MINISTRY OF HEALTH OF UKRAINE
O.O. BOGOMOLETS NATIONAL MEDICAL UNIVERSITY

"Approved"
at the methodological conference of hygiene and ecology department
Head of the department
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GUIDELINES
FOR STUDENTS

Subject	Hygiene and ecology
Module № 1	Assessment of the environment and its impact on the population health
Submodule № 5	Hygiene of children and adolescents
Topic of the lesson	Physical development as a main criterion for assessment of children' and adolescents' health.
Course	6
Faculty	medical
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Kiev

1. Learning objective

1.1. Strengthen theoretical knowledge about factors and conditions of environment which influence the formation of children's health, general patterns of the child and adolescent organism growth and development, main criteria and indices of the children and adolescents health.

1.2. Master methods of complex assessment of the children and adolescents health and physical development.

2. Basics

2.1. You should know:

2.1.1. Principal factors of environment and social conditions of life, which influence health of childern and adolescents.

2.1.2. Main patterns of growth, development and peculiarities of morphological and functional state of the child and adolescent organism.

2.1.3. Methods of assessment of the children and adolescents health and physical development and criteria of allocation by health groups.

2.2. You should have the following skills:

2.2.1. To determine the health groups, somatometric, somatoscopic and physiometric indices of the children's and adolescents' physical development.

2.2.2. To assess of the children's and adolescents' physical development.

3. Self-training questions

3.1. Factors of environment and social conditions of life which influence the children and adolescent health formation.

3.2. General patterns of the child and adolescent organism growth and development. Assessment criteria and indices of the children's and adolescents' health.

3.3. Method of complex assessment of the children's and adolescents' health. Peculiarities of allocation of children and adolescents by health groups.

3.4. Physical development as a main criterion of assessment of health. Main incides of physical development.

3.5. Rules of anthropometry. Requirements to tables of regional standards of physical development.

3.6. Biological and chronological age. Indices of the biological development level of children and adolescents. Modern concepts of epochal and interage acceleration and deceleration (retardation).

3.7. Methods of assessment of the children's and adolescents' physical development (method of sigmal deviations, assessment by regression scales, complex and centile methods).

3.8. Methods of assessment of health state and physical development in

organized children collectives.

3.9. Tasks of doctor concering organization and carrying out of sanitary measures in children collectives (schools, gymnasiums, lyceums, colleges, hostels, vocational schools, children's homes, infant schools, labour and rest camps, extracurricular (out-of-school) establishments). Systems of the children's and adolescents' health management.

4. Self-training assignments

4.1. Deep medical examination of 11-year-old schoolboy was carried out. The following data were revealed: the boy has poor health (he suffers from acute viral respiratory infections every month), has weak myopia and carries. His body length is 133.5 cm, body weight – 23.5 kg, chest circumference – 59.2 cm. Determine health group for this schoolboy, assess his physical development using method of sigmal deviations and draw up the profile of physical development.

4.2. 14-year-old schoolgirl has 175 cm of height, 54.0 kg of body weight and 75.5 cm of chest circumference. Her body length has increased by 5 cm during previous year, number of permanent teeth is 28, level of secondary sexual signs development is: Ma_3, P_3, Ax_3, $Me_{1,2}$. Lung vital capacity is 2560 ml, muscle strength of right hand is 20 kg, left hand – 16 kg. No pathological changes were objectively detected in internal organs. She takes physical training in main group. Determine health group and assess this girl's physical development using sigmal deviations and complex methods.

4.3. 10-year-old practically healthy boy studies in general not specialized school during 3 years. His height is 125 cm, body weight – 30 kg, chest circumference – 64.0 cm, number of permanent teeth – 12, yearly height increase – 5 cm, level of secondary sexual signs development is: P_0, Ax_0. Determine health group of this schoolboy and assess his physical development using complex method.

5. Structure and content of the lesson (duration of the lesson 160 min + 10 min break)

5.1. Preamble – 5-10 min.
5.2. Test control for assessment of students' knowledge datum level – 10-15 min
5.3. Theoretical training – 30-40 min.
5.4. Typical situational tasks "Krok-2" solution – 30-40 min.
5.5. State exams situational tasks solution – 30-40 min.
5.6. Test control for assessment of students' knowledge final level – 10-15 min.
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Appendix 1

TRAINING INSTRUCTION
on complex assessment of children's and adolescents' health

Assessment of health state is the most important role of a physician, who works with children and adolescents. It's main importance lies in the fact, that the formation of physical and psychological human health, organism's resistance to influence of

unfavourable environmetnal factors and social contitions takes place in childhood.

The following *criteria of complex assessment of the children and adolescents health state* are used nowadays in everday practice of sanitary doctors, doctors of general education establishments, pediatricians, general practitioners and family doctors*:*

- Presence or absence of chronical diseases during examination;
- Functional state of main systems of organism;
- Level of organism resistance to unfavourable influence of environemntal factors;
- Current level of nervous and psychological, and physical development, its harmonicity.

According to listed above criteria, allocation scheme of children and adolescents by health groups was elaborated. There are *5 health groups*:

First health group includes healthy children and adolescents with harmonious development and development level of organism functional systems corresponding to the age.

Second health group includes healthy children and adolescents who have functional and some morphological deviations, low resistance to acute and chroonic diseases, they are ill frequently during long period of time.

