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DYNAMICS OF MORPHOLOGICAL INDICATORS OF LONG-DISTANCE RUNNERS' PHYSICAL DEVELOPMENT

Shoxrux Fayzullo og'li Sirojev
Asia International University
Lecturer, Department of Physical Culture

Abstract: This article analyzes the dynamics of morphological indicators observed in the process of physical development of long-distance runners. During the research, such parameters as body height, body mass, body mass index, chest circumference, percentage of muscle mass, as well as certain morphological changes related to the cardiovascular system were examined. It was found that regular long-distance running leads to a moderate decrease in body weight, adaptation of muscle fibers to endurance, an expansion of respiratory system capacity, and an increase in the functional volume of the heart. Moreover, it is noted that morphological indicators are directly related to age, gender characteristics, and training loads. The research results have important scientific and practical significance for improving training programs, monitoring athletes' health, and achieving maximum performance in long-distance running.

Keywords: long-distance runners, physical development, morphological indicators, dynamic changes, endurance.

Physical development is a process expressed in quantitative indicators of body shape changes and the improvement of its functions. The growth and development of the human organism continue continuously and unevenly until the end of puberty. Growth refers to the increase in linear dimensions of the body, the mass of substances between tissues and cells. These processes lead to morphological and functional changes in the organism.

The aforementioned considerations raise questions regarding the mechanisms of individual development laws in human growth, the interaction of the organism with the external environment, the degree of influence of hereditary factors in these mechanisms, as well as the pedagogical approach in achieving physical maturity and the volume of physical education and sports loads. The length and mass of the human body are important indicators of physical development and the degree of biological maturity of the organism. Their changes during development occur unevenly; differences in some stages are expressed not only in quantitative but also in qualitative aspects.

Body length has a high hereditary component (80–90%) and is relatively easy to predict. The most intensive increase in body length is observed during the first year of life (about 50%) and during puberty (sexual maturation). The growth of the whole organism and its individual parts demonstrates that this process occurs at different rates and durations. In our research, we focus on the increase of linear and circumferential dimensions of the body and their derivatives, since these indicators form the basis for predicting specialization and orientation in various sports.

In general, when discussing human growth processes, three phases of uneven growth of certain segments are distinguished. Between the ages of 11 and 14, the legs grow significantly; at the age of 9, the trunk and chest circumference develop; and by the age of 19, the body reaches proportions typical of adults.

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According to D.J. Wilmore and D.L. Costill, the disharmonic growth of legs and trunk occurs at different times in boys and girls, lasting 2–3 years. In boys, disharmony reaches its peak at ages 10–11 and 14–15. The first peak is explained by a sharp increase in leg length, while the second is due to the rapid growth of the trunk. In girls, the peak of disharmony is observed 1–2 years earlier than in boys. Researchers in our country have noted that these growth periods coincide with heightened sensitivity to the effects of physical training.

The growth of arms, legs, and trunk length between the ages of 14 and 20 proceeds unevenly and differs by age and gender. During this period, the empirical growth curve of arm length is relatively uniform until the age of 13 in girls and until the age of 18 in boys, while the growth of legs resembles the curve of trunk growth.

In the process of individual growth and development, the rate of change in body mass is reflected in a B-shaped curve. Studying body mass together with anthropometric indicators is considered highly promising, as it provides insights into the influence of environmental and social factors on the organism's structure.

The data presented above demonstrate the importance of considering body mass and its dynamics in predicting various changes in the human organism under investigation.

According to the views of several authors, the number of muscle fibers is genetically predetermined. During growth and purposeful training, muscles may undergo hypertrophy, but their number, as well as the ratio of "fast" and "slow" fibers, does not change.

The increase in muscle mass occurs due to the active growth of muscle thickness and length. This is achieved through the transverse enlargement of muscle fibers and the formation of new sarcomeres, which leads to fiber elongation. These processes are associated with different stages of child development; however, most authors emphasize that the differentiation of muscle fibers is most active between the ages of 7–9 and 12–14.

Both under normal conditions and during training, muscle tissue development follows several general laws, the most important of which are proliferation, differentiation, determination, continuous integration of muscle fibers in response to loads, and adaptation processes. During adolescence, the physico-chemical properties of muscles undergo significant changes, and their functional properties improve.

In terms of chemical composition (proteins, fats, water balance), adolescent muscle tissue becomes closer to that of adults. Morphological signs of maturity are observed in muscle fibers, and the mass of contractile tissues increases. Compared to adults, adolescent muscles are more elastic and demonstrate a greater capacity for contraction. The development of the adolescent organism is closely related to the growth of muscle mass.

By the age of 18–20, muscles make up 40–45% of body weight. After the age of 16, the rapid increase in strength (relative to body weight) slows down. The greatest increase in maximal strength (by 400–500%) occurs between the ages of 13 and 17, which must be taken into account when designing training exercises.

