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Study of the Component Body Composition in Children Engaged in Freestyle Wrestling

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INTRODUCTION

Modern sports anthropology has accumulated a vast amount of data on the influence of physical exercise on the human body and the subsequent effects of such exposure. As a result of regular and intensive sports training, changes occur in the athlete's body, which ultimately lead to the formation of a specific morphotype characteristic of a given sport specialization. At the same time, the morphofunctional status is one of the most informative indicators not only of the individual development of the body but also of its overall state of health. Studying the morphometric composition of athletes' bodies allows for a more comprehensive characterization and assessment of their activity regimen, the dynamics of recovery processes, and the level of physical performance, especially in sports with weight category divisions [1].

Sport indeed affects both the macro- and microstructure of the human body, and morphological characteristics become more pronounced with longer durations of training. Physical exercises significantly influence a person’s constitutional traits. Experts note that systematic training in wrestling promotes the harmonious development of all muscle groups, the cardiovascular system, and the musculoskeletal system [2].

Adaptation to the training process is the main factor determining the body’s component composition—this is the principle of preferential structural support of the systems that dominate during adaptation [3]. This principle implies the formation of a system that ensures the successful execution of motor functions. The determination and assessment of body mass composition—based on the relative proportions of bone, muscle, and adipose tissue—provide valuable information for evaluating the health status, physical development, and physical capabilities of children and adolescents [4, 5].

The relevance of this study lies in the importance of establishing patterns of bodily changes under the influence of sports, particularly freestyle wrestling. There is a lack of information in the literature regarding the morphological characteristics of the bodies of children who practice freestyle wrestling. Meanwhile, such data are essential for assessing health status and developing physical development reference tables. Researchers emphasize the need for periodically revising standards in light of the changing processes of physical development in modern humans. This is associated with altered social conditions and the search for new approaches to physical education and training.

The aim of the study is to investigate the morphological characteristics and component composition of the bodies of children engaged in freestyle wrestling.

Research objectives:

1. To analyze the literature on the topic of the study.
2. To determine the total, transverse, and circumferential body dimensions in children with varying sports experience.
3. To establish the diameters of bone epiphyses.
4. To identify differences in the component composition indicators among wrestler athletes with different lengths of sports experience.

The object of the study is children practicing freestyle wrestling for different periods of time.

The subject of the study is the anthropometric parameters and the indicators of muscle, fat, and bone components of the athletes’ bodies.

Research methods include anthropometry (measurement of height and body mass, transverse and circumferential body dimensions, diameters of bone epiphyses, and skinfold thickness) and methods of mathematical statistics.

The novelty of this work lies in the fact that most previously conducted studies focused on athletes of the highest sports mastery. In the literature, there is a near absence of comparative analyses of anthropometric indicators among children who are just beginning to engage in sports. This study will provide an opportunity to observe, over time, the influence of the training process on morphological parameters and, potentially in the future, to use the research results to adjust training strategies and load regimes, ultimately helping to bring future athletes to their peak physical condition.

CHAPTER 1
PATTERNS OF PHYSIOLOGICAL CHANGES IN THE BODY INDUCED BY SPORTS ACTIVITIES

1.1. The Impact of Sports Activities on the Skeletal System

The art of wrestling is as old as humanity itself. Interestingly, different peoples, often isolated from each other, developed various wrestling rules, but the essence remained the same: to throw the opponent down, pin them on their back, and force them to acknowledge defeat. The accumulated “wrestling” experience was passed down from generation to generation, and over time wrestling came to be seen as a means of general physical development and the acquisition of certain practical skills.

Interest in the issue of human adaptation to physical loads is quite broad and concerns people of different professions, ages, and genders. In recent years, numerous studies have been published on various aspects of this problem in sports. This is quite natural, as the adaptive changes occurring in the bodies of wrestlers during systematic training form the physiological basis of their work capacity.

The study of athletes’ body types is one of the main tasks of sports anthropology. The morphological characteristics of athletes’ bodies were noted even by the ancient Greeks. They understood which body shape was better suited for certain sports and even observed physical traits in athletes likely to succeed in the Olympic Games. However, scientific justification of athletes’ morphological features dates back to the first half of the 20th century, with the emergence of sports medicine, from which sports anthropology originated.

For freestyle wrestling, the most important qualities are speed-strength abilities: speed, endurance, agility, and flexibility, which largely determine the comprehensive physical development and health of athletes [4].

A child’s entry into sports begins either by choosing a particular sport or by being selected for a sports section. Only after that does the process of training, socialization within the team, and adaptation to environmental factors begin. In sports life, it is extremely important that this first step is successful. Francis Bacon said in the 16th century that those whose nature is aligned with their activities are fortunate; therefore, before a person chooses a type of activity, it is necessary to understand their "nature." Often, innate human characteristics determine their potential in labor and sports activities. The combination of innate morphological and functional features characterizes a person's talent in a particular field.

Observations and measurements through various tests typically reflect a combination of innate and acquired traits, but the proportion of each is unknown. Knowing this is necessary to confidently predict future sports achievements.

Any labor activity requires an overall compliance not only in size but also in the component and proportional levels of variation to be successful. Only with an optimal number of structures can an optimal state of the body be maintained, quick mastery of specific labor or sports activities be achieved, and high results be obtained.

Under the influence of sports training, progressive morphological changes occur in the muscular, skeletal, and cardiovascular systems that ensure the athlete's body adapts to high training and competitive loads. Any changes in one organ or group of organs induced by sports cause coordinated morphological remodeling in all other organs and systems of the body. This interdependence of morphological changes reflects the biological essence of the athlete's adaptation to physical loads.

Adaptive changes in the skeletal system of athletes occur at various levels of its organization: molecular, subcellular, cellular, tissue, organ, and systemic.

1. At the molecular level, bone tissue shows increased synthesis of proteins, mucopolysaccharides, enzymes, and other organic substances, along with enhanced deposition of inorganic substances that provide a high degree of bone tissue strength. The degree of mucopolysaccharide increase in bone tissue directly correlates with the intensity of the load: the more intense the load, the greater the amount of mucopolysaccharides found in the bones.