Third health group includes children and adolescents suffering from chronic diseases in compensation stage, with normal fucntional resources of organism.

Fourth health group includes children and adolescents suffering from chronic diseases in subcompensation stage with lowered funcional resources of organism.

Fifth health group includes children and adolescents suffering from chronic diseases in decompensation stage with significantelly lowered funcional resources of organism.

morbidity rate

Table 1

Patterns of rank distribution of diseases in different age groups

Rank place	*Age group, years old*			
	0–3	**3–6**	**7–14**	**15–17**
I	Diseases of respiratory organs	Diseases of respiratory organs	Diseases of respiratory organs	Diseases of respiratory organs
II	Diseases of nervous system and sense organs	Diseases of nervous system and sense organs	Diseases of nervous system and sense organs	Diseases of nervous system and sense organs
III	Diseases of gastrointestinal tract	Diseases of skin and subcutaneous	Diseases of gastrointestinal tract	Diseases of gastrointestinal tract

		fat layer		
IV	Diseases of endocrine system	Diseases of blood and hemopoietic organs	Diseases of endocrine system	Diseases of endocrine system
V	Diseases of skin and subcutaneous fat layer	Infectious and parasitic diseases	Diseases of musculoskeletal system	Diseases of musculoskeletal system

Allocation of children by health groups allows to reveal people who have *risk factors* concerning development of pathological deviations, children with initial forms of diseases and functional deviations, and, based on received results to work out complex measures for protection and strengthening of children's health, prevention of chronic diseases appearance.

First of all these measures must be directed on children, belonging to the second health group (children-reconvalexscents, children who are ill frequently during long period of time, with general delay and dysharmonicity of physical development due to being overweight or underweight without endocrine pathology, with bending disorders, flat feet, with functional deviations of cardiovascular system, myopia, carries, II stage hypertrophy of palatine tonsils, allergic reactions, thyriod gland enlargement of I and II stages, asthenic syndrom etc.).

Following data may be used for *assessment of organism resistance*: morbidity rate with temporal disability and exacerbation of chronic diseases during previous and current years, incides of nonspecific resistance (X-chromatine and geretochromatne content in the cheek mucous membrane epithelium, glicogen content in neutriphils, activity of alkaline and acid phosphotase in neutrophils, dehydrogenas in limphocytes, lysozyme and lactatedehydrohynase in saliva, level of skin bactericidal action etc.).

Assessment of functional state of organism is carried out using clinical methods and special *functional tests* (orthostatic sign, Martine-Kushelevskiy test), Letuvov test, step-test (PWC_{170}) etc.).

There are favourable (sanitary, health-improving) and unfavourable (or risk factors) *factors which form health* and significantly influence processes of development of growing organism.

Sanitary (health-improving) factors are the follwoing:

- rational regime of daily activity;
- adequate and balanced nutrition;
- correspondence of environment to hygienic standards;
- optimal motor activity;
- tempering;
- healthy lifestyle and following of the everyday hygienic rules.

Unfavourable (risk factors) are the following:

- disturbances in day regime, educational process;
- disadvantages in organization of nutrition;
- breaches of hygienic requirements to game, educational, extracurricular and

labour activity;

- insufficient or excess motor activity;
- unfavourable psychological climate in family and collective;
- Harmful habits and ignorance of the everyday hygienic rules.

Determination of favourable and unfavourable factors influence on pupils' health allows to work out, scientificaly substantiate and introduce the system (concept) for management of health state of children and adolescents.

Four main blocks are necessary to be distinguished in the *modern system of management of health state among children and adolescents collectives* (see diagram on fig. 38.2): 1st block – receiving of statistical information about health of children and adolescent collectives based on the data of annual medical examinations; 2nd block – establishment of cause and effect connection between main factors forming health; 3rd block – preventive and regular sanitary inspection in children and adolescents institutions based on existing hygienic norms and rules; 4th block – working out the complex of preventive measures and their realization as a direct influence both on organism and environment.

Appendix 2

TRAINING INSTRUCTION
on assessment of physical developent of children and adolescents

Physical development of children and adolescents is assessed based on somatoscopic (anthroposcopic), somatometric (anthropometric) and physiometric indices with their further interpretation using method of sigmal deviations, regression scales, complex or centile methods.

There are following *somatoscopic indices*: condition of skin and mucous membranes, degree of fat diposity, characteristics of musculoskeletal system (bearing, form of chest, sceleton, legs and feet), also signs of sexual development (pilosis/hair distribution on armpit and pubis, mammary glands development for girls, hair distribution on face, development of larynx thyroid cartilage, voice mutation for boys)

Main *somatometric incides* are the following: body length and weight, thorax circumference and other (circumferences of head, shoulder, hip etc.), and they are determined using special anthrpometric points

There are such *physiometric indices* as muscle strength of hands, lung vital capacity, torso strength etc.

Wooden auxanometer is used for determination of body length in standing and sitting positions. Wooden auxanometer is 2 meters high pole which is fixed on 70 x 45 cm frame with folding bench at 40 cm height used for length determination in sitting position. Two columns of centimeter points are marked on the pole. Results are read according to the first column from the frame, according to the second column – from the folding bench. Movable muff with horizontal plane is fixed on the pole. This muff is lowered until it touches the parietal bone of examined person.

