

## Original Article

### Analysis of the dynamics of physical development and functional state of 9-12-year-old schoolchildren playing volleyball

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#### Abstract:

The article reviews the dynamics of physical development and the functional state of the cardiovascular system of schoolchildren aging from 9 to 12 years, who play volleyball during their extracurricular time. *The aim* of the research is to identify the peculiarities of influence of volleyball practice on the body of boys and girls aged 9-12 years. *Materials and methods*: analysis of scientific and methodological literature, generalization of best educational experience, anthropometric methods, physiological methods, methods of mathematical statistics. Altogether 99 pupils (n=99) were involved in the research, including 49 girls and 50 boys aged 9-12 years. The study was carried out on the basis of secondary schools of the city of Chernivtsi schools № 6, 27. Volleyball classes were held 3 times a week. The length of a training session was 2 hours. *Results*: it has been analysed the age dynamics of the morpho-functional state of pupils playing volleyball. Analysis of the results of the research made it possible to supplement the knowledge in the field of morphology and physiology on the growth rates and development of the child population aging from 9 to 12 years. The research found out that the indicators of body length in the girls aged 9-12 years are higher than in the boys of this age group, and the indicators of body weight, on the contrary, are larger in boys. The total increase in the body length in the girls from 9 to 12 years is 14.3 cm, in boys, - 16.5 cm. For 4 years, the body mass index in girls increased by 11.7 kg, in boys - by 10.7 kg. It should be pointed out that there was no statistically significant difference ( $p > 0.05$ ) in the indicators of body length and body weight, dynamometry of the right and left hands, heart rate at rest, systolic blood pressure and Ruffier index between girls and boys aged from 9 to 12 years. A statistically significant difference ( $p < 0.05$ ) is observed between the boys and girls aged from 9 to 12 years in the indicators of chest girth, inspiratory and expiratory chest girth. And also a statistically significant difference ( $p < 0.05$ ) is observed between boys and girls of 9 years of age in the diastolic blood pressure indicator. *Conclusion*: it was established that volleyball training sessions have a positive effect on the development of the growth processes of the student population, improve functioning of the cardiovascular system.

**Key words:** physical development, functional state, schoolchildren, volleyball.

#### Introduction

At the present stage of the modernization of the school education in Ukraine, the role of physical culture and sports, as the main factor in the health promotion of the younger generation, increases significantly. Pedagogical efforts are focused on the organization of work aimed at formation of the basis of a healthy lifestyle in schoolchildren (Andrieieva, 2017). As well as the creation of the single socio-cultural space within the territory of secondary school (Alpatskaya, 2005; Hakman, 2017; Bakayev, 2018; Hakman, 2018; Voloshina, 2018). Extracurricular sports work is an important component of the educational process as a whole. Involvement of children of primary and secondary school age into systematic physical training and sports will increase the level of physical condition of children. Teachers of physical education, coaches, doctors, physiologists, psychologists are constantly searching for the most effective forms and methods of working with the pupils and young people in order to promote health and improve the morpho-functional state (Yarmak, 2017; Bolotin, 2017; Denysova, 2018; Yarmak, 2018).

To develop extracurricular sports activities, you need to pay attention to a number of individual characteristics of functional changes in the body of the pupils, which occur directly under the influence of physical exercises. Systematic sports activities, provided that a rational hygienic regime is observed, has a positive effect on the components of physical condition (Belyaev, 2004; Faigenbaum, 2005). With the right combination of the educational process with sports, the pupils have a significant increase in physical

performance (Galan, 2017; Blahii, 2018). A number of scientific studies (Kozina, 2017) confirm the positive impact of sports on the state of the nervous system of schoolchildren. The main nervous processes under the influence of the systematic physical exercises change: the strength of both stimulating and inhibitory processes increases, their balance and mobility improve. In the process of development of motor qualities, close relationships between the activity of the musculoskeletal system, the main systems of the body (cardiovascular, respiratory) and the main metabolism, are established in the cerebral cortex (Church, 2007; Moseychuk, 2018; Imas, 2018).

Sports activities have a positive effect on the physical development of the pupils. The main indicators of the physical development of schoolchildren who are systematically involved in sports are higher than the average data for the corresponding age range. Although, the degree of influence is not always the same. First, there are some differences in the influence of particular types of sports. Some of them support the development of the musculo-skeletal system, others influence to a larger extent on the indices of the respiratory function: the respiratory amplitude and circumference of the chest increases, as well as an increase in the vital capacity of the lungs (Nagovitsyn, 2005).