2. At the tissue level, there is increased osteonization of the bone tissue. E.A. Klebanova notes that "bone tissue primarily responds to training by forming new osteons, which are mature, differentiated structures with sufficient strength reserves" [5]. At the same time, old osteons break down and a large number of new, significantly more resilient

bone lamellae form. Thus, all cellular elements of bone tissue — osteoblasts, osteocytes, and osteoclasts — are functionally interconnected in the process of its remodeling.

3. At the organ level, adaptive changes are observed in all skeletal bones: changes in chemical composition, shape, internal structure, growth, and ossification timing [6].

The chemical composition of bones shifts slightly under load toward an increase in inorganic substances (calcium, phosphorus). The predominance of the mineral component is accompanied by an increase in bone tissue density up to 1.55 g/cm^3. The shape of the skeletal bones changes significantly due to enhanced muscular activity. At the sites of tendon attachment, crests, tuberosities, and roughened areas form. These features are more pronounced the stronger the muscles [7].

For example, in weightlifters, the shape of the scapula and clavicle changes considerably. The clavicle thickens, the lateral edge of the scapula becomes uneven, but the triangular shape remains intact. In swimmers, due to hypertrophy of the deltoid muscle, the diaphysis of the humerus enlarges, and the surgical neck smooths out. Kayakers exhibit a less pronounced neck of the radius due to an increased tuberosity where the biceps brachii attaches. Boxers and weightlifters may even have changes in the curvature of the radial diaphysis. Gymnasts' wrist bones are characterized by distinctive shapes, sizes, and outlines of the trapezium, capitate, and scaphoid bones. Those practicing rhythmic gymnastics, fencing, and hammer throwing show a rounded shape of the scaphoid and lunate bones. Track and field athletes, gymnasts, skiers, and divers show significant changes in the shape of the acetabulum region of the pelvis. Discus throwers develop thickening of the distal end of the femoral diaphysis. Runners exhibit considerable thickening of the tibia at its tuberosity and the fibula at its head. Hockey players and wrestlers show an increase in the width of the proximal epiphyses of the shin bones. Vertebrae undergo significant changes, with their shapes becoming rectangular or wedge-shaped. Rectangular shapes are mainly observed in swimmers. Wedge-shaped vertebrae with the wedge narrowing anteriorly appear in weightlifters, rowers, and cyclists; those with the wedge narrowing posteriorly are typical for wrestlers performing complex bridging maneuvers [8].

Morphological changes in the skeletal system of athletes affect the periosteum, compact bone, spongy bone, and bone marrow cavity.

The periosteum of bones thickens significantly during physical training due to increased functionality of its inner cambial or osteogenic layer. In young athletes, the normally invisible periosteum becomes visible on X-rays at a certain stage as a narrow band adjacent to the compact bone layer. Later, this part of the periosteum ossifies and fuses with the compact layer of the diaphysis, causing its thickening [6, 9].

The compact substance of bones usually thickens in athletes. Symmetrical thickening of the compact layer on limb bones is observed in swimmers, runners, weightlifters, skaters, and football players. In sports such as tennis and throwing, where the upper limbs are subjected to uneven loads, asymmetrical changes in the thickness of the compact bone layer occur. In both tennis players and throwers, predominant thickening happens on the right limb but in different segments.

Asymmetrical changes in the compact bone layer are also noted in boxers. The hand, especially the heads of the 1st, 3rd, and 5th metacarpal bones, undergoes the greatest impact. Their compact layer thickens, indicating very intensive physiological remodeling of the bone. In track and field jumpers, remodeling of the compact substance occurs predominantly in the supporting leg bones. The transverse diameter of the femoral diaphysis in the supporting leg exceeds the corresponding diameter in the other leg by 1–5 mm [10].

In individuals engaged in sports, the spongy substance of the epiphyses of bones typically exhibits a peripheral zone with relatively small trabeculae and a central zone with larger trabeculae. High athletic loads generally lead to an increase in the size of the trabeculae within the spongy substance. The epiphyseal regions acquire a more homogeneous structure, with the spongy substance no longer divided into peripheral and central zones.

The bone marrow cavity in athletes' bones decreases due to the thickening of the compact bone layer. On radiographs, it sometimes appears as a narrow cleft between two shadows of well-developed compact bone [11].

Bone growth is directly related to the process of synostosis or ossification and continues until synostoses form in the regions of the epiphyseal cartilage.

Typically, static loads cause some shortening of bones, not due to a reduction in longitudinal growth intensity but as a result of delayed ossification. The growth zone usually does not respond to either increased or decreased static loading, whereas with certain doses of dynamic loading, the sizes of limb segments increase.

A delay in synostosis in the distal parts of the forearm bones has been observed in acrobats, swimmers, rowers, and discus throwers, as well as an increase in the duration of longitudinal bone growth. In the sesamoid bones of the hand, which increase the leverage of muscle force, tennis players and weightlifters exhibit an earlier transition from cartilage tissue to bone.

Considering the skeletal system at the level of the whole organism, it can be stated that all adaptive changes within it proceed as favorable, progressive, and manifest as functional hypertrophy. Radiologically, functional hypertrophy of bones in young athletes is noted 6–7 months after the start of training, whereas in middle-aged and older athletes it appears after 1–1.5 years. General adaptive changes occur throughout all bones of the skeleton, while local changes are found in its most heavily loaded parts. Literature sources report regression of functional hypertrophy of bones upon cessation of physical loading [7, 8, 11]. Thus, the observed changes in the skeletal system of athletes reflect the morpho-functional remodeling caused by progressive shifts in the organization of the musculoskeletal system under the influence of specific athletic activity.

1.2. Structural Remodeling of the Muscular System Under Physical Loads

High physical loads, characteristic of modern sports, place increased demands on all systems of the athlete's body, including the skeletal muscles. Studying the changes occurring in muscles under the influence of various motor regimes at the macroscopic and microscopic levels has great theoretical and practical significance, as changes in muscle structure also affect their functional capabilities.

Hyperfunction of the muscular system is an integral component of most adaptive reactions of a healthy organism and is clearly manifested in humans during all types of physical work. Under the influence of physical loads, a complex structural remodeling occurs in the muscular system, the basis of which is functional hypertrophy of muscle tissue. Different types of sports activity impose specific demands on certain muscle groups that perform the characteristic work of that particular sport to a greater extent. Therefore, athletes of different specializations exhibit varying development of skeletal muscles and, correspondingly, their strength qualities [11].

During adaptive reactions, morphological transformations occur at various levels of the structural organization of skeletal muscles: organ, cellular, and subcellular.