The examined person has to stand still, leaning with his/her back to the pole, hold heels together and toes separately and touch the stick in three points – heels, buttocks and interscapular region during *examination of body length in standing position*. The head of examined person must be in such position that the line connecting lower border of eye-hole and upper border of ear tragus is parallel to floor.

Medical scale is used for the *body weight* measurement.

Thorax circumference is measured with tape-line when patient is maximally calm, takes a forced inspiration and expiration (tape line has to pass along lower border of mammillary ring for boys and along four rib for girls at the front, and along the lower border of scapulas with arms put down - behind).

Water or pneumatic spirometer is used for determination of *lung vital capacity*, hand dynamometer – for determination of *muscle strength of hands*, torso dynamometer – for determination of *torso strength*. Maximum result is registered during examination in any case.

The assessment of physical development is carried out comparing individual data and *regional standards of physical development* (average standard values for each age and sex group which reflect level of physical development of chlidren and adolescents living in same conditions).

Assessment of physical development using method of sigmal deviations

Method of sigmal deviations with image of physical profile is used to assess the physical development comparing each individual index with weight-average arithmetical value for this index at certain age. This allows to find out this index's actual deviation from standard values.

Then the *sigmal deviation (σ)* is found by division of actual value by the value of mean square deviation. This information reveals the sigma value which may vary, this value for each child may differ from average special for certain age and sex group values.

Deviations from -1σ to $+1\sigma$ mean *average* development of this index, from -1.1σ to -2σ – development is *below average*, from -2.1σ and below – *low*, from $+1.1\sigma$ to $+2\sigma$ – *above average*, from $+2.1\sigma$ and high – *high*.

To draw a *profile of physical development* the following procedure has to be done: horizontal lines corresponding to the number of indices for further assessment are drawn and the value of received sigmal deviation is pointed on each line, then these points are connected with straight line (see fig. 38.7).

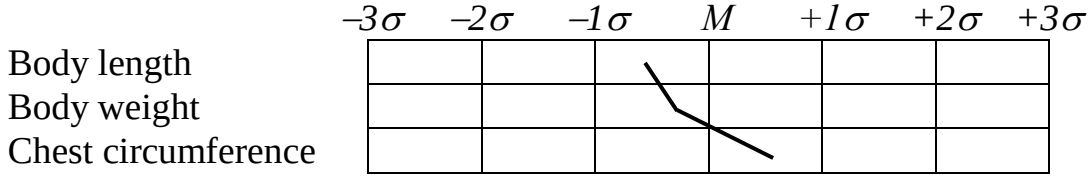


Fig. 38.7 Profile of physical development

Method of sigmal deviations allows to determine the level of each separate index of physical development and its proportionality based on the profile data. If values of deviations correspond to one sigma - the physical development is *proportional*, if the

values of deviations are two and more sigmas – the physical development is *disproportional*.

The conclusion about physical development of a child has to be the following while using method of sigmal deviations: *"Physical development of Petrenko I., 10years old, is average (below average, low, above average, high) accroding to the body length, average (below average, low, avobe average, high) according to the body weight, average (below average, low, avobe average, high) according to the ches girth, proportional (disproportional)".*

Example: it is necessary to assess the physical development of 10-year-old boy Petrenko with 129 cm body length, 37 kg body weight and 61 cm chest girth.

During self-training task the data about this pupil (surname, sex, age, health state) are drawn into the protocol, then according to the example (table 2) the column "Pupil" is filled with data of examined pupil concerning body length, body weight and chest girth.

Table 2

Data of individual assessment of physical development

Indices of physical development	***Pupil***	**Standard**		*Difference between actual and standard values*	*Value of sigmal deviation*	*Assessment*
		M	σ			
Body length, cm	129	137.3	5.6	– 8.3	– 1.48 σ	Below average
Body weight, kg	24	33.4	6.0	– 9.4	– 1.56 σ	Below average
Chest girth, cm	61	67.5	4.8	– 6.5	– 1.35 σ	Below average

After that, using the table 3, the sex and age of examined pupil are found, coresponding standard values of separate indices (body length and weight, chest girth) of physical development: average arithmetical weighted value (*M*) and mean square deviation (σ) and drawn into the table 2 (see column "Standard").

After that, the difference between actual and standard values is calculated for each index. In our example, body length of 10 years old boy is 129 cm, standard value of this index (*M*) is 137.3 cm, difference between them is 129 – 137.3 = –8.3 cm.

Received difference is divided by σ (in our example it's value is 5.6 cm) and sigmal deviation is found: –8.3 : 5.6 = –1.48σ. And, at last, the assessment of physical development according to each index is substantiated based on value and indication of sigmal deviation.