The system and methods of training are important for improvement of the indicators and degree of the performance and harmonious physical development of the pupils. The greatest positive impact on the indicators of physical development of the pupils occurs in the case when the methodology of teaching and training involves a large amount of general physical fitness practice (Fletcher, 2004; Alpatskaya, 2005; Tomenko, 2017).

Among the large number of physical education practices, the most significant role in the recovery and comprehensive development of schoolchildren is played by sport games, in particular, volleyball. The specialization of schoolchildren in volleyball, like in any other sport, contributes to their full physical development, mastering and improving their vital skills. According to (Kozina, 2012), a large range of physiological effects of the volleyball practice on the body of schoolchildren, indicates a positive and diversified effect on physical abilities and mental functions. Among team sports, volleyball is characterized by a low level of injuries, low cost of the preparation and conducting of the training process and the high level of emotionality of the game match. There are a large number of options for conducting classes with volleyball practice, which have a significant health-improving effect. But in the practice of organizing mass health and fitness and sportive work during extracurricular time with pupils aged from 9 to 12 years, volleyball practice is used quite rarely. As a result of the foregoing, the relevance of this research becomes apparent.

## Materials and Methods

The following research methods were used to study the dynamics of physical development and functional state of 9-12-year-old schoolchildren under the influence of volleyball lessons: theoretical analysis and synthesis of scientific and methodical literature, anthropometric methods, physiological methods, and methods of mathematical statistics.

Over the course of the research, the scientific literature on the peculiarities of training young volleyball players was analysed. We studied the literature on medical and pedagogical control, as well as the effect of special physical exercises on the body of schoolchildren aged 9-12 years.

To determine the physical development of schoolchildren, the somatoscopy quantities were studied: body length and body mass, chest girth at rest, inspiratory and expiratory chest girth, and dynamometer of the right and left hand. The cardiovascular system was assessed by indicators of heart rate at rest, systolic and diastolic blood pressure, and the response of the cardiovascular system to dynamic load (Ruffier index).

The study involved 49 girls and 50 boys aging from 9 to 12 years. The study was conducted based on the secondary schools of the city of Chernivtsi.

## Results

Over the course of our research, we carried out the analysis of the dynamics of physical development and functional status of pupils aged from 9 to 12 years, systematically training in the volleyball section in the extracurricular time. Knowledge of the general laws of the age development of children, as well as observation of the effects of exercise on their body, help to correctly solve important issues of the organization and methods of training sessions at school age.

Analysis of the average group indicator of body length in the girls aged from 9 to 12 years playing volleyball, indicates a significant increase in the age range, the results are presented in Table 1. The body length is a summary indicator characterizing the state of growth processes in the body. This is the most stable indicator of all indicators of physical development. The difference in body length between girls of 9 and 10 years is 4.9 cm ( $p > 0.01$ ), in the girls aged 11 years, the body length increased by 4.5 cm ( $p > 0.05$ ), in the girls aged 12 years, the average group result of body length increased by 4.9 cm ( $p > 0.05$ ). Consequently, the total increase in body length for the girls from 9 to 12 years is 14.3 cm.

Analysis of the average group results of body weight in the girls indicates an increase in the rate with age. Body weight indicates the development of the musculoskeletal system, subcutaneous fat, and internal

organs. In contrast to body length, body weight is relatively labile and can change under the influence of changes in the daily regimen, a violation of the diet, and even a minor illness. Analysis of body weight dynamics in the age aspect indicates that in the girls aged from 9 to 10 years, body weight increased by 5.0 kg ( $p < 0.05$ ), from 10 to 11 by 3.0 kg ( $p < 0.05$ ), from 11 years to 12 years by 3.7 kg ( $p > 0.05$ ). The total weight gain in the girls aged from 9 to 12 years, playing volleyball, is 11.7 kg.

The chest girth characterizes its volume and development of the pectoral and spinal muscles, as well as the functional state of the organs of the chest cavity. The chest girth of the girls under the influence of volleyball training sessions for 4 years increased by 9.9 cm. A statistically significant difference ( $p < 0.05$ ) is observed between the girls of 11 and 12 years. In the girls aged from 11 to 12 years, who play volleyball, the chest girth increased by 5.7 cm. The total increase in the average group result of a chest expansion in the girls aged from 9 to 12 years increased by 2.0 cm.

The results of the dynamometry of the right and left hand in the girls aged from 9 to 12 years indicate the asymmetric development of muscles. A significant increase is observed in the average group indicator of the dynamometry of the right hand, so during 4 years of volleyball practice, this indicator has increased by 7.5 kg, and the indicator of the left hand dynamometry - by 6.8 kg. It should be pointed out that at the age of 10-11 years the girls have the smallest increase in the result of the dynamometry of the right and left hand, for a year the indicator of the dynamometry of the right hand grew by 1.3 kg ( $p < 0.05$ ), and of the left hand - only by 0.4 kg ( $p < 0.05$ ).

