

Ministry of Education and Science of Ukraine  
V. N. Karazin Kharkiv National University

## **PHYSICAL DEVELOPMENT OF CHILD**

Methodical recommendations for medical students of 3<sup>rd</sup> year of study

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Methodical recommendations are worked out on the basis of Programs of discipline «Propaedeutic to pediatrics» for students of higher medical educational institutions of III–IV levels of accreditation, authorized by Ministry of Health of Ukraine. These recommendations are intended for English-speaking medical students of the 3rd year.

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## **LIST OF ABBREVIATIONS**

WHO – World Health Organization

BMI – body mass index

HC – head circumference

CC – chest circumference

Kg – kilogram

L – length

## INTRODUCTION

Physical development of a child The World Health Organization defines as a total indicator of the health of an individual child and population, and indicators of physical development of young children as a criterion for assessing the socio-economic development of a particular region and country. The monitoring of the physical development of young children is considered by WHO as one of the most effective measures undertaken by healthcare professionals on reducing the mortality and morbidity rates of young children.

The level of physical development of a child at a certain age is one of the most objective and sensitive indicators of health. Anthropometry makes it possible to quantify and assess physical development. It is very widely used in medicine. One of the first procedures that are occurred after the birth of a new person is its anthropometric study. The most serious diseases are often diagnosed precisely after the establishment of negative anthropometric changes, which stipulates attention to the anthropometry of medical workers of different specialties.

## **THE CONCEPT OF PHYSICAL DEVELOPMENT OF A CHILD**

Physical development is a complex of morphofunctional properties an organism that defines the stock of its physical forces. Growth is hereditary programmed process of increasing the linear and bulk sizes, body weight for optimal assimilation of nutrients and favorable environmental conditions. In the case of children, physical development, in addition, the dynamic process of growth, is a process of age-related changes in body size, type of body, appearance, muscle strength, performance of the child's organism. Identifying the individual characteristics of the growth and development of the child allows only a dynamic observation of its physical development, and also to some extent a criterion for the health of the child. Violations of the growth and development of the child are inherent in many diseases of childhood, and may also occur under the influence of adverse environmental factors.

Growth is a reflection of the systemic development process; with age the growth rate is reduced; the child is not growing gradually: periods of accelerated growth alternate with periods of reduced growth. Growth of separate parts of the body of the child is not proportionally. There is a so-called craniocaudal growth gradient - distal segments of the body grow faster than proximal ones.

The physical development of the child, reflecting its biological maturity, is one of the criteria for assessing the biological age of children and adolescents, often considered by doctors as a dynamic growth process, change in body size and used in diagnosis.

Both endogenous and exogenous factors impact physical development. Endogenous factors include: genetic (the health of parents, the level and sequence of their physical development); endocrine regulation, child health status (birth defects, chronic somatic pathology, patho-central nervous system logic, etc.);

Exogenous factors affect the level of physical development of the child from the outside: the nature of the food and its relevance to age, physical activity, compliance with the daily regime, the state of the environment, climatic conditions, and others. It is the influence of these factors that is the basis for solving the problem of finding the causes for violations of the child's physical development.

## ANTHROPOMETRIC MEASUREMENTS OF A CHILD

Anthropometric (somatometric) measurements include measurements of the child's body weight, body length (height), head and chest circumference, and body proportions. The results of the measurements are compared with the reference values of the tables, or the corresponding graphs, which makes it possible to notice the deviations of the indicators from the expected, inherent in healthy children. It should be emphasized that in most cases the deviation of the anthropometric indices does not have a purely specific diagnostic value, but may be the first stimulus for in-depth diagnostics. It is possible to observe the tendencies towards the development of abnormalities of anthropometric indicators under dynamic observation, which allow to construct an individual schedule of physical development. Each child should have a schedule according to which an assessment of physical development is carried out and on the basis of which adequate medical observation is carried out.

*Measuring the length of the body* of children under the age of 2 years of life is made by a special horizontal rotor in the lying position, which can be put on a table or bed. A movable plate is applied to the child's feet without pressing.

Measurement of growth in children after 3 years is performed by a vertical rotor in the position of the child standing.

The child should put off shoes. He turns with he/her back to the vertical rack, touching her heels, buttocks, neck. Arms are lowered along the trunk, heels together, socks-crosswise. The head is set in a position in which the lower edge of the orbit and the upper edge of the ears are in one horizontal line. A moving plate is attached to the head without touching.

*The head circumference* is measured by overlaying the tape, by holding it behind the occipital point, and in front of the eyebrow. The overlay is carried out in the direction from the right temporal area to the left, the result is considered over the forehead.