At the cellular and organ levels, among the morphological features characterizing muscle hypertrophy, one should note increases in volume, organ weight, and the size (length and thickness) of cellular elements of the organ. Sometimes there is an increase in the number of muscle fibers (this is not a mandatory characteristic of muscle hypertrophy, although it often accompanies it). The greatest remodeling occurs at the subcellular level. Changes are clearly revealed by histochemical methods and serve as indicators of the dynamics of the functional activity of skeletal muscles. Changes in the fine structure of muscle tissue during adaptation to physical loads are characterized by enhanced deposition of myoglobin, especially at the level of myofibrils, focal changes in glycogen content, and an increase in mitochondria [8].

An increase in muscle contraction intensity predictably causes activation of energy production processes and protein synthesis. Active energy production is characterized by a significant increase in oxygen consumption per unit mass of muscle tissue, as well as an increase in oxidative phosphorylation, i.e., aerobic resynthesis of ATP.

Since energy is used not only to intensify muscle activity but also for increased synthesis of contractile proteins, mobilization of the anaerobic pathway of ATP resynthesis occurs via breakdown of glycogen and creatine phosphate stored in myocytes.

Following activation of the synthesis of energy-producing structures (mitochondria), protein synthesis increases and the mass of functioning structures — myofibrils — grows. Overall, the increase in muscle tissue mass leads to a correspondence between the enhanced functional activity of muscles and their structure. Morphologically, this is expressed by an increase in muscle fiber size [8].

An increase in the functional activity of the organ and contraction of skeletal muscles necessarily occurs alongside intensified tissue metabolism. Their metabolism and blood supply increase.

Changes in muscles under predominantly static loads differ from those under predominantly dynamic loads. During static loads, alongside an increase in muscle volume, the surface area of their attachment to bones increases, the tendinous portion elongates, and intramuscular connective tissue layers thicken. At the microscopic level, there is an increase in the trophic apparatus of the muscle fiber (sarcoplasm, nuclei, mitochondria). Due to the increase in sarcoplasm quantity, each individual muscle fiber thickens, and numerous nuclei adopt a rounded shape.

However, the myofibrils of the muscle fiber are relatively less developed and are loosely arranged.

Prolonged contraction of muscle fibers and intensification of metabolic processes within them contribute to an increase in the number of blood capillaries, which form a dense, narrowly looped network. Motor endplates on muscle fibers increase more significantly in their transverse dimensions.

Under predominantly dynamic loads, the weight and volume of muscles also increase, but to a lesser extent than under static loads. In muscles, the muscular portion elongates while the tendinous part shortens [11].

Muscle fibers are more often arranged almost parallel to the longitudinal axis of the muscle. Microscopic examination shows an increase in the number of myofibrils in muscle fibers. The nuclei become elongated and their number increases. Motor endplates are usually elongated along the muscle fiber. The number of nerve fibers in muscles performing predominantly dynamic functions is 4-5 times greater than in muscles whose work is mainly associated with performing static functions. With an increase in the number of nerve elements, the number of nerve impulses received by the working muscle also increases [6].

Scientific justification of movement regimes beneficial for the muscular system under various conditions (including in a state of overtraining after maximal and submaximal loads) has great practical importance. Research in this area has shown that during chronic fatigue, hypodynamia affects the restoration of functional properties of muscles.

When designing a rational movement regime, both in the process of sports training and in the recovery period, it is necessary to take into account the structural changes in muscles that occur as a result of physical loads of varying intensity.

With systematic moderate physical loads, muscles increase in size, becoming dense and elastic to the touch. Microscopic examination reveals an improvement in their blood supply. Individual muscle fibers undergo hypertrophy. The increase in muscle volume occurs not only due to an increase in the size of muscle fibers but also due to an increase in their number. The area of contact between muscle fibers and nerve elements grows. A pronounced longitudinal striation is observed in muscle fibers [11].

After maximal physical loads, there should be a rest period sufficient for reparative processes in muscles. Otherwise, chronic fatigue or overtraining develops in the body. Disturbance of the movement regime associated with athlete overtraining is accompanied by pre-pathological and pathological changes in muscle tissue.

Morphological changes in muscles during chronic fatigue occur in two directions: on the one hand, muscle fiber breakdown is observed; on the other, functional hypertrophy of muscle tissue continues to develop (depending on the degree of overtraining, one or the other process predominates).

During muscle fiber breakdown, motor endplates decrease in volume, becoming compressed, which results in reduced contact surfaces between muscle and nerve fibers. The influx of nerve impulses into the muscle decreases, thereby impairing the functional properties of the muscles. The capillary network in the muscles narrows and shows pathological changes. Pathological changes also occur in muscle fibers: their longitudinal and transverse striation decreases, some fibers undergo dystrophy, and some show swelling and constriction. Under the microscope, fragmentation of muscle fibers can sometimes be observed. Connective tissue forms in place of the broken-down muscle fibers [8].

1.3. Component Composition of Body Mass

Body composition is the quantitative ratio of structural components with different metabolic activities, reflecting the individual characteristics of the organism [12, 13]. Special attention is given to the study of somatotypes and their body composition among children engaged in sports for varying durations [14–17].

An important indicator of physical development is body mass. Body mass and length are genetically determined to a significant extent (64% and 86%, respectively). However, body mass alone does not provide an objective representation of individual body shape without its fractionation into three main components: bone, muscle, and fat. Metabolically active tissues (muscle, bone, nervous tissue, and internal organs) and less active tissues (subcutaneous and visceral fat) form the body's energy reserves [18, 19].

Measurements of muscle and fat components under the influence of training loads reflect the direction and magnitude of adaptive structural changes in the athlete's body and the predominant nature of energy supply. The labile morphological parameters of an individual can serve as markers of adaptation to intense muscular activity. Maintaining water balance is of critical importance for athletes, as even mild dehydration is poorly tolerated by the body [20, 21]. Physical activity is accompanied by loss of micro- and macroelements through sweating, primarily sodium and potassium, which adversely affect the functional state of the cardiovascular system and neuromuscular regulation [22].

It is also known that body composition changes depending on the dietary intake of proteins, fats, and carbohydrates [23]. An increase in fat mass occurs with a higher proportion of carbohydrate-fat complexes in the diet, whereas reducing the intake of fats and carbohydrates leads to the opposite changes in body composition. The use of various pharmacological agents also affects body composition: anabolic drugs increase muscle mass, enhance work capacity, and improve endurance [24].