Table 3

Regional standards of physical development indices for schoolchildren

Age	*Body length, cm*	*Body weight, kg*	*Chest girth, cm*

	M	σ	M	σ	M	σ
Boys						
7	121.6	5.8	24.3	3.98	61.0	3.68
8	128.1	5.56	27.9	4.94	62.5	4.92
9	132.6	5.4	30.2	5.3	65.4	4.74
10	137.3	5.6	33.4	6.0	67.5	4.8
11	142.5	6.26	37.0	6.82	69.9	5.2
12	147.0	6.96	39.9	6.7	71.6	4.46
13	153.5	8.22	45.1	8.74	75.0	5.48
14	161.1	8.74	50.8	8.7	78.7	6.14
15	166.9	8.16	57.2	10.12	82.0	6.0
16	173.1	7.02	62.98	8.24	85.3	4.52
17	178.4	7.6	65.6	7.8	87.0	4.0
Girls						
7	121.5	5.54	23.3	3.65	59.0	2.4
8	127.0	5.26	26.8	4.74	59.0	3.2
9	131.5	5.74	29.0	4.52	61.9	2.7
10	137.4	6.15	33.3	7.0	63.4	2.4
11	142.8	7.1	37.0	7.30	66.8	4.0
12	149.3	6.8	40.4	7.08	70.4	4.8
13	156.2	6.2	48.5	7.74	73.2	5.6
14	159.2	5.42	51.8	8.78	79.4	5.1
15	161.5	5.54	23.3	3.65	82.1	5.1
16	1680.	5.2	54.6	6.6	83.4	4.5
17	169.5	4.9	55.9	7.0	84.8	4.2

In our example, taking into account that sigmal deviation is -1.48σ, physical develpment of a boy according to the body length is under average.

Using mentioned above sequence, data of physical development according to other indices are analyzed.

Based on received results the conclusion is substantiated. In our example the conclusion is following: *"Physical development of 10 years old Petrenko I. According to the body length and weight, chest girth is below average, proportional"*.

There are such main disadvantages of this method of physical development assessment as indices are assessed separately and level of their correlation is not taken into account. At the same time certain values of body weight and chest girth correspond to certain body length of an organism, and physical development has to be proportional. This disadvantage can be removed using method of physical development assessment by regerssion scales, complex and centile methods.

Assessment of physical development using regression scales

Usage of method of assessment of *physical development using regression scales* allows to overcome the main disadvantage of method of sigmal deviations – separate character during assessment of each somatometric index. In this case tables for

assessment include correlation between height, body weight and chest girth. This correlation allows to give more substantiative assessment of physical development taking into account interconnected indices.

First stage of the physical development assessment using regression scales tables includes *search of group* (developmnt is average, below average, above average, high, low) to which the child body length is attributed.

Then the body weight and chest girth indices corresponding to actual height are compared with actual indices of examined people. For this, it is necessary to subtract standard value of examined index from value of actual development of this index and the received result is divided by sigma-regression (σ_R) for each examined index.

Physical development may be:

– *harmonic,* if determined individual indices of body weight and chest girth circumference have values $M \pm 1\sigma_R$;

– *disharmonic,* if determined individual indices of body weight and chest girth have values from $M–1.1\sigma_R$ to $M–2\sigma_R$ or from $M+1.1\sigma_R$ to $M+2\sigma_R$ due to increased fat deposity;

– *sharply disharmonic*, if determined individual indices of body weight and chest girth have values from $M–2.1\sigma_R$ and low or from $M+2.1\sigma_R$ and high due to increased adipopexis.

If the method of regression scales is used for the physical development assessment the conclusion has to be the following: *"Physical development of 10 years old Petrenko I. is average (above average, high, below average, low) according to the body length, harmonic (disharmonic, sharply disharmonic) according to the body weight and chest girth.*

Fuethermore, this type of examination can determine one from four groups of physical dvelopment for this child: *normal physical development* – if body weight is from $M–1\sigma_R$ to $M+2\sigma_R$; *body weight deficiency* – if body weight is lower than $M–1.1\sigma_R$; *body weight excess*– if body weight is more than $M+2.1\sigma_R$; *low height* – if body length if lower than $M–2\sigma$.

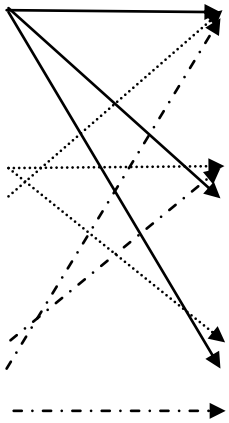
Assessment of physical development using complex method

Complex method of the physical develoment assessment includes both peculiarities of morphological and functional state of the organism and correspondence of the organism biological development to his chronological age (table 4).

Table 4

Assessment criteria of physical development of children and adolescents

(using complex method)

Level of biological development	*Diagram of dependence of biological development, morphological and functional state*	*Morphological and functional state of the organism*	*Body weight, chest girth ($M\pm\sigma_R$)*	*Functional indices*
Corresponds to the age		**Harmonic**	$M\pm\sigma_R$	$M-\sigma$ *and more*
Ahead of chronological age		***Disharmonic***	$M-1{,}1\sigma_R...M-2\sigma_R$ due to body weight deficiency $M+1{,}1\sigma_R...M+2\sigma_R$ due to increased adipopexis	$M-1.1\sigma$... $M-2\sigma$
Behind the chronological age		***Sharply disharmonic***	$M-2{,}1\sigma_R$ *and low* due to body weight deficiency $M\pm2{,}1\sigma_R$ *and more* due to increased adipopexis	$M-2.1\sigma$ *and low*

At first, *biological age of a child* has to be determined based on the body length and annual body length increase, number of permanent teeth, secondary signs of sexual development, time of ossification of hand bones and compared with chronological age. Depending on the received data the biological age may be *corresponding to the chronological age, ahead of or behind the chronological age*.