*The circumference of the chest* is measured three times: at rest, at the deep inspiration and at the deep exhalation. The child should be in a standing position with lowered hands. The measuring tape is applied behind under the lower corners of scapula and nipples..

*Child weighting technique.* Firstly diaper is weighed. The child is placed on the wider part of the tray with his head and shoulder girdle, his feet in the narrow part of the tray. Indicators of weight you see from the side of the lever, where there are cuts with figures. The accuracy of the weighing is 5 grams. To determine the weight of the child it is necessary to take away from general weight of the diaper.

Determination of the body weight of a child over 3 years old is performed on medical scales. Weighing should be done in the morning on an empty stomach, preferably after urination and bowel movements.

## ASSESSMENT OF PHYSICAL DEVELOPMENT OF CHILD WITH USING EMPIRICAL FORMULA

We can calculate the *weight of the fetal body* with the using of the empirical formula. The average weight of the fetus at the gestational age of 30 weeks is 1300g. To calculate the weight of fetus at the gestational age less than 30 weeks:

1300g -100 g for each gestational week before 30 weeks

To calculate fetal weight gestational age more than 30 weeks

1300g +200g for each gestational week after 30 weeks

Example: a gestational age of 24 weeks will have a weight of  $1300-600 = 700\text{g}$  ; The weight of the fetus by the gestation age of 33 weeks will be  $1300 + 600 = 1900\text{ g}$ .

*The length of the fetal body from 25 to 42 weeks of gestation* can be calculated by the formula:

the pregnancy (in weeks) + 10 cm.

Example: the length of the body of 32 weeks of fetal will be  $32 + 10\text{ cm} = 42\text{ cm}$ ;

*The length of the body of the fetus during the first 5 months of pregnancy* is:

the pregnancy (in months) x 2

Example: body length of the fetus with gestation age of 3 months is  $3 \times 2 = 6\text{ cm}$ ;

*The length of the fetal body in the gestational age from 6 to 9 months of gestation* is the formula:

the pregnancy age (in months) x 5.

Example: The length of the body of the fetus is 7 months, calculated  $7 \times 5 = 35\text{ cm}$ .

**Assessment of weight of infant** Normal body weight of a newborn is 2500-4000 g.

*The ideal body weight of the infant from 0 to 6 months* is defined as follows:

birth weight + 800 grams x n (where n - number of months);



Example: determining the weight of a child for 5 months (birth weight 3300gr)  $3300 + 800 * 5 = 7300\text{gr}$

*The ideal body weight of the infant aged 6 to 12 months:*

$$\frac{\text{birth weight} + (800 \times 6) + 400 \times (n-6) \text{ or } (n + 9) / 2}{(\text{where } n - \text{number of months}).}$$

Example: determining the weight of a child in 10 months birthweight 3300 gr + (800x6) + 400x (10-6) = 9700gr;

*To calculate the weight of children older than 1 year of life, the following formula is used:*

$$\frac{10,5\text{kg (average weight of the child's body in 1 year)} - 2n}{(\text{where } n - \text{number of years}).}$$

Example: determining the weight of a 5 year old child -  $10.5 + 2 \times 5 = 20.5\text{kg}$ . After determining the actual weight of the child's body, it is compared with the ideal body weight corresponding to age and deficiency or excess weight is determined.

Example: Determining the ideal weight of the child for 5 months (birth weight 3300gr)  $3300 + 800 \times 5 = 7300\text{gr}$ , the actual weight of the child when measured on the scales is 5600gr, then it is necessary to take away from the ideal body weight the actual one  $7300 - 5600 = 1700\text{gr}$ , we determined that the child's weight deficit is 5 months 1700 grams, now it is necessary to calculate how many percentages to the ideal weight of the child is not enough  $1700 * 100 / 7300 = 23.3\%$  is not enough for this child to the ideal weight.

### **Assessment of body length of the infant**

Normal body length of the newborn is 50-52 cm

*The ideal body length of the infant from 0 to 6 months is calculated by the formula:*

$$\text{length at birth} + 3 \times n \text{ or } 66 - 2.5h (6-n) \text{ (where } n - \text{number of months).}$$

Example: child height 3 months -  $57 \text{ (height at birth)} + 3 \times 3 = 66 \text{ cm}$ ;

*The ideal body length of the infant from 6 months to one year is calculated with using the formula*

$$64 + n \text{ or } 66 + 1,5 h (n-6) \text{ (where } n - \text{number of months).}$$

Example: body length of infant 8 months is  $64 + 8 = 72$  cm.