Furthermore, changes in body composition in young athletes vary across different age periods. The dynamics of body mass components primarily reflect the maturation of the hormonal system, as well as growth and development processes influenced by sports training. Children of both sexes aged 5–9 years, training in sports for 1–4 years, exhibit low muscle mass (43–45% of total body mass) and moderate fat mass (10–13% of total body mass). The prepubertal period is characterized by gradual and slight increases in muscle mass and variations in fat deposition. The pubertal period shows more pronounced changes, especially in boys, with an increase in muscle mass accompanied by a decrease in fat mass, while girls tend to increase fat mass. The postpubertal period mainly reflects sports-related refinement, with increased muscle and decreased fat components. A direct correlation between body composition indicators and physical activity levels has been demonstrated [25].

Additionally, the specific values of body mass components depend on the type of sport and the athlete's qualification level. Athletes of higher ranks have greater muscle mass and lower fat mass compared to those less qualified. Strength athletes exhibit the highest muscle mass; endurance athletes have lower muscle mass and minimal fat mass; athletes involved in team sports show differentiated muscle and fat mass according to their playing positions. Athletes engaged in sports requiring prolonged body movement in space tend to have moderate muscle mass, whereas those involved in speed-strength and power sports can have muscle mass equal to or exceeding 50% of total body mass.

Thus, each sport develops a specific morphological body model, the conformity to which serves as a fundamental advantage for success and professional longevity [26].

CHAPTER 2
MATERIALS AND METHODS OF RESEARCH

In the study of the functional state of athletes, a whole set of methods is used, among which the body composition assessment method proposed by the Czech researcher Matejka (1921) [27] has gained considerable popularity. This method is exceptionally simple and accessible, and the body composition indicators obtained using it provide valuable complementary information to other data, allowing for a more comprehensive characterization of athletes' functional condition.

When evaluating body composition indicators, particular attention is paid to analyzing the ratio of muscle to fat components during different periods of the training macrocycle. This focus is due to the considerable lability of the muscle and fat components of body weight. For instance, an athlete's overall body weight may remain constant throughout a training cycle, while the ratio of muscle to fat components changes significantly.

The research was conducted among children aged 8 to 9 years who train in a freestyle wrestling section within the preliminary basic training group at Youth Sports School №7 in Kharkiv.

During the first stage of the work, an analysis of scientific and methodological literature on the chosen topic was carried out, resulting in determining the extent to which the issue has been covered by various researchers. The relevance of the research problem at present was established, and the research methodology was selected.

At the second stage, the young wrestlers were divided into two groups. Group I consisted of children who have been practicing the sport for 1–2 years, while Group II included children training in the section for 4–5 years. The children examined did not differ in terms of family social status (average), the nature and balance of their nutrition, frequency and duration of training sessions (4 times per week, 3 hours each), and none had chronic illnesses. Voluntary informed consent from the parents for conducting the measurements was also obtained.

Alongside the aim of achieving sports results, sports training is also directed towards strengthening health and ensuring good physical development of children. Therefore, a comparative analysis of physical development indicators in children with different sports experience is justified to characterize the degree of sports training influence on a developing child's organism.

Recently, anthropometric studies have become widely applied to address practically important issues in assessing athletes' physical development. For coaches, anthropometric data are of significant interest because they allow continuous monitoring of physical development characteristics, recommending appropriate sports for beginners, and planning individualized training loads.

The examination included anthropometry [28]: longitudinal, transverse, and circumferential body measurements; diameters of bone epiphyses; and body mass determination. Body length, in particular, is used as a leading indicator of physical development, considered a conservative trait genetically determined and therefore informative from a prognostic perspective.

All requirements ensuring not only the accuracy but also the comparability of the anthropometric results were strictly followed during the study. Before starting the research, a measurement program and a protocol form for recording results were developed (Appendix A). Standard verified instruments were used: a wooden stadiometer; large and small thick-joint calipers; millimeter tapes up to 1.5–2 m in length; medical scales with a measurement accuracy of up to 50 g.

The calculation of fat, muscle, and bone components of body mass was performed using special formulas detailed below, taking into account anthropometric data and the caliperometry method.

The calculation of the absolute amount of body fat mass was performed according to Matejka's formula [27]:

$$D = d \times S \times k$$

D – weight of the fat component (in kg);

d – average thickness of the skinfolds on the shoulder, forearm, thigh, calf, chest, abdomen, and back (in mm);

The average thickness of subcutaneous fat together with the skin is equal to the half-sum of the skinfold measurements and is calculated as follows:

$$d = \frac{1}{2} \times (d_1 + d_2 + d_3 + \ldots d_7) / 7$$

S – body surface area (in m^2);

$$S = (100 + \text{weight (kg)} + (\text{height (cm)} - 160)) / 100$$

k – coefficient equal to 1.3, obtained experimentally from anatomical material.

The determination of the absolute amount of the muscle component of the body was carried out using the following formula:

$$M = L \times r^2 \times k$$

M — absolute amount of muscle tissue (in kg);

L — body length (in cm);

r^2 — average radius of the arm, forearm, thigh, and shin at the sites of greatest muscle development, excluding the subcutaneous fat layer (in cm);

k — constant equal to 6.5.

The radius values of the indicated segments are determined by the formula for the circumference (body segment girths):

$$Q = 2\pi r$$

$$r = (P\_arm + P\_forearm + P\_thigh + P\_shin) / (2 \times 3.14 \times 4) - (d\_arm + d\_forearm + d\_thigh + d\_shin) / (2 \times 4 \times 10)$$

P — perimeter (circumference) of the arm, forearm, thigh, and shin (in cm);

d — average thickness of skinfolds (in mm).

The absolute bone mass was determined using the formula:

$$O = L \times C^2 \times k,$$

O — absolute bone mass (kg);

L — body length (height) (cm);

C_2 — average diameter of the distal parts (arm, forearm, thigh, and shin);

k — constant equal to 1.2.

$$C = (C\_arm + C\_forearm + C\_thigh + C\_shin) / 4.$$

To compare the development of fat, muscle, and bone components, alongside absolute values, relative values are also determined as percentages of body weight. For this, the absolute value of the studied body mass component is divided by body weight and multiplied by 100%. Thus:

$D_{rel,.} = (D/P) \times 100\%$;

$M_{rel,} = (M/P) \times 100\%$;

$O_{rel.} = (O/P) \times 100\%$;

The third stage of the study involved statistical processing of the obtained data using methods of mathematical statistics. To establish statistically significant differences between the arithmetic means of the results, the Student's t-test was employed.