During adolescence, the motor qualities of muscles, the sensitivity of the neuromuscular system, and contraction speed improve. Muscle fibers increase in cross-section, specific muscles gain mass, growth continues, and the composition of connective tissues develops further. Differentiation of muscle fibers and the structural-functional remodeling of specific muscle groups are completed by the age of 20–25.

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The analysis of muscle mass and its distribution in athletes of different specializations shows that sprinters have highly developed leg muscles, ski jumpers – pelvic and hip muscles, while cross-country skiers – shoulder and thigh muscles. Morphological data on the muscular system provide essential guidance for selecting appropriate physical and special exercises, as well as determining the proper allocation of training time to improve the locomotor system and motor skills.

Research by B.A. Nikityuk established the following laws in the formation of muscular strength:

- In individuals not engaged in sports, the correlation between muscle mass and muscle strength is very low.
- In athletes engaged in strength-demanding sports, as their sports mastery increases, the correlation between muscle mass and muscle strength becomes stronger and reaches a functional level.
- Individuals with greater muscle mass demonstrate a higher rate of strength growth under the same training loads.
- Each individual has a specific adaptive response to training loads, which reflects a normative balance between muscle mass and growth processes.

The period from ages 12 to 18 is the most intensive stage for the development of physical qualities and coordination abilities, and it is considered the optimal time for targeted engagement in sports. During this period, the organism undergoes intensive neuroendocrine restructuring, which may serve as an additional stimulus for sports activity. At the same time, this can either facilitate or hinder the natural course of biological processes.

Middle school age (12–14 years) coincides with puberty, characterized by significant changes in the endocrine system. The hormonal function of the thyroid gland intensifies, and the adrenal medulla develops further. The relative balance achieved during late childhood is once again disrupted, while the central nervous system develops actively. Although morphologically the adolescent brain differs little from that of adults, functionally it continues to develop, forming new temporary neural connections and improving analytic and synthetic activity. At this stage, excitation processes in the higher nervous system dominate over inhibition.

Nevertheless, the body composition of long-distance runners differs from that of other athletes such as sprinters, jumpers, and throwers. They are distinguished by specific characteristics in body structure, particularly in subcutaneous fat layer thickness and other morphological indicators.

From the age of 15–18, due to the improvement of peripheral and central physiological mechanisms, the reserve capacities of all organs and systems expand, the development of the central nervous system is completed, and the analyzer-synthetic activity of the cerebral cortex—leading to qualitative changes in cognitive functions—significantly improves. The capacity of memory intensively increases. During this period, the brains of young men and women acquire high plasticity and possess great reserve potential. Although excitation processes still dominate over inhibition, nervous processes are characterized by high mobility. As a result, adolescents at this age exhibit frequent mood changes, which are related to heightened emotional sensitivity to various life events.

In the physical development of long-distance runners, morphology plays an important role. Particularly, the body structure of long-distance runners should include a well-developed chest width, since this has a specific function during training. For 19–20-year-old athletes, the average

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body height should be between 172–178 cm, while body weight should be around 58–65 kg. Chest circumference should be 90–92 cm, and leg length should range between 90–95 cm—characteristics that allow athletes to achieve high results.

For long-distance runners, special endurance is the main physical quality, which reflects their physiological capacity. Special endurance develops through the ability to manage motor skills, improve coordination mechanisms, and sustain work capacity, thereby ensuring high performance. The improvement of physical qualities is closely linked to both functional and morphological changes. It develops when performing high-speed physical exercises. Running short, middle, and long distances, throwing events, long jumps, and sports games all contribute to the enhancement of physical qualities.

In long-distance running, athletes can cover approximately 10 meters per second. The high-speed performance of cyclic dynamic work depends on the rapid alternation between excitation and inhibition processes in antagonist muscle nerve centers. Various pathways of energy production and the duration of exercise highlight the importance of aerobic energy supply. During prolonged intense work, glycogen and carbohydrate metabolism play a major role, though a large amount of fats are also oxidized. **Aerobic reactions** are defined as the energy-producing breakdown of nutrients in the presence of oxygen.

Aerobic performance refers to the set of functional characteristics that ensure oxygen uptake, transport, and utilization during muscular activity. It is influenced by four main factors. A reliable indicator of aerobic performance is the effective interaction of the respiratory and cardiovascular systems, which ensures maximal oxygen uptake when these systems function at full capacity. The production of energy in aerobic mode depends not only on the type of sport, but also on the athlete’s sex, age, and other factors.The ability of the body to maintain a high oxygen uptake rate for a long time is called **aerobic endurance**. The greater the aerobic endurance, the easier and longer the athlete can perform physical work.

The **second indicator** of the aerobic mechanism is its mobility—meaning the time required for the body to reach **VO_2max (maximum oxygen uptake)**. The **third indicator** is its efficiency, which refers to the useful work coefficient of the mechanism—that is, how much of the energy produced by oxidative phosphorylation is utilized for muscle contraction. The efficiency of the aerobic mechanism ranges from 30% to 60% and increases with improved physical training and fitness. One of the simplest indicators of efficiency is the oxygen utilization coefficient during breathing at VO_2max, which increases with higher levels of physical conditioning.

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