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Analysis of Physical Development Indicators Of 14-16-Year-Old Adolescents Engaged in Track and Field Under Regular Sports Training Conditions

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Abstract: This article presents a comprehensive analysis of the physical development indicators of adolescents aged 14-16 engaged in track and field athletics. Anthropometric and physiological measurements were employed in the study. The obtained data were processed using mathematical and statistical methods, with mean values and variance determined. The study assessed anthropometric parameters such as body height and body mass, as well as physiological indicators including heart rate, arterial blood pressure, respiratory rate, vital lung capacity, and handgrip strength measured by dynamometry. The differences among these indicators were analyzed statistically. The results of the study demonstrate the positive impact of regular sports training on physical development and functional capacity.

Keywords: Track and field athletics, anthropometry, physiological indicators, statistical analysis, adolescents, physical development, sports selection.

Introduction: In recent years, in the Republic of Uzbekistan, the upbringing of the younger generation as comprehensively developed, physically healthy, and spiritually mature individuals has been defined as one of the priority directions of state policy. Particular attention is being paid to the development of children's and adolescent sports, the broad involvement of youth in regular sports activities, and the обеспечение их физического развития. Promoting a healthy lifestyle among young people through sports, enhancing their physical fitness, and increasing their social activity are among the urgent tasks of today.

In this direction, a number of normative legal documents have been adopted in the country, and the institutional foundations for the development of physical education and sports have been strengthened. In particular, the Decree of the President of the Republic of Uzbekistan No. PF-5924 dated January 24,

2020, “On measures to further improve and popularize physical education and sports in the Republic of Uzbekistan,” defined the priority areas for the development of physical education and sports and предусмотрел the implementation of systematic measures to involve the population, especially youth, in an active physical lifestyle.

Also, the Law “On Physical Education and Sports” (new edition) established the legal foundations for state support of physical education and sports, the organization of sports activities, the training of athletes, and the development of youth sports.

The recently adopted Resolution No. PQ-443 dated December 18, 2024, outlined comprehensive reforms aimed at further developing children’s and adolescent sports, improving the system of sports schools, and promoting sports among youth.

These normative legal documents further strengthen the need to widely involve the younger generation in sports, ensure their physical development, and organize the process of sports training on a scientific basis.

Among various sports, track and field athletics is considered an important type of sport that contributes to the development of the main physical qualities of the human body, including speed, strength, endurance, and agility. In particular, adolescence, especially the age range of 14-16 years, represents a stage of intensive growth and development of the organism, during which sports training has a significant impact on physical development.

METHODS

The main objective of this study was to determine the anthropometric and physiological indicators of 14-16-year-old track and field athletes, to compare them according to age and gender factors, and to investigate their relationship with sports performance. A total of 60 adolescents regularly engaged in sports activities were involved in the study and divided into groups according to age and gender. The participants were healthy and represented athletes at the initial training stage who regularly attend sports training sessions. In our observations, morphological and functional indicators were studied in order to assess the level of physical development of young athletes. Based on the obtained indicators, the level of physical development and functional capacity of the athletes’ organisms were evaluated.

In our observations, the following morphological indicators were studied to determine the physical development level of the student-athletes: body height and body mass.

Body height was measured using a stadiometer with an accuracy of 1 cm. The measurement was performed with the athletes in a standing position, with the head positioned in the Frankfurt plane.

Body mass was measured using a medical scale in kilograms. Measurements were carried out in the morning with athletes wearing light sports clothing.

Each athlete’s physical fitness and sports performance are directly related to the functional state of their organism. Therefore, the following functional indicators were studied in this research: heart rate, arterial blood pressure, respiratory rate per minute, vital lung capacity, and handgrip dynamometry.

The obtained results were processed using mathematical and statistical methods, with mean values (Mean), standard deviations (SD), and Student’s t-test (t) calculated. The results were statistically analyzed using Student’s t-test, and the level of significance (P) of differences between indicators was assessed.

RESULTS

In this study, morphological indicators such as body height and body mass of 14- and 16-year-old boys and girls regularly engaged in track and field athletics were investigated and statistically analyzed.