*The ideal height of a child aged 2-12 years can be determined using the formula: age (in years) x 6 + 77.*

Example: the height of a child 5 years is  $5 \times 6 + 77 = 107$  cm.

After determining the actual length of the body (height) of the child and comparing it with the ideal values of the child's body length (height) calculated by the formula, then their deficiency or surplus is determined.

Example: the ideal body length of the infant 8 months is  $64 + 8 = 72$  cm, Actual body length is 75 cm. Comparison shows that the actual body length exceeds ideal body length by 3 cm.

### **Assessment of head circumference**

*The ideal circumference of the head of the child at birth is 34 - 36 cm. From birth to 6 months, each month, the circumference of the head increases by 1.5 cm, from 6 to 12 months the circumference increases by 0.5 cm, from 1 year to 5 years, the circumference of the head increases by 1 cm annually, from 6 to 15 years the circumference increases by 0.6 cm.*

After determining the ideal circumference of the head, it is compared with the actual one,

Example: the ideal HC of infant 4 month is  $34 + 6 = 40$  cm, the actual HC - 39 cm and less than ideal by  $40 - 39 = 1$  cm.

*The ideal chest circumference at birth is 32-34 cm. Every month from birth to 6 months, the gain is 2 cm, from 6 to 12 months the gain is 0.5 cm, from 1 to 10 years, the annual increase is 1.5 cm, and in children aged 11 up to 15 years, the gain is 3 cm. After measuring the actual chest circumference and determining the ideal chest circumference, comparisons are made.*

Example: the ideal chest circumference of infant 5 month is  $34 + 2 \times 5 = 44$  cm, actual chest circumference is 40 cm and less than ideal by 4 cm

### **Assessment proportionality of growth**

You can also evaluate the physical development of a child and the proportionality of growth by using formulas and indexes.

*Erismann's index* characterizes the development of the child's chest. It is determined by the formula:

Erisman's index = chest circumference (cm) -  $\frac{1}{2}$  height (cm).

Normal values of Erisman's index:

- 1st year - 13,5 - 10 cm;
- 2-3 years – 9 - 6 cm;
- 6-7 years – 4 - 2 cm;
- 8-15 years – 3 - 1 cm;

An example of the Erisman index for a 2 year old child. We know that at this age the child's chest circumference should be equal to 53 cm, and the height is 90 cm, and the index 53 is  $\frac{1}{2} \times 90 = 45$  cm, that is, the physical development of this child is proportional.

*Index of Chulitskaya* characterizes the degree of malnutrition of the child and the development of the subcutaneous fat base and determined for formula:

Index Chulitskaya = 3 x shoulder circumference (cm) + thigh circumference (cm) + circumference of the leg (cm) – length/height (cm).

- up to a year - 20-25 cm;
- 2-3 years - 20 cm;
- 4-5 years - 19-16 cm;
- 6-7 years - 15-10 cm;
- 7-8 years - 10-6 cm;

Reducing the value of the index confirms the lack of adequate development of the child.

# ASSESSMENT OF THE PHYSICAL DEVELOPMENT OF A CHILD WITH USING GROWHT STANDARTS (WHO)

Assessment of a child's physical development is based on the "Growth Standards" developed by the WHO in 2006 (for children aged 0-5) and in 2007 (for children aged 5-19).

Main criteria for assessing the physical development of child include:

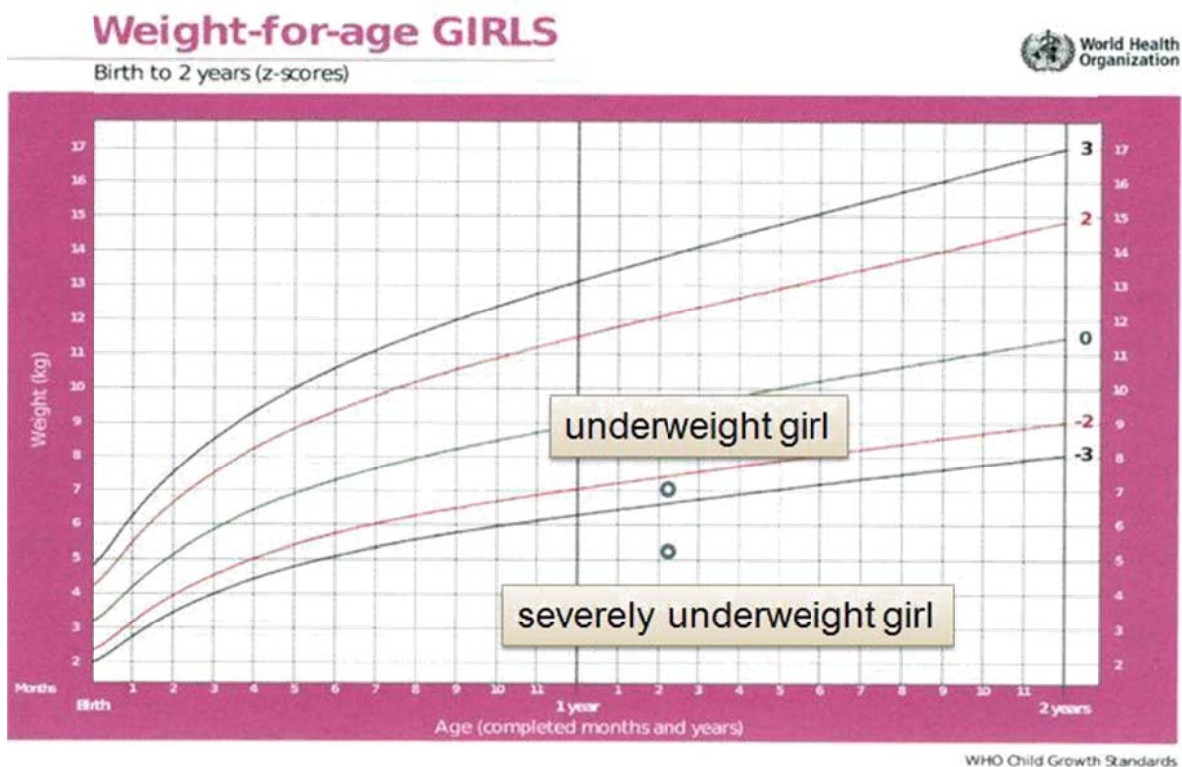
- Weight - by - age
- Length / height-by – age
- Weight – by – length / height
- Body mass index ( BMI –for-age) Head circumference

## Assessment of physical development by method of standard signal deviations

Assessment of physical development is possible by the method of calculating standard sigma deviations or z-scores for population of children, depending on age and sex.

The principle of assessing physical development is based on solving the issue how specific the indicator of physical development coincides with the average statistical and if it does not match, then how far it is from the standard.

For each indicator of anthropometry there are corresponding schedules of the standard deviations for an example, a graph of weight-to-age dependency is given boys and girls up to 2 years old ( fig.1)



**Fig. 1.** The Growth Chart ( z-sccore) for girl 0-2 years WHO

As can be seen from the graph, the standard deviations of anthropometry contain a line "0", which coincides with the average statistical data and is a median. Other lines define standardized deviations (SD, z-scores) with positive (+1, +2, +3) or negative (-1, -2, -3) values. Those values between the standard deviation lines -2 and -3 are considered to be lower than the standard deviation of - 2.

Values that are between the standardized deviation lines "+2" and "+3" are considered higher than the standard deviation "2". The result obtained from measuring a child far from the median (median line) in both directions, for example, close to "3" or "-3" standard deviations, usually indicates a violation of physical development.

If, the indicator is directly on the standard deviation line, it is assumed that this value falls into the category of lesser severity. For example, if the weight for this age is on the line "-3", it is considered that the child is inadequate, but not extremely insufficient weight.

We also can use methods of standard sigmal deviation for estimation length or height, BMI.

During the 1st year of life indicators of the physical development of a healthy child, if you put them on the corresponding graphs, they will be grouped in parallel with the lines of the middle cents or medians and the lines of "+1" or "-1" standard deviations. If you carefully follow the history of the child's development, conducting anthropometric studies in infants every 1-2 months, and then quarterly and annually according to existing recommendations, you can get individual development schedules

Harmonious physical development is considered, in which the indicators of height, body weight, chest circumference do not differ from the mean, and thus the body weight and chest circumference correspond to height.

Children with disharmonious physical development require a thorough clinical examination to find hidden diseases and pathological conditions.