CHAPTER 3
CHARACTERISTICS OF ANTHROPOMETRIC PARAMETERS IN YOUNG WRESTLERS

3.1. Study of Total Body Dimensions

For the investigation of the primary anthropometric indicators, body length and mass were measured. The analysis of body length in children practicing wrestling for 1–2 years (Group I) and 4–5 years (Group II) showed no statistically significant differences in height between the two groups ($P < 0.90$) — the difference in height was 2.8%.

According to the literature, wrestlers with longer sporting experience tend to have significantly shorter stature compared to those with shorter training duration; moreover, shorter athletes tend to be more successful in wrestling [29]. Anthropometric measurements of longitudinal dimensions indicate smaller leg lengths in highly qualified athletes, suggesting shortening of the lower limbs, particularly due to a reduction in tibia length [1]. The findings regarding “short-legged” wrestlers align well with data from other researchers, who associate this phenomenon with advanced physical development of individuals [30, 31]. In our study, no differences in height were observed, likely due to the relatively short training periods of the children. American researchers, however, dispute the existence of a specific body type among wrestlers, arguing that wrestling promotes diverse physical development [22].

Body mass is an indicator of physical development. This parameter is considered integrative, as it collectively reflects the development level of subcutaneous fat, internal organs, and the musculoskeletal system. Measurements were taken using stationary medical scales with an accuracy of 0.1 kg.

When assessing body mass, children in Group II showed a tendency toward increased weight by 10.6% compared to Group I. However, this quantitative measure alone does not provide reliable information about body composition at the individual level and has low informativeness for assessing fat mass. Nevertheless, the increase in body mass observed in children training for 4–5 years may be related to physical activity and regular training, resulting in increased muscle mass [32, 33].

3.2. Study of Transverse Body Dimensions

Analysis of transverse body dimensions among children engaged in sports for varying durations revealed an increase in these measurements. Specifically, the transverse and sagittal diameters of the chest in athletes from the second group were significantly greater compared to those in the first group ($P < 0.05$): the transverse chest diameter in the second group was 9% larger, and the anteroposterior diameter was 6.9% greater (see Fig. 3.1). At the same time, no significant differences were found in the acromial diameter (shoulder width).

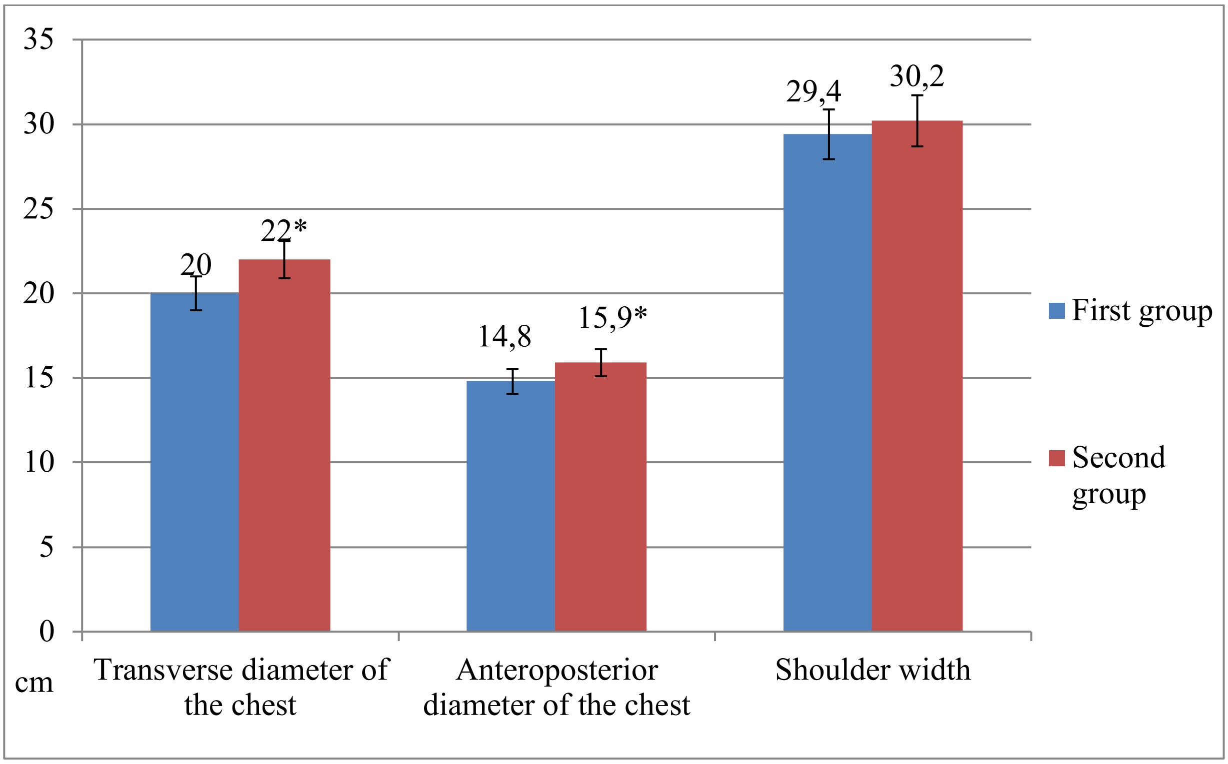

Fig. 3.1 Indicators of transverse body dimensions

In wrestlers, the dimensions of the upper chest region provide essential support for the specific functioning of the upper limb muscles. The increase in the overall size in some of the analyzed parameters showed a strong correlation with the duration of sports training.

3.3. Study of Circumferential Body Dimensions

As a result of measuring body circumferences, it was found that these measurements were significantly larger in children of Group II ($P \leq 0.05$) (Fig. 3.2): arm circumference increased by 9%, forearm by 9.1%, thigh by 11.5%, and calf by 7.8%.