In our observations, the mean body height of 14-year-old boys engaged in regular track and field training was 164.73 ± 0.93 cm. In 16-year-old boys, the mean body height was 172.87 ± 0.78 cm. The difference between the obtained results was +8.13 cm.

Among 14-year-old girls regularly engaged in track and field athletics, the mean body height was 163.33 ± 0.88 cm. In 16-year-old girls, the mean body height was 165.8 ± 1.14 cm. The difference between the obtained results was +2.47 cm. An increase in body height was observed; however, it was less pronounced compared to boys.

When comparing boys and girls, the difference in body height at 14 years was +1.4 cm. At 16 years, the difference between boys and girls increased to +7.07 cm. It is evident that the gender difference becomes more pronounced with age. In both age groups, boys demonstrated a greater increase in body height compared to girls.

Based on the obtained data, the differences between 14- and 16-year-old boys and girls were found to be statistically significant ($P < 0.001$) (Table 1, Figure 1).

During the study, body mass indicators of 14- and 16-year-old boys and girls engaged in regular track and field training were also analyzed. The mean body mass of 14-year-old boys was 53.0 ± 0.95 kg, while in 16-year-old boys it was 58.33 ± 1.18 kg. The difference

between the results was 5.33 kg.

Among 14-year-old girls, the mean body mass was 48.66 ± 0.61 kg, whereas in 16-year-old girls it was 51.4 ± 0.76 kg. The difference between the results was +2.74 kg.

The analysis of body mass data showed that the difference between boys and girls at the age of 14 was +4.33 kg. At the age of 16, the gender difference increased to +6.93 kg.

The results of the analysis indicate that the differences in body mass between 14- and 16-year-old boys and girls are statistically significant (P < 0.001) (Table 1, Figure 2).

Table 1

Morphological indicators of 14–16-year-old male and female track and field athletes						
Groups	**Body height (cm)**			**Body mass (kg)**		
14-year-old boys	164.7333	±	0.933333	53	±	0.956182887
14-year-old girls	163.33	±	0.8819	48,667	±	0.6146
16-year-old boys	172.8667	±	0.779906	58.33333	±	1.18187368
16-year-old girls	165.8	±	1.1431	51.4	±	0.761
P	<0.001			<0.001		

Figure 1. Mean body height of students (cm)

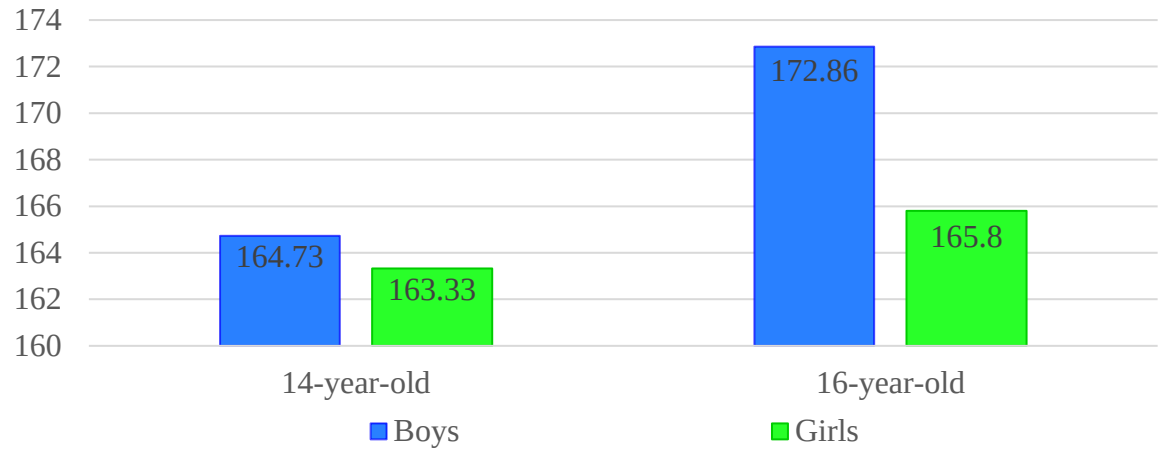
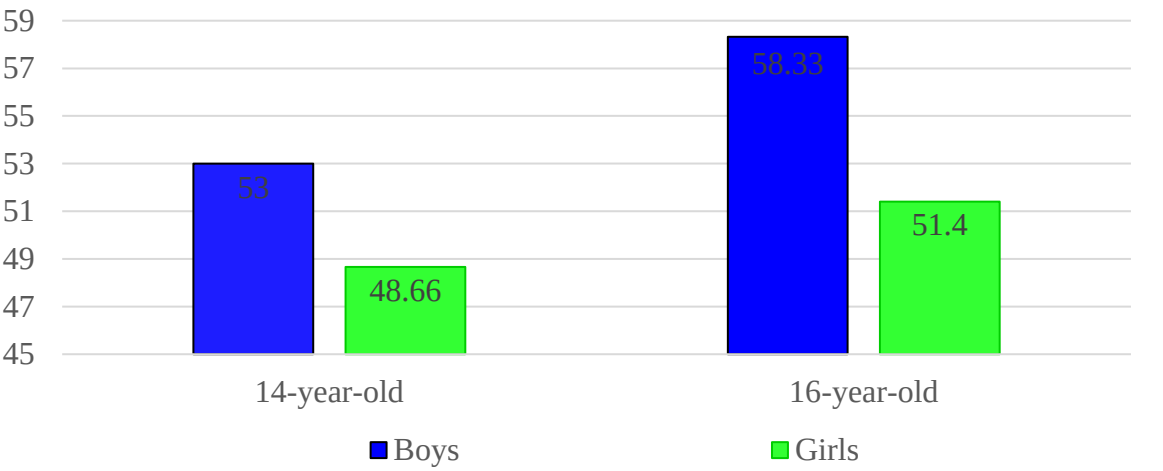


