport	PWC_{170} ($x \pm \sigma$)	
	kgm/min	kgm/min/kg
Athletics	1106±211	12.7±2.0
Cycling	1074±144	17.2±2.2
Track and field (average spacing)	1046±73	19.3±1.3
Snorkeling	937±209	15.4±2.9
Figure skating	932±191	19.8±2.8
Ski race	899±117	15.1±2.2
Swimming	880±172	14.3±1.5
Aerobics	799±128	13.8±2.2
Diving	710±112	13.5±1.9
Track and field (sprint)	626±43	10.8±1.5

Appendix 9

Evaluation of physical working capacity of men and women aged 20-29, kgm/min/kg

Points	Men	Women
5	> 16	> 13.4
4	15.6 -16.5	12.4 – 13.3
3	14.2 – 15.5	11.1 – 12.3
2	13.3 – 14.1	10.0 – 11.0
1	< 13.2	< 9.9

Evaluation of physical working capacity of men and women using PWC_{170} test (kgm/min/kg)

Age		Physical working capacity				
		Very low I group	Low II group	Fair III group	Good IV group	Excellent V group
20-29	M	< 14.6	14.6-16.4	16.5-19.1	19.2-20.9	> 20.9
	W	< 10.4	10.4-12.5	12.6-15.7	15.8-17.5	>17.5
30-39	M	< 13.1	13.1-14.9	15.0-17.9	18.0-19.4	> 19.4
	W	< 10.0	10.0-12.1	12.2-15.0	15.1-16.9	> 16.9
40-49	M	< 11.6	11.6-13.4	13.5-16.4	16.5-17.9	> 17.9
	W	< 9.0	9.0-11.4	11.5-14.7	14.8-16.2	> 16.2
50-59	M	< 9.8	9.8-11.9	12.0-14.9	15.0-16.4	> 16.4
	W	< 7.9	7.9-10.3	10.4-13.2	13.3-14.8	> 14.8

Appendix 10

Protocol of physical working capacity examination

Date of examination_____ Name_____

Age_____Diagnosis_____Weight _____
Height_____

		Workload wattage (W)																			
Parameters	Basic data	50					100					150					200				
		1'	2'	3'	4'	5'	1'	2'	3'	4'	5'	1'	2'	3'	4'	5'	1'	2'	3'	4'	5'
P																					
BP																					
VO_2																					
LA																					
pH																					
BE																					

	Recovery time (minutes)				
	1	2	3	4	5
P					
BP					
VO_2					
LA					
PH					
BE					

Causes of examination termination:

Protocol of physical working capacity examination using PWC_{170} test

Date of examination_____ Name_____

Age_____Weight_____ Height_____

Parameters	Basic data	Workload wattage (W)			
		1^{st} step		2^{nd} step	
		3 min	5 min	3 min	5 min
P					
BP					

Appendix 11

Table of PWC_{170} determination per 1 kg of body weight considering pulse during 1st and 2nd step of workload (K = 1,3)

P1	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***	***25***	***26***	***27***
17	26.3	33.6												
18	21.7	25.0	31.8										***F***	
19	18.9	20.7	23.8	29.9										
20	17.0	18.1	19.8	22.5	27.9									
21	15.7	16.4	17.4	18.8	21.2	26.0								
22	14.7	15.1	16.4	16.6	17.8	19.8	23.8							
23		14.7	14.8	15.1	15.9	16.9	18.6	22.1						
24			13.8	14.0	14.5	15.1	15.9	17.3	20.1					
25				13.3	13.5	13.9	14.3	14.9	16.0	18.2				
26					12.8	13.0	13.2	13.5	13.9	14.7	16.0			
27						12.4	12.4	12.6	12.7	13.0	13.4	14.3		
28							11.8	11.8	11.9	11.9	12.0	12.1	12.3	
29								11.4	11.3	11.2	11.1	11.0	10.8	10.4
30									10.8	10.7	10.6	10.4	10.	9.5
31										10.4	10.2	9.9	9.6	9.1
32											9.9	9.6	9.3	8.8

	14	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***21***	***23***	***24***	***25***	***26***	***27***
17	32.5	45.0												
18	29.0	33.5	42.0										***M***	
19	25.3	27.7	31.7	39.8										
20	22.8	24.2	26.4	30.0	37.2									
21	21.0	21.9	23.2	25.1	27.7	34.6								
22	19.3	20.3	18.4	22.1	23.8	26.5	32.0							
23		19.1	19.5	20.2	21.1	22.5	24.8	29.5						
24			18.4	18.8	19.3	20.1	21.2	23.0	26.9					
25				17.8	18.0	18.5	19.0	19.9	21.3	24.3				
26					17.1	17.3	17.6	18.6	18.6	19.6	21.6			
27						16.4	16.5	16.7	16.9	17.3	17.8	19.1		
28							15.6	15.7	15.8	15.9	16.0	16.1	16.5	
29								15.1	15.1	14.9	14.9	14.7	14.4	13.9
30									14.5	14.3	14.1	13.9	13.4	13.6
31										13.9	13.6	13.3	12.8	12.1
32											13.2	12.8	12.4	11.8