Next stage of the complex method is assessment of *morphological and functional state of the organism* according to regression scales, age and sex standards of the functional indices development. Physical development may be:

– *harmonic*, if determined body weight and chest girth values are $M\pm1\sigma_R$ or from $M\pm1.1\sigma_R$ and functional indices have deviations from -1σ and more;

– *disharmonic*, if determined body weight and chest girth values are from $M-1.1\sigma_R$ to $M-2\sigma_R$ or from $M+1.1\sigma_R$ *to* $M+2\sigma_R$ due to body weight deficiency or increased adipopexis and functional indices are from -1.1σ to -2σ;

– *sharply disharmonic*, if determined body weight and chest girth values are from $M-2.1\sigma_R$ and low or from $M+2.1\sigma_R$ and more due to body weight deficiency or increased fat deposity and functional indices are from -2.1σ and lower.

If complex method is used for assessment of physical development the

conclusion has to be the following: *"Physical development of 10 years old Petrenko I. is average (above average, high, below average,low), harmonic (disharmonic, sharply disharmonic), biological age corresponds to chronological age (ahead of chronological age, behind ones)".*

Level of biological development is determined based on correlation between its main signs and age and sex standards (tables 5 and 6) while using complex method of the physical development assessment.

Table 5

Indices of biological development level for schoolboys

Age	*Body length ($M\pm\sigma$)*	*Annual body length velocity, cm*	***Signs of ossification of hand bones***	*Number of permanent teeth ($M\pm\sigma$)*	*Level of sexual development*
7	$M_7\pm\sigma$	4–6	Existence of centers of ossifications on all carpal bones except the piciform one, appearance of epiphysis of the ulnar bone	7±3	P_0, Ax_0
8	$M_8\pm\sigma$	4–6	Presence of epiphysis of the ulnar bone	12±2	P_0, Ax_0
9	$M_9\pm\sigma$	4–6	Well-defined epiphysis of the ulnar bone	14±2	P_0, Ax_0
10	$M_{10}\pm\sigma$	4–6	Appearance and formation of the styloid process of ulna	18±3	P_0, Ax_0
11	$M_{11}\pm\sigma$	4–6	Presence of well-defined styloid process of ulna	20±4	P_0, Ax_0
12	$M_{12}\pm\sigma$	4–6	Appearance of the piciform bone	24±3	$P_{0,1}$, Ax_0, V_1
13	$M_{13}\pm\sigma$	7–10	Appearance of sesamoid bone in the metacarpophalangeal joint	27±1	P_1, Ax_0, V_1, $L_{0,1}$
14	$M_{14}\pm\sigma$	7–10	Appearance of sesamoid bone	28	P_2, Ax_1, $V_{1,2}$, $L_{0,1}$, $F_{0,1}$
15	$M_{15}\pm\sigma$	4–7	Beginning of ossification in the I metacarpal bone	28	P_3, Ax_2, V_2, $L_{1,2}$, F_1
16	$M_{16}\pm\sigma$	3–4	Ossification of I metacarpal bone and distal phalanxes of fingers	28	$P_{3,4}$, Ax_3, V_2 L_2, $F_{1,2}$
17	–	1–2	Ossification of III-V metacarpal bones	28	P_4, Ax_3, V_2, L_2, $F_{2,3}$

Table 6

Indices of biological development level for schoolgirls

Age	*Body length (M±σ)*	*Annual body length velocity, cm*	***Signs of ossification of hand bones***	*Number of permanent teeth (M±σ)*	*Level of sexual development*
7	$M_7 \pm \sigma$	4–5	Existence of centers of ossifications on all carpal bones except the piciform one, appearance of epiphysis of the ulnar bone	9±3	Ma_0, P_0, Ax_0
8	$M_8 \pm \sigma$	4–5	Appearance and formation of the styloid process of ulna	12±3	Ma_0, P_0, Ax_0
9	$M_9 \pm \sigma$	4–5	Presence of well-defined styloid process of ulna	15±3	Ma_0, P_0, Ax_0
10	$M_{10} \pm \sigma$	4–5	Formation of the piciform bone	19±3	Ma_0, P_0, A_0
11	$M_{11} \pm \sigma$	6–8	Presence of well-defined piriform bone, appearance of sesamoid bone	21±3	Ma_1, $P_{0,1}$, $Ax_{0,1}$
12	$M_{12} \pm \sigma$	6–8	Presence of sesamoid bone	25±2	Ma_2, $P_{0,2}$, $Ax_{1,2}$
13	$M_{13} \pm \sigma$	4–6	Ossification in the I metacarpal bone	28	$Ma_{2,3}$, $P_{2,3}$, $Ax_{2,3}$, Me
14	$M_{14} \pm \sigma$	2–4	Ossification of III-V metacarpal bones	28	Ma_3, P_3, $Ax_{2,3}$, Me
15	$M_{15} \pm \sigma$	1–2	Total ossification of all hand bones	28	Ma_3, P_3, Ax_3, Me
16	–	1–2	Ossification of ulnar bone	28	$Ma_{3,4}$, P_3, Ax_3, Me
17	–	0–1	Ossification of radial bone	28	Ma_4, P_3, Ax_3 Me

Note: Ax – pits' covering with the hair, P – genital organs' covering with the hair, F – appearance of hair on the face, L – development of the Adam's ball, V – voice mutation, Ma – development of mammary glands, Me – appearance of menses.