Figure 2. Mean body mass of students (kg)



During the study, the heart rate (pulse) as an indicator of the cardiovascular system was investigated in 14- and 16-year-old boys and girls who regularly engage in athletics. The obtained results demonstrate that regular participation in sports is directly associated with age-related physiological adaptation processes.

In 14-year-old boys, the mean heart rate was 69.4 ± 0.67 beats/min, whereas in 16-year-old boys it was

63.73 ± 1.08 beats/min. A significant decrease in pulse rate was observed within this age range (P < 0.001), indicating improved cardiac efficiency and an increased level of adaptation of the organism to physical load.

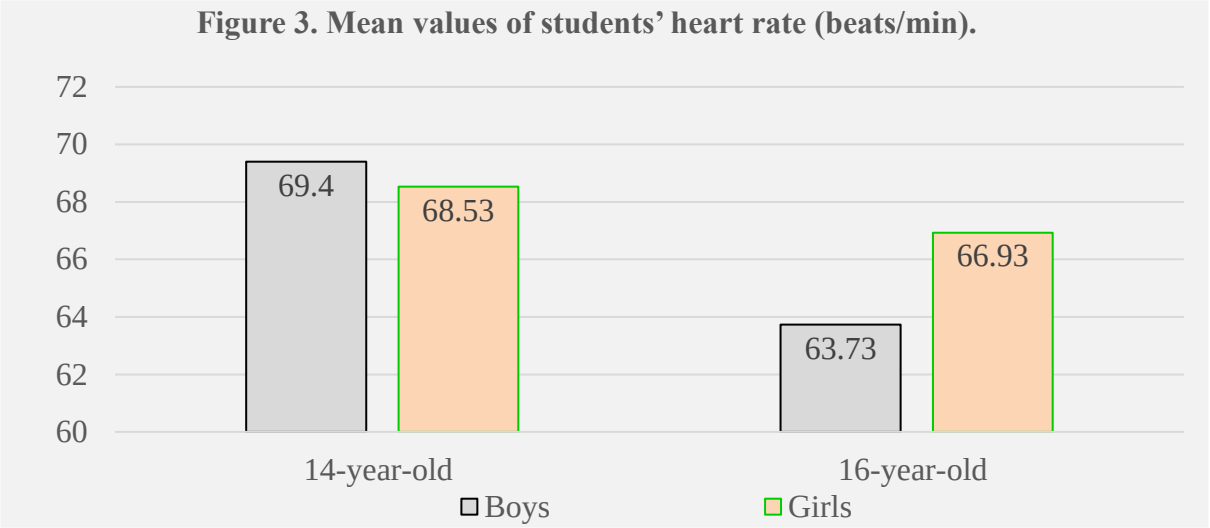
A similar trend was observed in girls: 68.53 ± 0.68 beats/min at the age of 14 and 66.93 ± 1.11 beats/min at the age of 16. However, the degree of reduction was considerably lower compared to boys, which can be explained by physiological differences between sexes.