In the body of the pupils under the influence of systematic volleyball training, a number of changes occur, which indicate an improvement in the functional capabilities of the cardiovascular system. It should be pointed out that for this age range, changes in the work of the cardiovascular system are also regular, since regular development processes occur.

In the girls aged from 9 to 12 years, there is a positive dynamics of the average group result of the heart rate at rest. We have found that volleyball practice has contributed to the optimization of the cardiovascular system.

This is evidenced by the improvement in the response of the cardiovascular system to the dynamic load, that is, the recovery time after the load decreases.

Table 1. The age dynamics of indicators of the morpho-functional state of the girls aged from 9 to 12 years engaged in volleyball (n = 49)

Indicators under study	Age, years	N	$\bar{x}$	S	Minimum	Maximum	V, %
Body length, cm	9	12	147.5	10.46	131.0	164.0	7.1
	10	12	152.4	9.14	138.0	166.0	6.0
	11	13	156.9	7.49	145.0	168.0	4.8
	12	12	161.8	6.45	150.5	171.0	4.0
Body weight, kg	9	12	38.1	6.50	28.0	48.0	17.1
	10	12	43.1	9.36	31.0	58.0	21.7
	11	13	46.1	8.19	34.0	59.0	17.8
	12	12	49.8	7.53	36.0	62.0	15.1
Chest girth, cm	9	12	68.1	4.96	61.0	76.0	7.3
	10	12	70.9	6.68	62.0	81.0	9.4
	11	13	72.3	5.58	64.0	82.0	7.7
	12	12	78.0	5.41	66.0	85.0	6.9
Inspiratory chest girth, cm	9	12	73.4	4.96	67.0	83.0	6.8
	10	12	77.7	7.11	68.0	88.0	9.2
	11	13	79.0	5.69	70.0	88.0	7.2
	12	12	83.8	6.73	72.0	95.0	8.0
Expiratory chest girth, cm	9	12	66.3	4.29	60.0	73.0	6.5
	10	12	69.0	6.61	60.0	80.0	9.6
	11	13	70.6	5.20	62.0	79.0	7.4
	12	12	75.2	6.26	63.0	85.0	8.3
Chest expansion, cm	9	12	7.4	1.38	6.0	10.0	18.6
	10	12	8.4	1.24	7.0	10.0	14.8
	11	13	8.7	1.44	6.0	10.0	16.6
	12	12	9.4	1.44	7.0	12.0	15.3
Dynamometry right, kg	9	12	9.3	3.05	3.0	15.0	32.8
	10	12	12.2	5.04	3.0	20.0	41.3
	11	13	13.5	5.74	5.0	24.0	42.5

	12	12	16.8	4.76	9.0	25.0	28.3
Dynamometry left, kg	9	12	8.5	3.09	5.0	15.0	36.4
	10	12	11.0	5.95	5.0	25.0	54.1
	11	13	11.4	5.12	5.0	20.0	44.9
	12	12	15.3	4.71	7.0	20.0	30.8
HR <sub>rest</sub> , beats /min-1	9	12	84.5	7.44	72.0	96.0	8.8
	10	12	82.0	8.22	72.0	96.0	10.0
	11	13	77.0	6.69	66.0	84.0	8.7
	12	12	72.5	8.66	66.0	90.0	11.9
SBP, mm Hg	9	12	103.3	9.85	90.0	120.0	9.5
	10	12	107.5	7.54	100.0	120.0	7.0
	11	13	110.8	6.69	100.0	120.0	6.0
	12	12	110.8	5.15	100.0	120.0	4.6
DBP, mm Hg	9	12	67.5	8.66	60.0	80.0	12.8
	10	12	70.0	8.53	60.0	80.0	12.2
	11	13	68.3	7.18	60.0	80.0	10.5
	12	12	73.3	4.92	70.0	80.0	6.7
Ruffier index, nominal units	9	12	9.3	1.98	6.0	11.6	21.3
	10	12	8.9	2.39	5.6	14.4	26.9
	11	13	8.0	1.93	5.2	10.8	24.1
	12	12	7.5	2.51	1.6	10.0	33.5

Analysis of the average group results of body weight, chest expansion, right and left hand dynamometry, as well as the Ruffier index indicates significant variability among 9-12- year-old girls, the variation coefficient exceeds 14.6 %, which indicates the heterogeneity of the samples.