Level of physical development according to the body length may be determined using regression scales or method of sigmal deviations.

As in a previous case there are five criteria of physical development according to the height: high, avobe average, average, below average, low.

Mean-weighted value for each sign of physical development can be found in the table 7.

Table 7

Regional standard indices of physical development for 7-16 years old children

and adolescents

Age	*Body length, cm*		*Body weight, kg*				*Chest girth, cm*			
	M	σ	*M*	σ	$R_{y/x}$	σ_R	*M*	σ	$R_{y/x}$	σ_R
Boys										
7	121.6	5.8	24.3	3.98	0.52	2.28	61.0	3.68	0.31	3.31
8	128.1	5.56	27.9	4.94	0.66	3.26	62.5	4.92	0.38	3.25
9	132.6	5.4	30.2	5.3	0.69	3.76	65.4	4.74	0.52	3.79
10	137.3	5.6	33.4	6.0	0.80	3.96	67.5	4.80	0.55	3.70
11	142.5	6.26	37.0	6.82	0.83	4.43	69.9	5.20	0.53	4.0
12	147.0	6.96	39.9	6.7	0.71	4.49	71.6	4.46	0.34	3.79
13	153.5	8.22	45.1	8.74	0.84	5.33	75.0	5.48	0.37	4.55
14	161.1	8.74	50.8	8.70	0.79	5.31	78.7	6.14	0.42	4.85
15	166.9	8.16	57.2	10.12	0.92	6.78	82.0	6.0	0.44	4.44
16	173.1	7.02	62.98	8.24	0.61	5.42	85.3	4.52	0.21	4.67
Girls										
7	121.5	5.54	23.3	3.65	0.53	2.19	58.7	3.51	0.38	2.51
8	127.0	5.26	26.8	4.74	0.58	3.60	60.6	4.36	0.43	3.71
9	131.5	5.74	29.0	4.52	0.55	3.21	62.4	4.06	0.38	3.45
10	137.4	6.15	33.3	7.0	0.80	5.11	65.7	5.28	0.53	4.17
11	142.8	7.1	37.0	7.30	0.74	5.11	69.7	5.28	0.47	4.06
12	149.3	6.8	40.4	7.08	0.75	4.88	69.8	5.02	0.38	3.66
13	156.2	6.2	48.5	7.74	0.45	6.38	74.7	5.32	0.40	4.73
14	159.2	5.42	51.8	8.78	0.83	5.55	77.3	3.86	0.33	5.47
15	158.0	5.2	54.6	6.6	0.65	6.44	83.4	4.5	0.45	4.76
16	159.5	4.9	55.9	7.0	0.85	6.55	84.8	4.2	0.35	5.66

Regression coefficient ($R_{y/x}$) reveals the value by which value of body weight (kg) or chest girth (cm) changes while body length increases or decreases by standard measurement unit (cm). Sigma-regression (σ_R) allows to determine the value of the individual body weight and thorax girth deviation from standard data of body length.

Assessment tables (regression scales according to height) are drawn using regression coefficient and sigma-regression. These tables allow to determine harmonicity of the organism development according to morphological indices. Comparing actual values of body weight and chest girth with their standard values for certain age and sex it is possible to identify level of the physical development harmonicity.

Difference between actual and standard values of the physical development index is divided by sigma-regression and the value of sigmal deviation is received, which allows to determine the level of harmonicity of the schoolchild's physical development.

Assessment criteria of the organism physical development using regression scales are presented above. If a child has deviation of body weight from standard values more than $\pm 3\sigma_R$ he/she should bee sent to the doctor-endocrinologist for further advice.

Table 8

Assessment of physical development of 11 years old schoolchildren
(regression scale according to the height)

Border of sigmal deviations	*Body length, cm*	*Body weight, kg*	*Chest girth, cm*	*Body length, cm*	*Body weight, kg*	*Chest girth, cm*
	11 years old boys			11 years old girls		
Low (from *M–2σ* and low)	123	20.9	59.8	123	22.1	58.0
	124	216	60.2	124	22.9	58.5
	125	22.7	60.6	125	23.6	59.0
	126	23.1	61.0	126	24.3	59.5
	127	23.7	61.4	127	25.1	60.0
	128	24.5	61.8	128	25.8	60.5
	129	25.2	66.2			
Below average (from *M–1σ* to *M–2σ*)	130	25.9	62.7	129	26.5	61.0
	131	22.6	63.1	130	27.2	61.6
	132	27.3	63.5	131	28.0	62.1
	133	28.1	63.9	132	28.7	62.6
	134	28.8	64.3	133	29.4	63.1
	135	29.5	64.7	134	30.2	636
	136	30.2	65.1	135	30.9	64.1
				136	31.6	64.6
Average (M±1σ)	137	30.9	65.5	137	32.4	65.1
	138	31.7	65.9	138	33.1	65.6
	139	32.4	66.3	139	33.8	66.1
	140	33.1	66.8	140	34.6	66.7
	141	33.8	67.2	141	35.3	67.2
	142	34.5	67.6	142	36.0	67.7
	143	35.3	68.0	143	36.7	68.2
	144	36.0	68.4	144	37.5	68.7
	145	36.7	68.8	145	38.2	69.2
	146	37.4	69.2	146	38.9	69.7
	147	38.1	69.6	147	39.7	70.2
	148	38.9	70.0	148	40.4	70.7
	149	39.6	70.4	149	41.1	71.2
	159	40.3	70.8	159	41.8	71.8
	151	41.0	71.3	151	42.6	72.3
Avobe average (from *M+1σ* to	152	41.7	71.7	152	43.3	72.8
	153	42.5	72.1	153	44.0	73.3
	154	432	72.5	154	44.8	73.8
	155	43.9	72.9	155	45.5	74.3