Intersex comparison results show that at the age of 14 the difference between boys and girls was minimal (-0.87 beats/min), whereas at the age of 16 the pulse rate was relatively higher in girls (-3.2 beats/min), indicating greater cardiovascular efficiency in boys. This suggests that sports training has different adaptive effects depending on sex-related physiological characteristics.

Overall, the obtained results confirm that regular engagement in athletics during the age range of 14–16 years leads to an improvement in the functional state of the cardiovascular system and a reduction in heart rate. This reflects the formation of more efficient mechanisms of energy expenditure regulation in young athletes, (Table 2, Figure 3).

Table 2

Heart rate (beats/min) of 14- and 16-year-old boys and girls.			
Groups	**Mean values of heart rate (pulse rate).**		
14-year-old boys	69.4	±	0.67
14-year-old girls	68.53	±	0.68
16-year-old boys	63.73	±	1.08
16-year-old girls	66.93	±	1.11
P	<0.001		



During our study, the participants' maximum (systolic) and minimum (diastolic) arterial blood pressure indicators were investigated and analyzed according to age and sex factors.

In 14-year-old boys, the mean systolic blood pressure was 108.66 ± 2.08 mmHg. In 16-year-old boys, this indicator was 115.73 ± 1.87 mmHg. The difference between the obtained results was +7.07 mmHg.

The mean diastolic blood pressure in 14-year-old boys was 72.4 ± 1.05 mmHg, while in 16-year-old boys it was 74.93 ± 1.69 mmHg. The difference between the obtained values was +2.53 mmHg (P < 0.001). An increase in both indicators was observed in boys.

In 14-year-old girls, the mean systolic blood pressure was 105.06 ± 2.22 mmHg. In 16-year-old girls, this indicator was 110.33 ± 1.98 mmHg. The difference between the obtained results was +5.27 mmHg.

The mean diastolic blood pressure in 14-year-old girls was 66.33 ± 1.92 mmHg, whereas in 16-year-old girls it was 72.8 ± 0.94 mmHg. The difference between the obtained values was +6.47 mmHg (P < 0.001). A statistically significant increase in arterial blood pressure was also observed in girls.

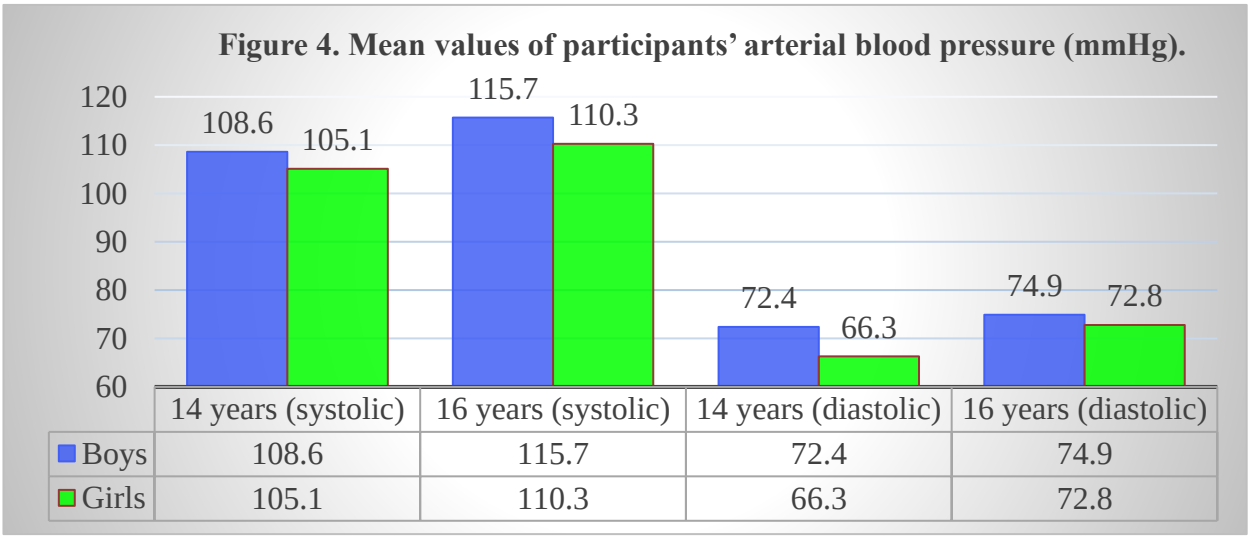
When comparing arterial blood pressure by sex, in 14-year-old participants the mean systolic blood pressure was 108.66 ± 2.08 mmHg in boys and 105.06 ± 2.22 mmHg in girls. As a result, the difference in systolic blood pressure between 14-year-old boys and girls was +3.6 mmHg. In terms of diastolic blood pressure, in 14-