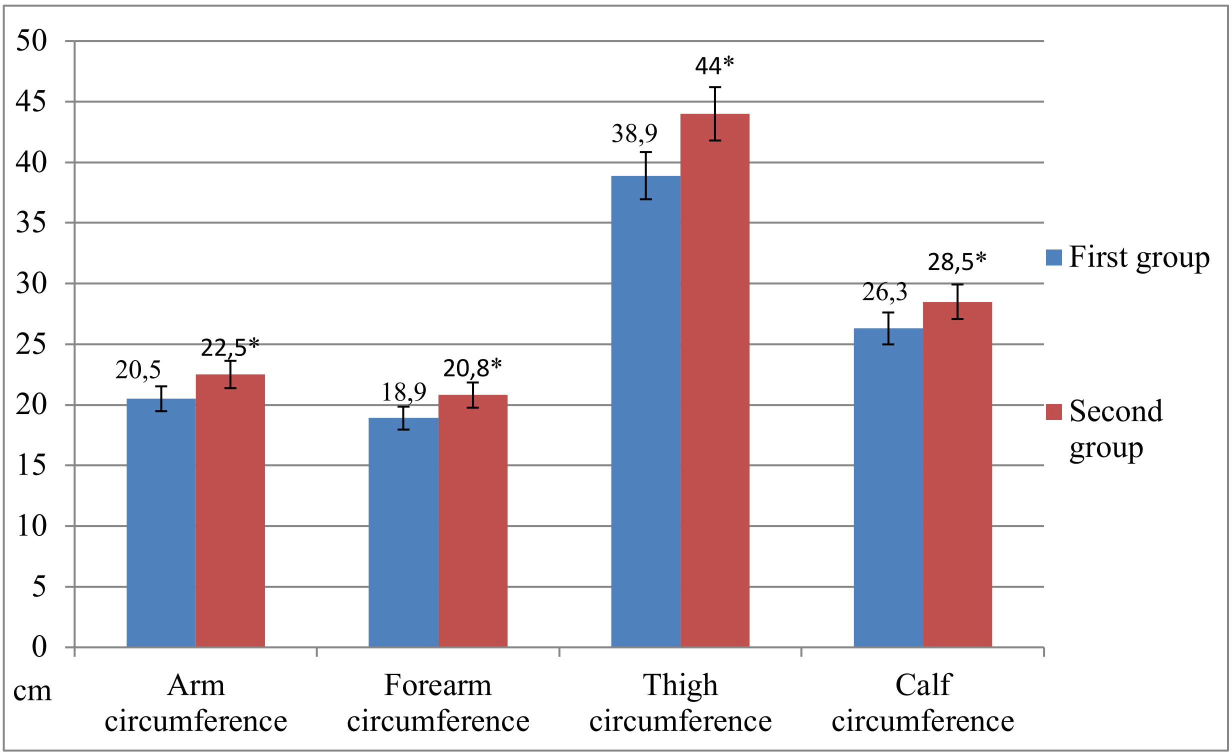

Fig. 3.2 Indicators of body circumference measurements

Measurement of chest circumference at rest revealed a statistically significant increase in its volume among children in Group II by 10.2% ($P \leq 0.05$) (Fig. 3.3).

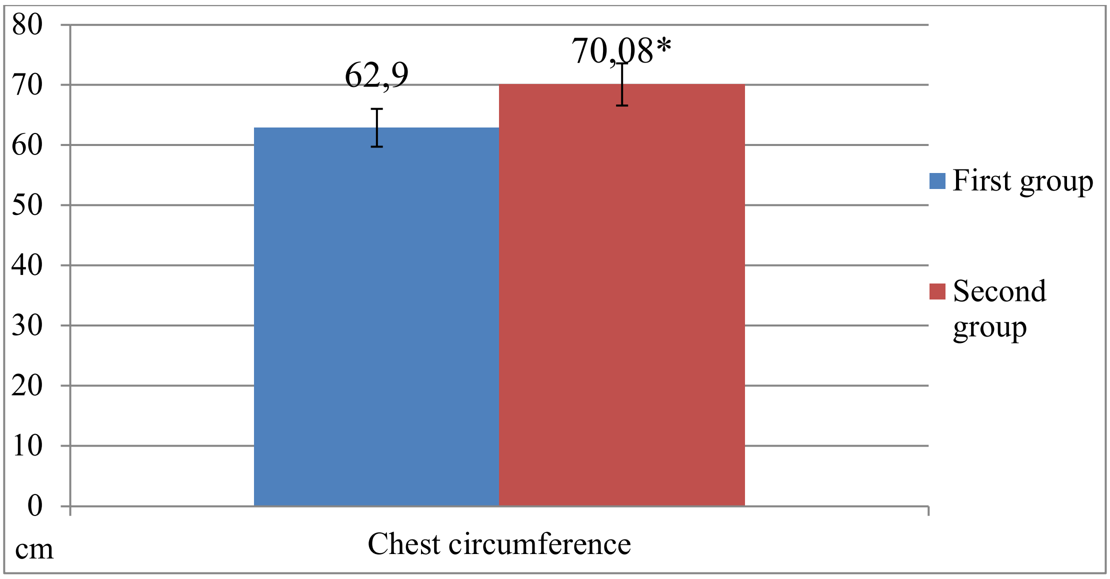

Fig. 3.3 Indicators of chest volume at rest

Some authors [29] note large transverse dimensions, significant circumferences of the chest, neck, shoulder, thigh, and calf, as well as a relative short-arm condition in wrestlers. With increasing athlete qualification, the level of speed-strength training improves, the circumferences of the neck, shoulder, thigh, and chest increase, the percentage of the fat component decreases, the muscle component increases, and the musculature development index rises. Among morphometric parameters, the transverse and circumferential body dimensions are most closely associated with wrestler qualification.