Border of sigmal deviations	*Body length, cm*	*Body weight, kg*	*Chest girth, cm*	*Body length, cm*	*Body weight, kg*	*Chest girth, cm*
	11 years old boys			11 years old girls		
$M+2\sigma$)	156	44.6	73.3	156	46.2	74.8
	157	45.3	73.7	157	47.0	75.3
	158	46.1	74.1	158	47.7	75.8
	159	46.8	74.5	159	48.4	76.3
High (from $M+2\sigma$ and more)	160	47.5	75.0	160	49.2	76.9
	161	48.2	75.4	161	49.9	77.4
	162	48.9	74.8	162	50.6	77.9
	163	49.7	76.2	163	51.3	78.4
	164	50.4	76.6	164	52.1	78.9
	165	51.1	77.0	165	52.8	79.4
M	144.5	36.4	68.6	143.9	37.4	68.6
σ	7.01	7.01	5.46	7.54	7.72	6.22
$R_{y/x}$		0.72	0.41		0.73	0.51
σ_R		4.89	4.63		5.37	4.92

Method of standard sigmal deviations is used for assessment of functional indices by complex method.

Example: it is necessary to assess the physical development of 11-year-old girl with 148 cm body length, 37 kg body weight, 71 cm chest girth, 8 cm annual body length increase, she also has 20 permanent teeth and secondary signs of sexual development are the following: Ma_1. P_1. Ax_1. The doctor's actions during physical development assessment include such steps.

First of all, the doctor has to compare data of examined girls with standards of biological development for 11 years old girls to determine level of biological development (table 5).

The values of examined girl must be the following: body length – 142.8±7.1 cm, annual body length increase – 6-8 cm, 21±3 permanent teeth, secondary signs of sexual development – Ma_1. $P_{0.1}$. $Ax_{0.1}$ according to the standards of biological development for 11 years old girls. In our example, indices of this girl's biological development correspond to standard values. It means that level of biological development corresponds to chronological age.

Then assessment tables according to regression scales (table 8) are used for assessment of physical development. According to the table data this girl's height corresponds to average, her physical development according to the body length is average. Next step – using values of sigma-regression to find values of body weight and chest girth which this girl must have according to her height. According to the regression scales tables data body weight has to be 40.4 kg, sigma regression (σ_R) – 5.37 cm for 11 years old and 148cm height girls. Difference between actual and standard values is 37 – 40.4 = –3.4; value of the sigma regression deviation is –3.4 : 5.37= $-0.63\sigma_R$. These data reveal that this girl has harmonic development according to the body weight comparing to the height.

Correspondence of chest girth to body length of this girl is calculated in the same way. Chest girth has to be 70.7 kg, sigma-regression (σ_R) – 4.92 cm for 11 yeas old girls with 148 cm. Difference between actual and standard values is 71 – 70.7 = 0.3; value of sigma-regerssion deviation is 0.3 : 4.92= $0.06\sigma_R$. This means that physical development of this girls is harmonic according to the chest girth comparing to her height.

If physical development is disharmonic or sharply disharmonic it is necessary to point the cause of revealed morphological and functional disorders (due to being overweight or underweight, small chest girth) and substantiate recommendations concerning physical development correction (increasing or decreasing of the food intake energy content, usage of other food products, implementation of active physical training, sport etc.).

Assessment of physical development using centile method

Centile method, opposed to traditional ones allows to assess physical development signs varying according to the normal distibution law. Centile method is effective non-parametric instrument to describe their distribution briefly which may have right-sided or left-sided asymmetry.

Essence of centile method means comparing of actual value of each separate index of the physical development to sorted series. These sorted series include 100 interval ranges of examined index. Probabilities of an index belonging to each of these intervals are equal, but sizes of those centile intervals are unequal in absolute units.

For determination of physical development level 7 fixed centiles are used: 3rd, 10th, 25th, 50th, 75th, 90th and 97th and corresponding 8 centile intervals:

- 1st interval (below 3%) – *very low indices;*
- 2nd interval (from 3% to 10%) – *low indices;*
- 3rd interval (from 10% to 25%) – *reduced indices;*
- 4th and 5th intervals (from 25% to 50% and from 50% to 75% correspondently) – *average indices;*
- 6th interval (from 75% to 90%) – *increased indices;*
- 7th interval (from 90% to 97%) – *high indices;*
- 8th interval (above 97%) – *very high indices*.