year-old boys it was 72.4 ± 1.05 mmHg, while in girls it was 66.33 ± 1.92 mmHg, with a sex difference of +6.07 mmHg. Thus, at the age of 14, arterial blood pressure was higher in boys compared to girls.

In 16-year-old participants, systolic blood pressure was 115.73 ± 1.87 mmHg in boys and 110.33 ± 1.98 mmHg in girls, resulting in a difference of +5.4 mmHg. For diastolic blood pressure, 16-year-old boys had 74.93 ± 1.69 mmHg, while girls had 72.8 ± 0.94 mmHg, with a sex difference of +2.13 mmHg. It is evident that arterial blood pressure remained higher in boys at the age of 16 as well; however, although the difference decreased, it remained statistically significant (P < 0.001), (Table 3, Figure 4).

Table 3.

Mean values of participants' arterial blood pressure (mmHg).						
Groups	**Systolic blood pressure.**			**Diastolic blood pressure.**		
14-year-old boys	108.66	±	2.08	72.4	±	1.05
14-year-old girls	105.06	±	2.22	66.33	±	1.92
16-year-old boys	115.73	±	1.87	74.93	±	1.69
16-year-old girls	110.33	±	1.98	72.8	±	0.94
P	<0.001			<0.001		



During our research, respiratory system indicators were studied. In 14-year-old boys, the average respiratory rate was 18.53 ± 0.36 breaths/min, while in 16-year-old boys it was 16 ± 0.43 breaths/min. The results showed that the difference between 14- and 16-year-old boys was +2.53 breaths/min (P < 0.001). A reliable decrease in respiratory rate was observed in boys, indicating improved development of the respiratory system.

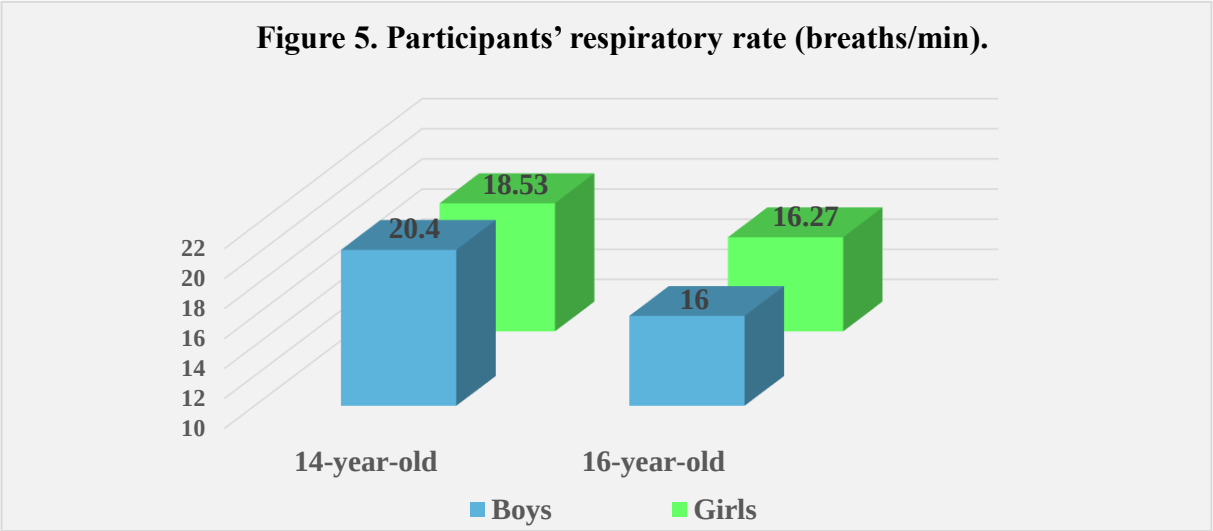
In the observations, the average respiratory rate of 14-year-old girls was 20.4 ± 0.4 breaths/min. In 16-year-old girls, it was 16.27 ± 0.43 breaths/min. The difference between the results was +4.13 breaths/min. A reliable decrease in respiratory rate was also observed in girls, although it was less pronounced compared to boys.