### **Assessment of physical development with using growth charts**

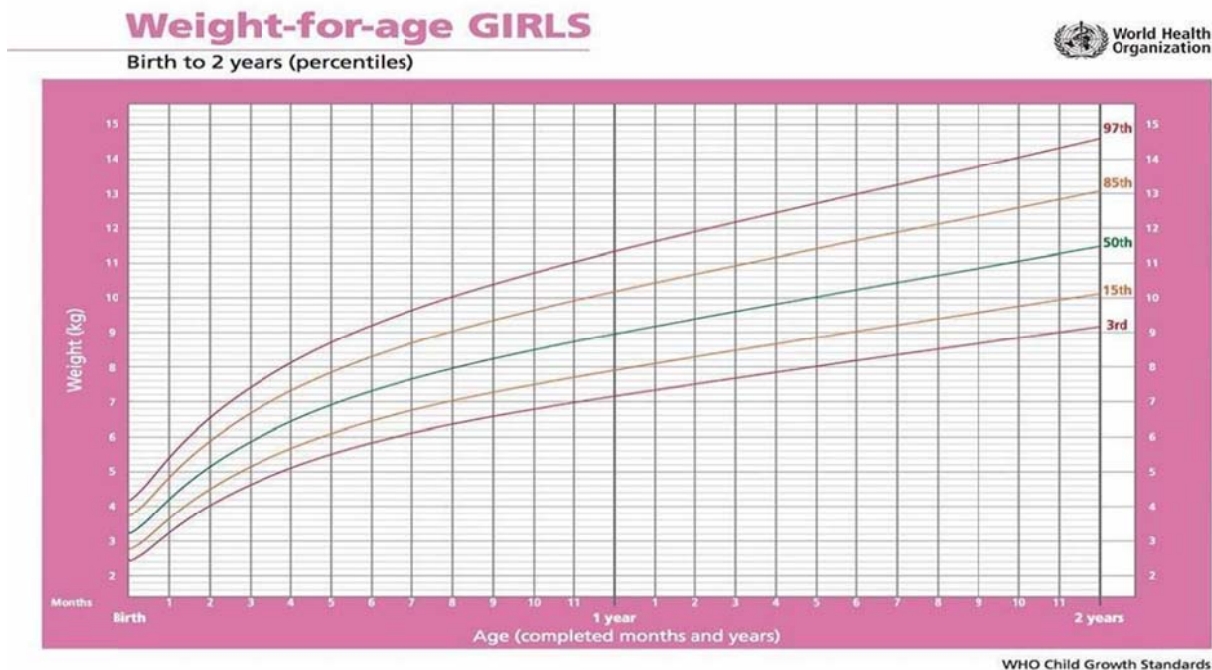
The term "centile" means the distribution of children united under the same age and sex, by physical development, which is distributed from the minimum to the maximum values. The practical use of statistics is extremely easy and convenient. Centile is an anthropometric measure, which corresponds to the percentage of its observations.

It is important to use graphs of the physical development of the child for the appropriate gender, because boys and girls develop differently.

Measurements of length, weight and head circumference between the 25<sup>th</sup> and 75<sup>th</sup> percentiles are likely to represent normal (average) growth.

Measurements between the 10<sup>th</sup> and 25<sup>th</sup> percentiles represent less than average data and between the 75<sup>th</sup> and 90<sup>th</sup> – above average data.

Measurements between the 10<sup>th</sup> and 3<sup>d</sup>, and the 90<sup>th</sup> and 97<sup>th</sup> percentiles belong to low and high data, which require further examination. Measurements below the 3<sup>rd</sup> and above the 97<sup>th</sup> percentiles are extremely low and extremely high and reflect pathological deviations of physical development (fig.2)



**Fig. 2.** The growth chart (percentile) Weight –for- age for girls aged 0 to 2

All charts of physical development assessment are present of WHO page <http://www.who.int/childgrowth/en/>

### Calculation of the body mass index

*Body mass index* (BMI) is used primarily to detect overweight and obesity. The body mass index is determined by the formula:

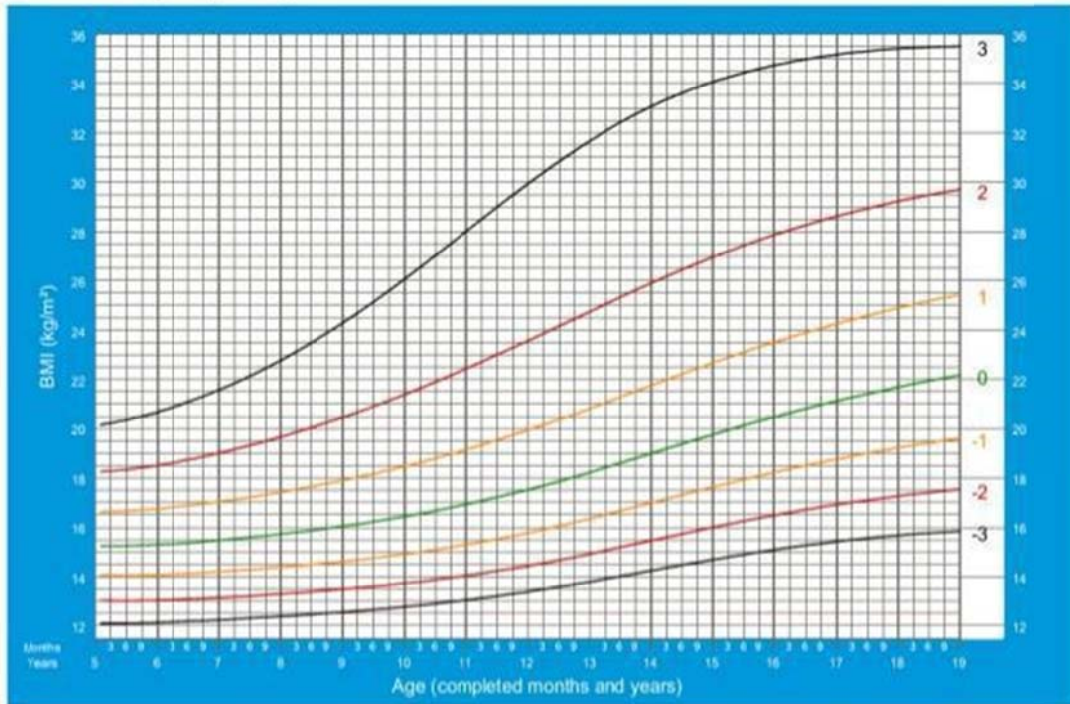
body weight in kilograms divided by height in meters in square (kg / m<sup>2</sup>).

The result of the calculations is rounded to the tenth. Typically, BMI scores are somewhat similar to the results of the weight / body weight / height chart and are used together. BMI is a complex addiction to age, unlike growth in weight and height separately. The BMI of a child increases dramatically when the baby is rapidly gaining weight in relation to height in the first 6 months of life. Further, BMI decreases at the age of 6-12 months and becomes stable in school-age children and adults.

If body mass index or BMI is higher than the 1<sup>st</sup> standard deviation line, then there is a potential risk. The progressive mass dynamics towards the 2<sup>nd</sup> standard deviation line in dynamic observation is confirmed presence of pathology (Fig.3)

## BMI-for-age BOYS

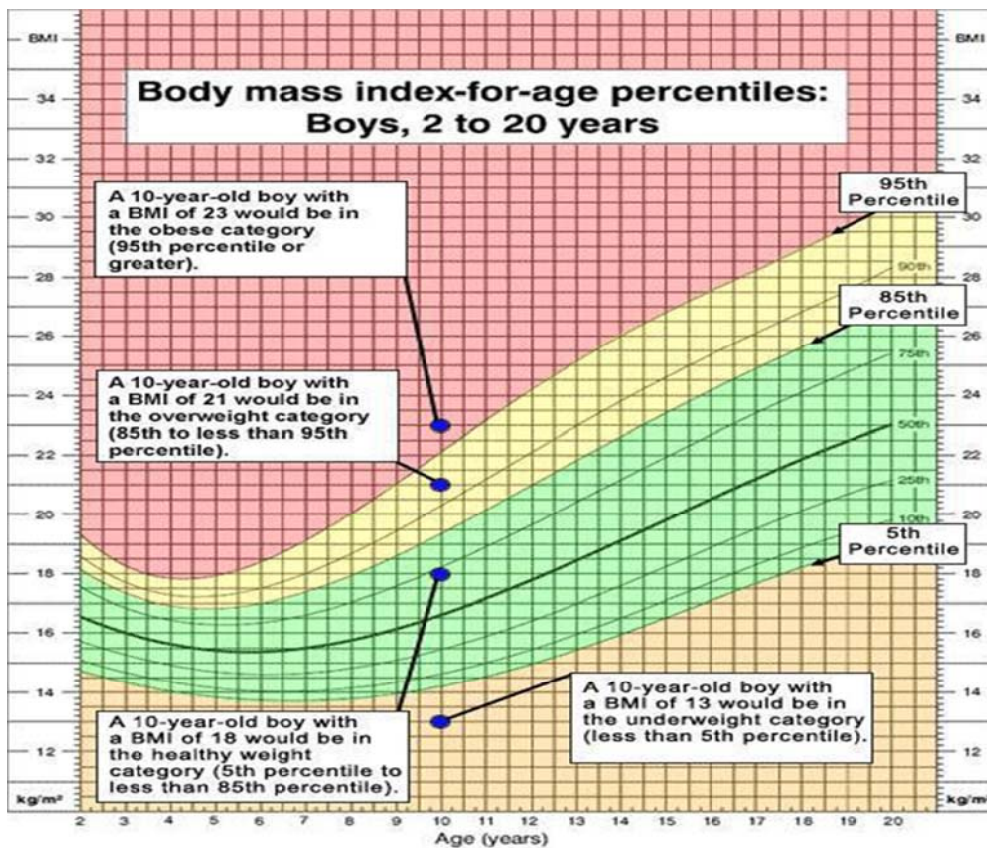
5 to 19 years (z-scores)