3.4. Study of Bone Epiphysis Diameters

The assessment of bone epiphyseal diameters revealed somewhat unexpected results. Only the measurements of forearm diameters showed a statistically significant increase of 10% among children in Group II ($P \leq 0.05$). Measurements of the diameters of the lower part of the arm, thigh, and calf did not show significant differences ($P > 0.05$); moreover, the diameters of the thigh and calf were non-significantly larger in children of Group I by 3.3% and 4.6%, respectively. An increase in arm diameters was observed among children in Group II (Fig. 3.4)

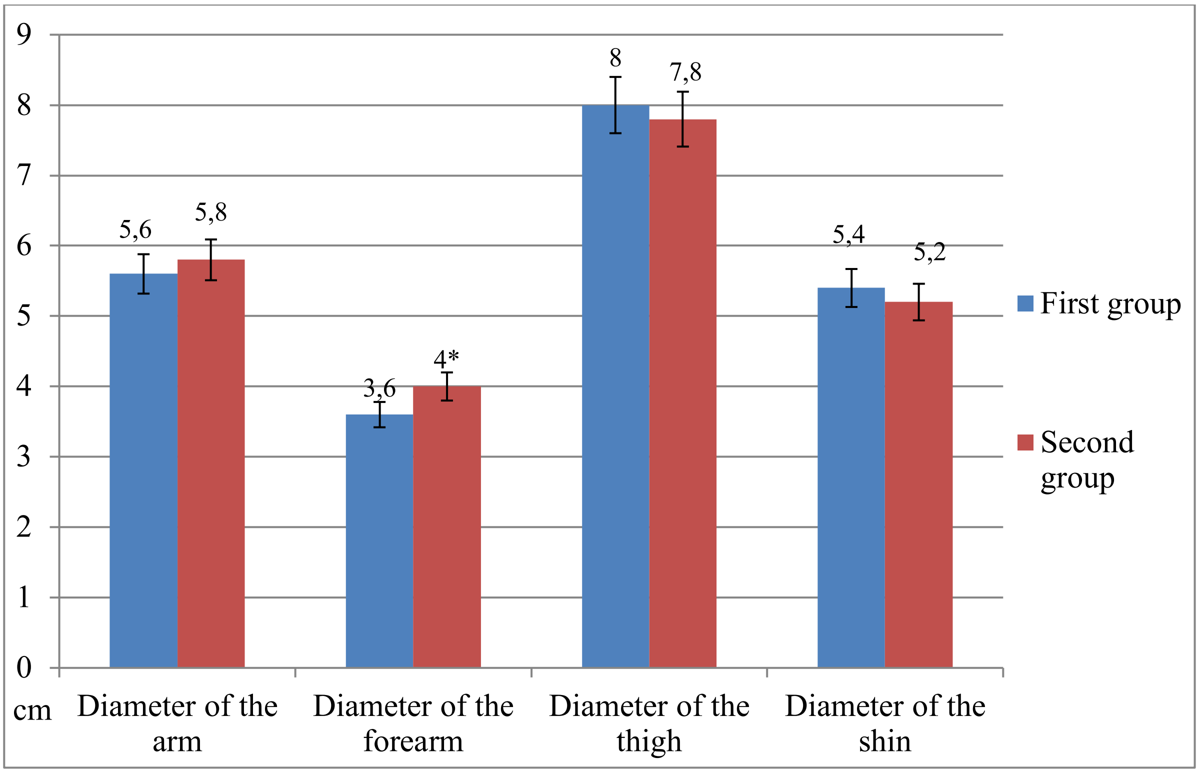

Fig. 3.4 Indicators of bone epiphysis diameters

Unlike transverse and circumferential body dimensions, the diameters of bone epiphyses are a less variable indicator when studying the morphotype of children.

3.5. Determination of Body Component Composition

Of great interest for sports practice is the monitoring of the variability in the proportions of individual components of athletes' body mass under the influence of training. A differentiated assessment of body mass components allows for evaluating both morphological and functional changes occurring in athletes' bodies [35]. The nature of activity and nutrition is reflected in the variability of human body composition. With intensified physical training, muscle mass increases while excess fat is lost, whereas limited physical activity (hypokinesia) leads to increased fat deposits and decreased muscle mass. Fat stores increase with overnutrition and are depleted with specially designed diets. In many sports, weight reduction under dietary restrictions represents a complex and relevant challenge (e.g., for weightlifters and boxers during pre-competition phases), where, besides energy balance accounting, body composition analysis plays an important role.

It is common to distinguish between relatively active and less active components of body mass in terms of energy expenditure. The less active component refers to body fat, while the active component is fat-free body mass. The development and variability of the body composition components depend on population, living environment, age, and sex [36, 37, 38]. The fat component is the most labile and can vary widely. It determines external appearance, shapes body form characteristic of age, sex, and ethnicity, and reflects the neurohumoral status [39, 40, 41]. The bone component defines proportions and somatotype. Studies of body composition components in ethnic groups and populations across different climatic and geographic zones have revealed a number of structural transformations that ensure adaptive mechanisms [38, 42, 43, 44, 45].

As adolescents mature, constitutional affiliation and the fractional structure of body composition components may change, which should be regarded as a modification rather than a radical restructuring of somatotypes [17]. Among brachimorphs, hypertrophs, and hypotrophs—both boys and girls—the fat component ranges from 10.5 to 33.2 kg (20.6–45.5%), the bone component from 7.3 to 9.5 kg (12.2–19.9%), and the muscle component from 12.8 to 15.9 kg (17.6–35.3%) of total body mass. Individual somatotypes undergo significant changes at ages 4 and 18–19 years, maintaining their forms in 85% of cases [46, 47].

Of primary importance in sports is the calculation of fat mass, which functions as a metabolically active organ; an adequate level of fat mass plays a significant role in maintaining overall health [25]. Knowledge about the quantity and distribution of bone and muscle tissues is used to assess athletic performance capacity. A reduction of fat mass to 5–6% of total body mass, and skeletal muscle mass to 46% during the competition period, is undesirable and often indicates athlete overtraining [48].

Intensive physical activity causes a decrease in fat mass and an increase in muscle mass [24]. Generally, the higher the fat component in athletes, the lower their endurance and associated physiological indicators (such as maximal oxygen uptake, physical work capacity according to the PWC170 test, etc.).