When comparing respiratory rate by gender, at the age of 14 the difference between boys and girls was +1.87 breaths/min. At this age, respiratory indicators were almost similar, and no significant gender difference was observed. At the age of 16, the difference between boys and girls was -0.27 breaths/min (higher in girls). The results show that at 16 years of age, girls have relatively higher respiratory rates, while boys show more economical respiratory function. The differences observed between 14- and 16-year-old boys and girls were statistically significant (P < 0.001) (Table 4, Figure 5).

Table 4

Participants' respiratory system indicators.						
Groups	**Respiratory rate (breaths/min)**			**Vital capacity of the lungs (ml)**		
14-year-old boys	18.53	±	0.36	3720	±	61.87
14-year-old girls	20.4	±	0.4	2393.33	±	39.60
16-year-old boys	16	±	0.43	4233.33	±	54.91

16-year-old girls	16.27	±	0.43	3113.33	±	27.37
P	<0.001			<0.001		

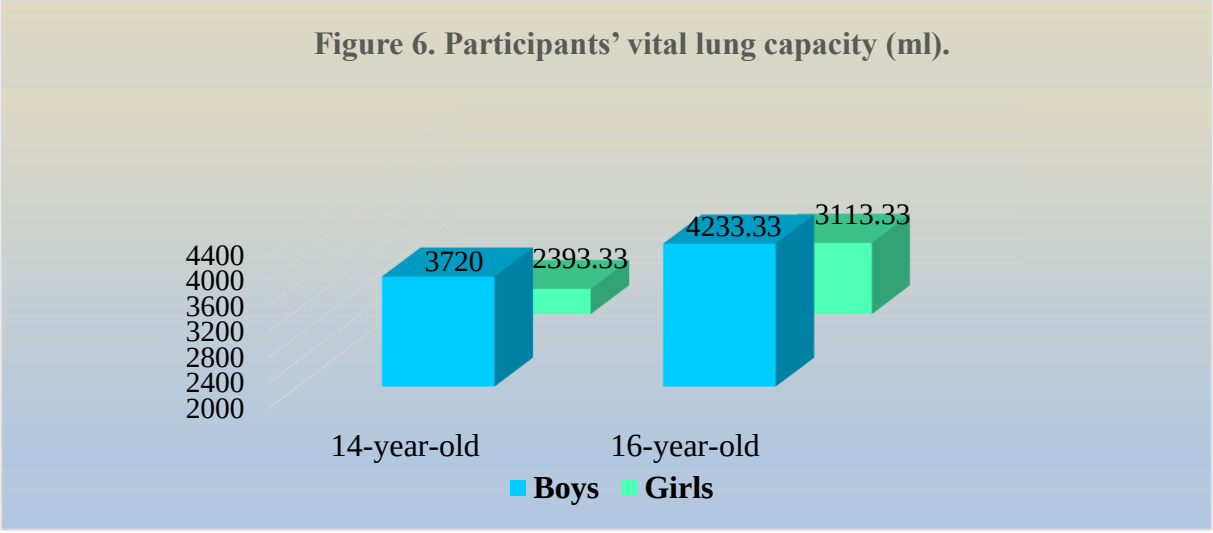


In the next stage of our research, one of the respiratory system indicators - vital lung capacity (ml) - was studied. In 14-year-old boys, the average value was 3720 ± 61.87 ml. In 16-year-old boys, this indicator was 4233.33 ± 54.91 ml. The results showed that the difference between 14- and 16-year-old boys was +513.33 ml (P < 0.001).