2007 WHO Reference

**Fig. 3.** Growth chart (z-score) BMI-for-age for boy 5-19 years

BMI could be estimated by chart BMI - for age percentiles. You can see explanation below ( Fig.4)



**Fig. 4.** Growth Chard (percentile) BMI -for- age for boy 2-20 years

## Monitoring of physical development

During the 1st year of life indicators of the physical development of a healthy child, if you put them on the corresponding graphs, they will be grouped in parallel with the lines of the middle cents or medians and the lines of "+1" or "-1" standard deviations. If you carefully follow the history of the child's development, conducting anthropometric studies in infants every 1-2 months, and then quarterly and annually according to existing recommendations, you can get individual development schedules

Example. The boy was born in a row with a weight of 3.8 kg. In the first year of life, he received mixtures. From 6 months of life, the mother abuses a carbohydrate supplement. The child quickly increases the weight that the mother does not pay attention to. Mother suffers from alimentary-constitutional obesity. If you draw a graph of sigma deviations, it will be clearly visible as the boy first finds himself in a state of increased risk of overweight, then crosses the line of overweight, and then at the age of 2 years has a BMI of 19.3, which corresponds to obesity at an elevation of 0.80 m, weight 17.6kg.

Harmonious physical development is considered, in which the indicators of height, body weight, perimeters and anthropometric indices do not differ from the mean, and thus the body weight and perimeter of the chest correspond to height. The harmony of physical development well describes the values of centimetric assessments. In cases where anthropometric indicators belong to the same centile (corridor) areas, that is, between any two of them

There is no difference in more than two centimeters, we can say that the child is developed harmoniously. But in some cases, this does not mean that physical development is sufficient. For example, in proportionately developed children with an unusually low growth, the rule of neighborhood of centile corridors will be fulfilled.

Children with disharmonious physical development require a thorough clinical examination to find hidden diseases and pathological conditions.



## DISORDERS OF PHYSICAL DEVELOPMENT IN CHILDREN

Delay in physical development at any age of a child occurs due to severe chronic somatic diseases (heart, kidneys, gastrointestinal tract, lungs); qualitative and quantitative food restriction; passive and active smoking of children; lack of parental love and care. For example, the disadvantages of the fetus are the result of the effects of chromosomal diseases, intrauterine infections, mother's illnesses, especially those that are accompanied by disturbances in placental function, as well as social and family factors (poverty, drug addiction, substance abuse and alcoholism).

The World Health Organization defines malnutrition as "the cellular imbalance between supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions

### Types of malnutrition

#### 1. Undernutrition(hypotrophy:

Protein Energy Malnutrition (PEM);

Micronutrient deficiencies.

#### 2. Overnutrition: Parathrophy; Obesity

*Hypotrophy* - a nutritional disorder is a disease predominantly of young children. Hypotrophy manifests as a decrease in body weight, insufficiency of fat, and a violation of the general condition of the child. It is characterized decreased resistance of the organism to infections.

Depending on the power failure, there are three degrees of hypotrophy. *Hypotrophy of the I degree* is characterized by a thinning of the subcutaneous basis on the trunk and extremities, with a mass deficit of up to 20%. The skin becomes pale, the tissue turgor is lowered. Sleep, appetite and emptying are slightly disturbed or saved. There is a tendency to constipation.

*Hypotrophy of the II degree* is diagnosed with the almost complete disappearance of the subcutaneous basis on the abdomen and limbs, its reduction on the face and the lag in body weight by 20-30%. The skin is pale, dry, flabby. Mucous membranes are dry. Turgor tissues are significantly reduced. Muscle hypotension. Turgor tissues are significantly reduced. Muscle hypotension is present. There is no appetite. The overall resistance of the body is reduced. Neuropsychiatric and physical development of the child is inhibited. Periods of excitement change with laxity, apathy, adynamia. Body temperature daily fluctuates by 1 ° C and more. Sleep restless.