In the study of young wrestlers, a tendency toward a 9.3% reduction in fat mass was observed in the second group (Fig. 3.5). The decrease in skinfold thickness among wrestlers in the second group can be explained by the high physical loads, which predominantly affect the upper and lower limbs

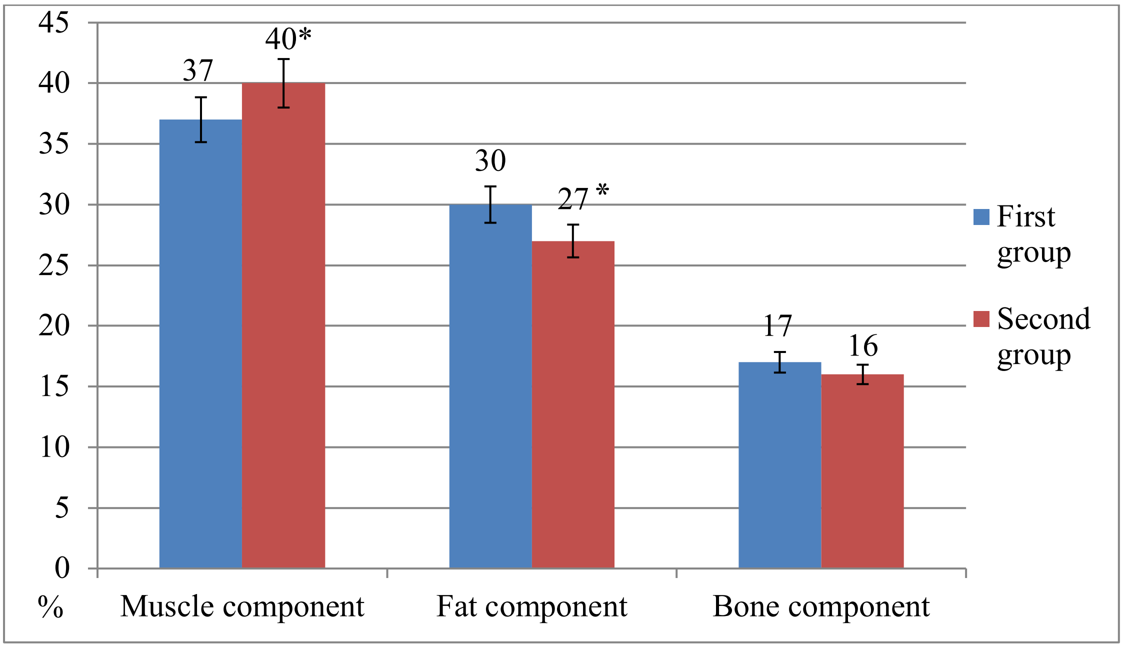

Fig. 3.5 Component composition of body mass

It is known that the muscular component of human body mass is one of the indicators of body build and a marker of its structural-functional state during ontogenetic stages, primarily in childhood and adolescence. During ontogeny, the muscular component can dynamically change under the influence of internal and external factors [49]. Intensive physical activity causes a decrease in the fat component and an increase in muscle mass [24]. A significant increase in muscle mass has been observed with training lasting nine or more hours per week [26].

Analysis of the muscular component in wrestler athletes revealed a statistically significant increase of 8.4% ($P \leq 0.05$) in athletes of the second group (see Fig. 3.5), which demonstrates the influence of training loads on the earlier onset of accelerated muscle growth in children who have been engaged in sports for a longer period. Thus, it can be stated that sports training leads to adaptive shifts in the bodies of young athletes, and such a morphological indicator as the muscular component can serve as a marker of adaptation to intense muscular activity.

The bone mass indicators showed a tendency to decrease by 5.9% in representatives of the second group (see Fig. 3.5). The bone component highlights body proportions and somatotype but is less variable compared to the muscular and fat components. According to literature sources, the study of the relative bone component of body composition in young athletes revealed a wave-like dynamic of this indicator. A significant increase is observed at ages 14 and 17, with a decrease at age 15. Higher values of the relative bone component were found in untrained individuals at age 13 [34].

Research has shown that the duration and intensity of the training process significantly affect the athlete's morphotype. The level of the anthropomorphological profile depends on the level of sports mastery. In wrestlers who have been practicing sports for a longer time, there is a tendency for an increase in muscle mass and, accordingly, a decrease in body fat.

The study demonstrated a direct relationship between circumferential and transverse body measurements and the level of physical activity. With intensified physical training, muscle mass increases, while restricted motor activity leads to increased fat deposits and decreased muscle mass. It is likely that circumferential body characteristics are among the indicators of body build and markers of its structural-functional state during ontogeny, especially in childhood and adolescence. In other words, the level of the anthropomorphological profile depends on the level of sports mastery. In wrestlers who have been engaged in sports for a longer time, a tendency to increase muscle mass and correspondingly reduce the fat component is observed.

Thus, under the influence of sports training, namely freestyle wrestling, young athletes develop a specific morphological body model, the conformity of which is a fundamental advantage for success and professional longevity.

CONCLUSIONS

Research has shown that the duration and intensity of the training process significantly affect the morphotype of young wrestlers.

1. Analysis of the overall physical development sizes of children engaged in wrestling showed no significant differences in height between young athletes of both groups. However, there is a tendency for increased body weight in young wrestlers with longer sports experience (Group II).

2. It was found that the transverse and sagittal diameters of the chest in children of the second group increased compared to those in children of the first group ($P \leq 0.05$); acromial diameters showed no significant differences.

3. It was established that the circumferential body measurements (circumferences of the arm, forearm, thigh, calf, and chest volume) were significantly greater in children of Group II.

4. It was found that the diameters of bone epiphyses were significantly larger by 10% in wrestlers of Group II ($P \leq 0.05$). The diameters of the thigh, calf, and arm showed no significant differences.

5. The ratio of individual body mass components was revealed: indicators of the fat component tended to decrease by 9.3% in wrestlers of the second group, while their muscle component increased by 8.4% ($P \leq 0.05$). The bone mass component indicators in the studied athletes did not differ significantly.

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APPENDICES

Appendix A

Anthropometric examination form

First name, last name ______________________________

Date of birth ______________________________

Sport specialization ______________________________

Sporting experience (years)______________________________

Measured parameter	Value of parameter	
	Right side	Left side
1. Body weight		
2. Body height		
3. Body diameters Acromial (shoulder width)		
Midsternal transverse diameter		
Anteroposterior midsternal diameter		
Pelvic width		
Distal part of the arm		
Distal part of the forearm		
Distal part of the thigh		
Distal part of the shin		
4. Body circumferences Chest: a) at rest		
b) at maximum inspiration		
c) at maximum expiration		
Chest excursion		
Arm: a) tense state		
b) relaxed state		
Forearm		
Thigh		
Shin		
5. Skinfold thickness On the chest		
On the arm: a) anterior		
b) posterior		
On the forearm		
On the hand		
On the abdomen		
On the thigh		
On the shin		
Below the scapula		