Among the participants, the average vital lung capacity in 14-year-old girls was 2393.33 ± 39.60 ml. In 16-year-old girls, the average value was 3113.33 ± 27.37 ml. The difference between the results was +720 ml.

When comparing vital lung capacity by gender, at the age of 14 the difference between boys and girls was +1326.67 ml. At this age, a large difference in vital capacity was observed, with boys showing higher values. In the 16-year-old group, the difference in vital lung capacity between boys and girls was +1120 ml. The results indicate that at 16 years of age, boys have higher respiratory parameters in terms of vital lung capacity, reflecting more efficient respiratory function.

The above data show that the differences between 14- and 16-year-old boys and girls included in our study were statistically significant (P < 0.001), (Table 4, Figure 6).



During our study, hand muscle strength indicators (right and left hand dynamometry) of 14- and 16-year-old boys and girls were examined and analyzed according to age and gender factors.

In the study, the average right-hand dynamometry value in 14-year-old boys was 25.47 ± 0.34 kg/s, while in 16-year-old boys it was 36.8 ± 0.53 kg/s. The difference between the results was +11.33 kg/s (P < 0.001), indicating a significant increase in hand muscle strength in boys.

Among the participants, the average right-hand dynamometry in 14-year-old girls was 22.6 ± 0.36 kg/s. In 16-year-old girls, this indicator was 26.47 ± 0.46 kg/s. The difference between the results was +3.87 kg/s. A reliable increase in right-hand dynamometry was also observed in girls.

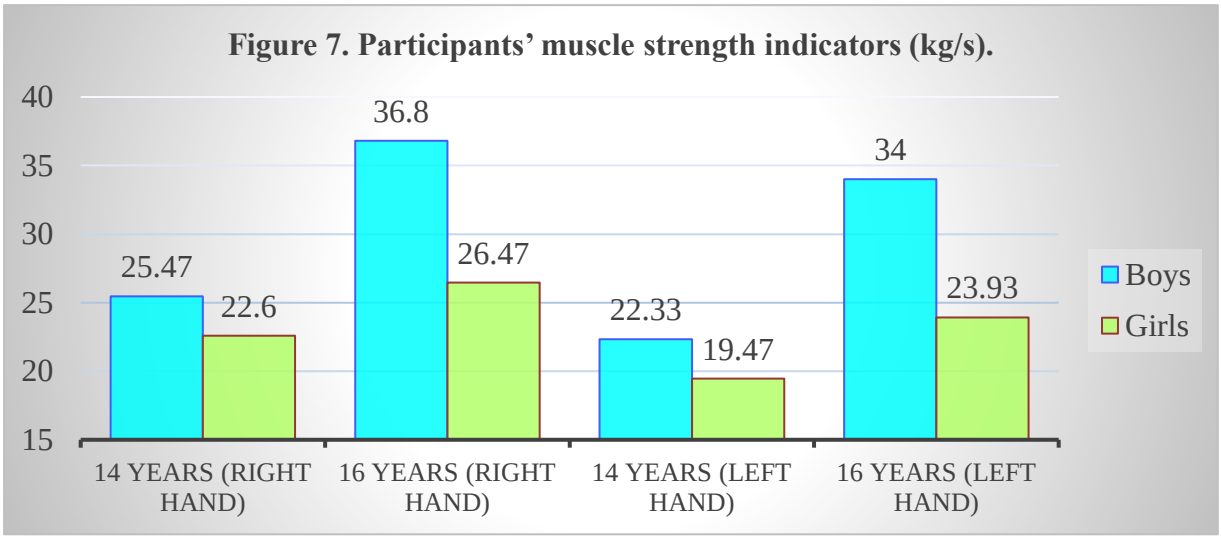
In the study, the average left-hand dynamometry in 14-year-old boys was 22.33 ± 0.29 kg/s, while in 16-year-old boys it was 34 ± 0.60 kg/s. The difference between the results was +11.67 kg/s (P < 0.001).