Analysis of the average group indicators of body length in children who play volleyball are presented in Table 2, and indicate a significant increase in the boys aged from 11 to 12 years, which is 7.4 cm ( $p > 0.05$ ). The body length indicators in the boys aged from 9 to 12 years have increased by 16.5 cm. The average group body mass indicator in the boys aged from 9 to 10 years has increased only by 0.1 kg ( $p < 0.05$ ), and in the boys aged from 10 to 11 years the increase was 5.5 kg ( $p < 0.05$ ), in the boys aged from 11 to 12 years; body mass index increased by 5.1 kg ( $p < 0.05$ ). Consequently, the total weight gains in the boys aged from 9 to 12 years, who played volleyball is 10.7 kg. The total increase in the average group chest girth in the boys aged from 9 to 12 years, increased by 4.9 cm, the inspiratory chest girth by 9.5 cm, and the expiratory chest girth by 8.9 cm. Indicators of the chest expansion in the boys aged from 9 to 12 years improved by 1.7 cm

The average group indicators of the right hand dynamometry in the boys aged from 9 to 12 years is higher than that of the left hand, indicating asymmetric muscle development. The total increase in dynamometry of the right hand in the boys aged from 9 to 12 years is 11.1 kg. It should be noted that the largest increase is from 11 to 12 years and amounts to 4.7 kg ( $p < 0.05$ ), and the smallest increase is from 9 to 10 years and is 2.0 kg ( $p < 0.05$ ).

The indicators of the dynamometry of the left hand in the boys aged from 9 to 12 years in total has improved by 7.9 kg, the largest increase is from 11 to 12 years and amounts to 3.5 kg ( $p < 0.05$ ), and the smallest increase is in the boys aged from 9 to 10 years and amounts to 1.7 kg ( $p < 0.05$ ).

Table 2. The age dynamics of indicators of the morpho-functional state of the 9-12-year-old boys (n = 50) playing volleyball

Indicators under study	Age, years	N	$\bar{X}$	S	Minimum	Maximum	V, %
Body length, cm	9	12	141.2	9.10	130.0	151.0	6.4
	10	12	145.1	9.30	135.0	156.0	6.4
	11	13	150.3	9.16	137.0	161.0	6.1
	12	13	157.7	8.88	145.0	170.0	5.6
Body weight, kg	9	12	45.0	12.92	29.0	65.0	28.7
	10	12	45.1	11.31	30.0	58.0	25.1
	11	13	50.6	10.66	35.0	62.0	21.1
	12	13	55.7	12.13	37.0	70.0	21.8
Chest girth, cm	9	12	76.4	9.78	65.0	94.0	12.8
	10	12	76.1	6.84	67.0	83.0	9.0
	11	13	79.1	7.82	67.0	90.0	9.9
	12	13	81.3	8.71	68.0	94.0	10.7

Inspiratory chest girth, cm	9	12	81.6	10.60	72.0	103.0	13.0
	10	12	82.3	6.40	74.0	90.0	7.8
	11	13	88.0	7.37	79.0	100.0	8.4
	12	13	91.1	8.99	80.0	105.0	9.9
Expiratory chest girth, cm	9	12	73.7	9.66	64.0	92.0	13.1
	10	12	73.9	6.18	65.0	82.0	8.4
	11	13	78.9	8.76	65.0	90.0	11.1
	12	13	82.6	8.83	65.0	92.0	10.7
Chest expansion, cm	9	12	8.3	2.14	4.0	11.0	25.8
	10	12	8.4	0.53	8.0	9.0	6.3
	11	13	9.1	2.79	5.0	14.0	30.7
	12	13	10.0	2.65	6.0	13.0	26.5
Dynamometry right, kg	9	12	11.0	3.92	7.0	18.0	35.6
	10	12	13.0	3.37	10.0	18.0	25.9
	11	13	16.4	3.82	12.0	22.0	23.3
	12	13	21.1	3.98	15.0	25.0	18.9
Dynamometry left, kg	9	12	9.0	3.51	5.0	16.0	39.0
	10	12	10.7	2.81	7.0	16.0	26.3
	11	13	13.4	2.88	10.0	17.0	21.5
	12	13	16.9	4.88	10.0	22.0	28.9
HRrest, beats /min-l	9	12	82.3	7.52	72.0	91.0	9.1
	10	12	84.0	6.93	72.0	90.0	8.3
	11	13	75.4	9.07	66.0	90.0	12.0
	12	13	72.9	10.64	60.0	90.0	14.6
SBP, mm Hg	9	12	110.0	5.77	100.0	120.0	5.2
	10	12	111.4	6.90	100.0	120.0	6.2
	11	13	110.0	5.77	100.0	120.0	5.2
	12	13	114.3	5.35	110.0	120.0	4.7
DBP, mm Hg	9	12	60.0	0.00	60.0	60.0	0.0
	10	12	71.4	9.00	60.0	90.0	12.6
	11	13	70.0	8.16	60.0	80.0	11.7
	12	13	70.0	8.16	60.0	80.0	11.7
Ruffier index, nominal units	9	12	8.8	1.62	6.4	11.0	18.4
	10	12	9.3	2.21	5.6	11.6	23.8
	11	13	8.7	2.46	4.0	11.4	28.3
	12	13	8.3	2.25	4.0	10.7	27.1