Individual assessment of morphologicl and functional indices is carried out using single-measured assessment scales which include double-amplitude peaks (maximum and minimum values), centile tendency (median of sorted series) and 8 centile intervals. Such approach allows to determine both separate characteristics of the somatometric signs development and level of physical development harmonicity taking into account the fact, that 4th and 5th centiles of nomorgam correspond to *harmonic physical development*, 3rd and 6th – *disharmonic*, 1st, 2nd, 7th and 8th – *sharply disharmonic due to being overweight or underweight.*

Appendix 3

TRAINING INSTRUCTION

on hygienic assessment of health state and physical development among organized children collectives

Comparative assessment of physical development level in different organized collectives or the same collective during study in modern school is carried out based on the determination of difference of main health state indices and physical development values using methods of mean arithmetic values comparison, algebraic number distribution and square deviation comparison, and correlation method.

While using *method of mean arithmetic values comparison* only indices of health state and physical development of similar age and sex groups have to be compared. First of all it is necessary to establish difference between mean values of comparative groups by using Student's test (t) calculation according to the following formula:

$$t = \frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}};$$

where: M_1 and M_2 – mean arithmetic-weighted values of comparative groups;

m_1 and m_2 – errors of mean arithmetic-weighted values.

Assessment of Student's test (t) includes the following parameters: if t value exceeds 3, than differences of mean values are valid ($p<0.05$), if t value does not exceed 3 – differences between mean values are invalid ($p>0.05$).

Example: deep medical examination was carried out among 10 years old schoolchildren in towns B. and K. Following physical development indices were revealed during this examination:

- in town B.: average body length of boys is 156.00±0.72 cm, average body weight – 44.40±0.38 kg.
- in town K.: average body length of boys is 151.00±0.58 cm, average body weight – 43.20±0.73 kg.

Assessment of validity of differences between schoolchildren's body length and weight in mentioned above towns is carrying out by following way:

For body length: $t = \frac{156-151}{\sqrt{0.72^2 + 0.58^2}} = \frac{5}{0.88} = 5.6;$

For body weight: $t = \frac{44.3-43.2}{\sqrt{0.38^2 + 0.73^2}} = \frac{1.1}{0.83} = 1.3.$

10-year-old schoolchildren in town K. are significantly shorter than schoolchildren in town B. Additional research is necessary to identify main causes of this phenomenon.

While using *method of algebraic number distribution,* at first physical development of each child of organized collective is assessed and the assessment group is determined for each child. After that, the percentage of children in each group is calculated.

Validity of differences is calculated according to the following formula:

$$t = \frac{P_1 - P_2}{\sqrt{m_1^2 + m_2^2}};$$

where: P_1 – number of children (%) in first comparative collective;

P_2 – number of children (%) in second comparative collective;

m_1 – error of P_1;

m_2 – error of P_2.

Error of percentage of children is calculated according to the following formula:

$$m_1 = \sqrt{\frac{P_1 - (100 - P_1)}{n}} ;$$

where: m_1 – error of P_1;

P_1 – number of children (%) in first comparative collective.

Method of square deviation comparison is used for assessment of health state and physical development homogeneity according to the certain index. If standard deviation *(σ)* value is higher, double-amplitude peaks of examined indices is also higher and, as a result, higher is the degree of their variability and heterogeneity.

Correlation method allows to discover the certain correlation between characteristics of health state and physical development by calculation of correlation coefficient *(r)*. If value of *r* equals to 0 the correlation between examined indices is absent. On the contrary, if value of *r* equals to 1, correlation between indices is very strong, absolute, functional. If values of *r* are from 0 to 0.3, correlation is weak; if values of are from 0.3 to 0.5, correlation is moderate, if values of *r* are from 0.5 to 0.7, correlation is strong, if values of *r* are from 0.7 to 1.0, correlation is very strong. If value *r* is positive, correlation is direct (if one examined index increases - another one also increases), if value of *r* is negative, correlation is reverse (if one examined index increases another one decreases).

6. Literature

6.1. Principal:

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В.Г.Бардова, І.І.Швайка. — К., 1994. — ч.ІІ. — С. 48—51.

6.1.10. Берзінь В.І. Основи психогігієни. — К., Вища школа, 1997. — С. 70—84.

6.1.11. Lecture materials.

6.2. Additional:

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3. Medicine of emergency situations: textbook for students of higher medical institutions / V.V. Chaplyk, P.V. Oliynyk, S.T. Omelchuk, V.V. Humenyuk. – Vinnytsia: Nova Knyha, 2012. – 344 p.

4. General nutrition: Study guide for the 4th accreditation level Medical School Students / edited by S.T. Omelchuk, O.V. Kuzminska. – Kyiv, 2016. – 146 p.

5. Гигиена и экология: учебник для студентов высших медицинских учебных заведений. – Винница: НОВА КНИГА, 2008ю – 720 с.

7. Equipment required for the lesson

1. Anthropometer, tape-line, caliper (thickness compasses).
2. Hand and torso dynamometers.
3. Spirometer, tonometer.
4. Tables:

– Criteria of schoolchildren physical development;

– Criteria for assessment of physical development of children and adolescents;

– Indices of the biological development level for schoolboys and schoolgirls;

– Standardized criteria of physical development for 7-17 years old children and adolescents;

– Assessment of schoolchildren's physical development (regression scales according to the height).

5. Situational tasks for assessment of children's and adolescent's physical development (students' self-training tasks).