Among the studied 14-year-old female athletes, the average left-hand dynamometry was 19.47 ± 0.41 kg/s. In 16-year-old girls, this indicator was 23.93 ± 0.28 kg/s. The difference between the results was +4.46 kg/s (P < 0.001).

The above data indicate that with increasing age, both boys and girls show significant improvements in right and left hand dynamometry. However, gender differences become more pronounced with age, and these differences are statistically significant (P < 0.001) (Table 5, Figure 7).

Table 5

Participants' muscle strength indicators (kg/s).						
Groups	**Right hand**			**Left hand**		
14-year-old boys	25.47	±	0.34	22.33	±	0.29
14-year-old girls	22.6	±	0.36	19.47	±	0.41
16-year-old boys	36.8	±	0.53	34	±	0.60
16-year-old girls	26.47	±	0.46	23.93	±	0.28
P	<0.001			<0.001		



DISCUSSION

The obtained results indicate that regular sports training accelerates the morphological development of adolescents and increases the level of adaptation of physiological systems. This phenomenon can be explained by the expansion of the body's adaptive capacity.

The economization of cardiac activity is associated with an increase in stroke volume, strengthening of the cardiac muscle, and improved efficiency of blood circulation. In boys, the heart is relatively larger, stroke volume is higher, and pulse rate decreases more rapidly. In girls, cardiac activity is relatively more stable, and pulse rate remains higher.

The age-related increase in arterial blood pressure is associated with an increase in stroke volume, enhanced vascular tone, and increased peripheral resistance. In boys, due to a larger heart size, higher muscle mass, and a more active circulatory system, arterial blood pressure tends to be higher. In girls, physiological processes are relatively more stable, and blood pressure values are lower.

Athletics training enhances cardiac function, normalizes pulse rate, improves the circulatory system, and increases vascular elasticity. The obtained results confirm that regular sports training has a positive effect on the development and efficiency of the cardiovascular system.

A decrease in respiratory rate reflects qualitative changes in breathing, allowing for deeper inhalation and improving pulmonary ventilation efficiency; in other words, the organism absorbs more oxygen with

fewer breaths. An increase in vital lung capacity is explained by improved breathing quality, expansion of lung volume, enhanced alveolar function, and development of respiratory muscles. Athletics training improves the respiratory system, enhances oxygen utilization, increases overall endurance, and significantly develops respiratory function.

From a physiological perspective, at the age of 14-16, muscle fiber hypertrophy occurs, neuromuscular coordination improves, and strength indicators increase rapidly. Sexual dimorphism is explained by higher testosterone activity in boys, which leads to a pronounced increase in muscle mass and strength indicators. Athletics training increases muscular strength, improves coordination, and expands functional capacity.

In addition, anthropometric indicators are directly related to sports performance and serve as important criteria in sports selection. The results are consistent with other scientific studies and indicate the necessity of an evidence-based approach in the training of young athletes.

CONCLUSIONS

The results of this study demonstrate that regular engagement in athletics among adolescents aged 14-16 has a positive effect on their morphological and physiological development. At this age, the rapid growth of the organism enhances the effectiveness of sports training.

During the study, it was found that with increasing age, anthropometric indicators such as height, body mass, and BMI consistently increase; however, in athletes, this process occurs in a more balanced manner.

The analysis of physiological indicators revealed positive adaptations in the cardiovascular and respiratory systems. A decrease in heart rate and stabilization of breathing patterns indicate successful adaptation of the organism to training loads.

It was also shown that there is a relationship between anthropometric and physiological indicators. This emphasizes the need for a scientifically based approach in sports selection, particularly taking into account the individual physical development level of young athletes.

Based on the results, it can be concluded that regular athletics training not only improves the physical development of adolescents but also expands their functional capacities, serving as an important factor in achieving sports performance. Therefore, individualization of training processes, consideration of athletes' age and morphological characteristics, and continuous monitoring are essential for increasing the effectiveness of sports preparation.

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