*At hypotrophy of the III degree* There are no subcutaneous fat on the trunk, limbs and face, a deficiency of body mass exceeds 30%. The skin is pale, with a grayish tinge, dry, wrinkled. Mucous membranes are dry. There is no appetite. Food tolerance is sharply reduced, dyspeptic disorders arise. The child is flabby, apathy, sometimes monotonously cries, restless. All parameters of physical and psychomotor development are significantly reduced. Deficiency anemia. Reduced reactivity leads to frequent respiratory viral infections, pneumonia, otitis media, purulent-septic diseases.

*Paratrophy* is characterized by excessive increase in the body weight of the child and excessive deposits of the subcutaneous layer. It can develop due to the constant overfeeding of the baby, endocrine disorders. Excess carbohydrates in the baby's food leads to a violation of trophic processes. Distinguish the paratrophy with the predominance of mass over height, with normal mass and height, with excessive mass and height.

Paratrophy is manifested by pallor, some dryness of the skin and mucous membranes, increased thickness of the subcutaneous basis, decreased turgor tissue, restless sleep, signs of rickets, some lagging psychomotor development. The resistance of the body is reduced. Often there are acute respiratory viral infections, otitis, bronchoobstruction

*Obesity* is a chronic polyethiological disease characterized by excessive deposition of adipose tissue in different parts of the human body. It is characterized by metabolic, neuro-regulatory disorders.

It is important to note that obesity increases the thickness of not only subcutaneous fat cells. This disease is accompanied by an increase in the amount of fatty layer around the internal organs.

*A child's growth retardation* is determined if the child has a lag in height that exceeds 2 sigma deviations or a growth rate of less than 4 cm per year in children older than 3 years.

*Growth Hormone Deficiency.* The most common symptom of growth hormone deficiency in children is that a child is significantly shorter than children his or her age. However, a child with this condition can have normal body proportions.

Some other growth hormone deficiency symptoms in children: child's face may appear younger than children who are the same age; delayed puberty—but sometimes a child won't go through puberty; increased fat around the face and stomach; mild to moderate chubbiness; slow tooth development; sluggish hair growth

*Gigantism* refers to abnormally high linear growth due to *Excessive growth* hormone production while the epiphyseal growth plates are open during childhood. Acromegaly is the same disorder of excess *Excessive growth* hormone production but occurs after the growth plate cartilage fuses in adulthood. In acromegaly: increase in the volume of the skull, wide nose, rough facial features, liquid teeth, prothagnacity, thick fingers, dorsal kyphosis; neurological symptoms: fatigue, headaches (sometimes very intense), increased drowsiness, narrowing of the field of vision (bi-temporal hemianopia); splenomegaly; sometimes arterial hypertension; disturbance of glucose tolerance up to the development of secondary diabetes; possible delay in puberty and hypogonadism.

Acute pathological enlargement of the head may be in *hydrocephaly*. Hydrocephaly - a disease characterized by excessive accumulation of cerebrospinal fluid in the ventricular system of the brain as a result of complications of its movement from the site of secretion (ventricles of the brain) to the absorption site to the circulatory system (subarachnoid tanks (subarachnoid space), or as a result of absorption impairment.

## **QUESTIONS FOR SELF-CONTROL**

1. Definition of the physical development.
2. Measurement of the main parameters of physical development
3. Assessment of weight, height, head circumference in infant.
4. Assessment of physical development by percentile graphs.
5. Assessment of physical development by method of standard deviations.
6. Main disorders of physical development in children.

## CONTROL TESTS

1. The boy at the age 2 years old has deviation in neuropsychological development. His head circumference is 51 cm. Estimate this anthropometric index if it's included in percentile space 90-95%?

- A. Extremely excessive (high)
- B. More than average
- C. Excessive (high)
- D. Less than average

2. An infant has pylorospasm, weakness, hypodynamia, signs dehydration as a result of frequent vomiting. Body weight deficiency is 13%. Does the infant have hypotrophy? What it's degree?

- A. III degree;
- B. Normal weight;
- C. II degree;
- D. I mild degree;
- E. Parathrophy.

3. Assess a development of child if his chest circumference is +1.2 sigma, length is +0.9 sigma and weight is +1.5 sigma?

- A. Disharmonic;
- B. Obesity;
- C. Harmonic;
- D. Hypotrophy.

4. Calculate ideal body length of the girl 8 months?

- A. 70
- B. 72
- C. 71
- D. 74

5. Choose a formula for calculation weight of the fetus 28 weeks pregnancy

A.  $1300 - 2 \times 200$

B.  $1300 - 2 \times 100$

C.  $1300 - 3 \times 200$

D.  $1300 - 2 \times 400$

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### Additional sources of information

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<https://www.who.int/childgrowth/standards/en/>