Under the influence of volleyball training sessions, the children have a decrease the indicators of heart rate at rest and an increase in the functional capabilities of the body. The results of the Ruffier index indicate variations of the result in the age range. At the age of 10 years, this indicator has deteriorated by 0.5 nominal units ( $p > 0.05$ ). We found that the total increase of this indicator improved only by 0.5 nominal unit from 9 to 12 years.

Significant variability is observed in the indicators of body mass index, chest expansion in 9-11- and 12-year-old boys, dynamometry of the right and left hand, Ruffier index, which indicates the heterogeneity of the sample, and indicates the heterochrony of the formation of the main anatomical and physiological systems of the body.

## Discussion

Specialists in the field of physical culture and sports carry out an intensive search for new directions, forms and methods of mass sports work with pupils which meet modern requirements and can solve a complex of important tasks facing the school education system (Nakonechnyi, 2017; Pityn, 2017; Melnyk, 2017; Kozhokar, 2018).

Extracurricular work in groups of the volleyball sports section is an organic part of the whole system of the educational process, it ensures the unity of physical and spiritual education and training.

Sports games, especially volleyball, are characterized by considerable physical exertion, which is determined by the athletes' gaming activities, the conditions of the game, the nature of the performance of gaming activities and the features of competitive activity. The specificity of this sport, the nature, and content of the motor activity, as well as the conditions in which they are performed, mostly determine the level of specific training, both of individual players and the team as a whole. In the training process, volleyball players need to master the arsenal of techniques. The complexity of the game actions is based on the fact that the entire arsenal

must be used in various modifications and conditions that require absolute accuracy from the player, quickly changeover switching from one form of movement to another, completely different in speed and character.

Physical fitness of volleyball players during the game is complex and diverse, and is performed with great intensity of muscular efforts. Volleyball training sessions help strengthen the nervous system, which participates in every physical exercise, affects the contraction, tension and relaxation of muscles, ensures the activity of all organs.

The results of our research supplement the data (Goncharova, 2007) on the age dynamics of indicators of physical development of pupils aged from 9 to 12 years; they also supplement the data (Khrypko, 2016) on the features of the development of the cardiovascular system in the primary school pupils. Our findings supplement the data () on the insignificant dynamics of the Ruffier index in this age range; and confirm the data (Biletska, 2016) on the health effects of playing action-oriented and sports games (Cretu, 2010; Zadraznik, 2010; Croitoru, 2013; Grabara, 2015; Shchepotina, 2015; Claver, 2016; Palao, 2016; Aoki, 2017; Popelka, 2018; Cojocaru, 2018).

### Conclusions

Over the course of the research, we found that the indicators of physical development vary in accordance with the general biological patterns peculiar for the pupils aged from 9 to 12 years. The average group indicators of body length in the girls aging from 9 to 12 years who play volleyball are higher than in the boys of corresponding age. While the indicators of body weight, on the contrary in boys are higher. Comparing the 9-year-old boys and girls, we found significantly ( $p < 0.05$ ) higher indicators of chest girth, inspiratory and expiratory chest girth, diastolic blood pressure in the boys. There is no statistically significant difference ( $p < 0.05$ ) between all studied parameters between boys and girls of 10 years. There is a statistically significant difference between 11-year-old boys and girls ( $p < 0.05$ ) in the indicators of chest girth, inspiratory and expiratory chest girth; it should be noted that these indicators are higher in the boys. There is a statistically significant difference ( $p < 0.05$ ) between boys and girls of 12 years only in the indicator of the expiratory chest girth, this indicator is higher in boys. The average statistical indicators of the functional status of 9-12-year-old pupils playing volleyball are within the physiological norms, and their natural dynamics is observed.

### Competing Interests

The authors declare that they have no competing interests.

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