Appendix 12

Types of physical exercises used in ET

I. GYMNASTIC

1. According to activity degree:
   - passive
   - active
   - active with help
   - active with resistance
   - reflexive
2. According to muscle contraction:
   - isotonic
   - isometric
   - mixed
3. According to specificity:
   A. General development
   B. Specific:
   - breathing (static and dynamic)
   - for balance, relaxation, speed, coordination, flexibility, agility, strength, and endurance)
4. According to anatomic feature: (minor, medium, minor muscle groups of upper and lower extremities, face and neck, back, abdominal wall, pelvic floor).
5. According to objects, sports apparatus or exercises equipment:
   - exercises without objects and sports apparatus
   - exercises with objects and sports apparatus
   - exercises with sports apparatus and exercise equipment

II. PLAYING

- sedentary games
- low activity
- active

III. WORK-RELATED

- vocational
- self-service
- exercises to restore ability to work at home and in the garden

IV. SPORTS-APPLIED

- walking, running
- swimming
- skiing
- cycling
- rowing
- horseback riding (hippotherapy).

Appendix 13

Time standards for performing medical gymnastics procedures for adults and children
(Ministry of Healthcare of the Russian Federation, order No. 337 of 20.08.01)

№	Procedure name	Time (mins)	Quantity of conventional units of procedure performance
	For therapeutic patients:		
1.	- suffering acute disease or exacerbation of chronic disease in bed rest	15	1.5
	- in recovery period or in chronic course of disease when treated individually	25	2.5
	- when treated in a group	35	3.5
2.	For patients who underwent surgical intervention:		
	- when treated individually	15	1.5
	- when treated in a group	20	2.0
3.	For trauma patients in immobilization period:		
	- when treated individually	15	1.5
	- when treated in a group	25	2.5
	- with spine and pelvic injuries after immobilization (individual sessions)	25	2.5
	- with spine and pelvic injuries after immobilization (group sessions)	35	3.5
	- with spine injuries (individual sessions)	35	3.5
	- with spine injuries (group sessions)	45	4.5
	- with spine injuries combined with cord injury	60	6.0
4.	For neurology patients:		
	- when treated individually	30	3.0

	- when treated in a group	45	4.5
5.	For pregnant women and women in labor:		
	- when treated individually	15	1.5
	- when treated in a group	30	3.0
6.	For school age children:		
	- when treated individually	30	3.0
	- when treated in a group	45	4.5
7.	For pre-school age children:		
	- when treated individually	25	2.5
	- when treated in a group	30	3.0
8.	Mechanotherapy procedures (exercising in gym) for one area (one joint)	15	1.5
9.	Occupational therapy	30	3.0
10.	Therapeutic swimming, medical gymnastics in water:		
	- when treated individually	30	3.0
	- when treated in a group	45	4.5

Appendix 14

Protocol of medical and pedagogical supervision

Date_____Supervision goal_____

Patient's name_____ Date of birth_____

ET form_____ Start time _____the end of exercise_____

Exercise goal_____ Exercise duration_____

Physiological curve of exercise performance

VLC	BP	P	Before procedure	Preparatory part	Main part	Concluding part	In ___mins.
5000	200	200					
4800	190	190					
4600	180	180					
4400	170	170					
4200	160	160					
4000	150	150					
3800	140	140					
3600	130	130					
3400	120	120					
3200	110	110					
3000	100	100					
2800	90	90					
2600	80	80					
2400	70	70					
2200	60	60					
2000	50	50					
1800	40	40					
1600	30						
1400	20						
1200	10						
1000	0						

Medical decision:

_____

Recommendations:

_____

Doctor_____

Appendix 15

Physiological motion parameters by joints

Joint	Motion type	Deviation value, degrees
Upper extremity		
	Abduction	45 without scapula
	Flexion	Up to 180 with scapula
Shoulder joint	Extension	Up to 45
	Shoulder external rotation	Up to 80
	internal rotation	Up to 90
Elbow joint	Flexion	40
	Extension	180
	Supination	90
	Pronation	90
Radiocarpal joint	Flexion	130
	Extension	110
	Abduction	160
	Adduction	135
Lower extremity		
Hip joint	Abduction	Approx. 130
	Adduction	150-160
	Flexion	60
	Extension	165
	External rotation	Approx. 60
	Internal rotation	45
Knee joint	Flexion	45
	Extension	180
Ankle joint	Flexion (plantar)	Up to 170
	Extension (dorsal)	70
	Supination	60
	Pronation	25

Educational edition

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MANUAL TO PRACTICAL SESSIONS ON MEDICAL SUPERVISION IN PHYSICAL EXERCISE, SPORTS AND CLINICAL PRACTICE

Teaching guide

2nd revised and expanded edition

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Signed in print 06.03.2019 г.
Format 60x84 1/16. Offset paper.
Print the risograph. Headset «Times». Printed paper 5.
Edition 100 экз. Order № 11

Printed in the laboratory of operative polygraphy of SibGMU
634050,Tomsk, Moskovsky trakt, 2