

The state of the biogeometric profile of the posture of young athletes specializing in hand-to-hand combat as a prerequisite for the development of corrective and preventive measures

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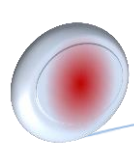
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Abstract

Purpose: The purpose of the presented scientific research was, on the basis of somatoscopic indicators, to substantiate the biological prerequisites for the introduction of corrective and preventive measures into the educational and training process of young athletes specializing in hand-to-hand combat.



Material and Methods: The scientific study involved 150 athletes specializing in hand-to-hand combat, aged 8–14 years. The problems identified during the study were solved using generally accepted methods: theoretical analysis of scientific literature on the chosen research topic; the Torso program was used to determine the types of posture, visual screening of the state of the biogeometric profile of the posture of young athletes specializing in hand-to-hand combat included a focus on the tribal system and the use of a method for comparing individual posture on a photogram and methods of mathematical statistics.

Results: It has been established that poor posture of various types is common among athletes aged 8-14 years, specializing in hand-to-hand combat, covering a contingent of 46.7 to 60% in different age groups. Based on the results of screening the biogeometric profile of posture of an experimental contingent of young athletes specializing in hand-to-hand combat, a general tendency was traced to a decrease in the average values of the number of points at high and medium levels of the state of the biogeometric profile of posture of martial arts athletes with normal posture, and at low and medium levels - the state of the biogeometric profile of the posture of athletes with a stooped back, flat back, round back and scoliotic posture.

In addition, a generalized examination of these results showed that some of the tested athletes who had a normal type of posture received the same scores (from 19 to 21 points) as those who had a certain type of posture disorder. We define the risk zone as the zone of overlap of assessments of the level of the biogeometric profile of posture, although theoretically it may appear wider if it is determined by values below the center of the distribution for athletes with normal posture. Since the distribution of all three indicators according to the test data in the group of athletes with normal posture and with various types of musculoskeletal disorders does not correspond to Gauss's law, its center was determined by the median, which in this case was equal to 22 points.

Conclusions: Understanding the findings and results of a wide range of scientific studies reveals the recent intensification of the dynamics of the occurrence of deviations in the state of posture of young athletes. Scientists are convinced that monitoring the state of athletes' posture will make it possible to control the effect of physical exercise on the musculoskeletal system of young athletes and minimize the risk of injury. In the course of the study, the features of the biomechanics of posture of young athletes specializing in hand-to-hand combat were determined. Differences (at the level of trends) between athletes of all ages have been identified, which indicate a certain deterioration in the state of the biogeometric profile of posture with increasing age, but such differences have not received statistical confirmation.

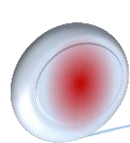
The theoretical and practical aspects of the scientific work presented above will be the basis for the theoretical substantiation of the biological prerequisites for the introduction of corrective and preventive measures into the educational and training process of young athletes specializing in hand-to-hand combat.

Keywords: martial arts, hand-to-hand combat, young athletes, biological prerequisites, biomechanics of posture, biogeometric profile, somatoscopic indicators, health.

Introduction

Experts are sounding the alarm by publishing data on the escalation of

negative trends regarding the somatic health of young athletes (Augustsson et al., 2021; Radu et al., 2022). The



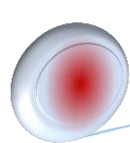
determinants of the dangerous dynamics of leveling the increase in the level of sportsmanship of young athletes, and, consequently, the evolution of the sports training system, are: the physiological characteristics of the child's body, which acquire a clear manifestation during critical periods of ontogenesis (Kashuba, et al., 2020); pedagogical features of the stages of the first stage of sports training, concerning the increase in the most important parameters of the educational and training process and the beginning of active competitive activity of athletes (Vako et al., 2024); ignoring the principles of periodization theory, which leads to the emergence of a number of pathologies (Todorova et al., 2019); dissonance between the functional potential of the body and the factors of the training process (Danyshchuk et al., 2020); limiting influence of non-obvious and chronic deviations on the effectiveness of the process of professional development of young athletes (Cakmakci et al., 2020; Byshevets et al., 2022). The above determinants are becoming a crisis against the backdrop of a sharp decrease in the number of children with a "safe" level of health (Augustsson et al., 2021), a decrease in their ability to train under the influence of physical activity, and also to achieve high sports results in order to attract higher achievements to sports in the future (Ivchenko et al., 2023).

The problem of health problems, especially the musculoskeletal system (MSS), of young athletes of various specializations at the present stage of development of sports is not new (Grabara, 2012; Alvero-Cruz et al., 2022; Barczyk-Pawelec et al., 2022; Krykun et al., al., 2024), but is clearly relevant. Incorrect posture and muscle imbalance have a negative impact on the effectiveness of the training process (working out technical elements, increasing the load, increasing the result) (Kashuba, et al., 2020; Radu et al., 2022). Functional disorders of the musculoskeletal system reduce the functionality of the cardiovascular, respiratory, digestive and nervous systems, as well as the adaptive abilities of the body and vice versa. (Kashuba, et al., 2020; Byshevets et al., 2022).

Material and methods of research

Study Design

The research was carried out on the basis of the Department of Kinesiology and Physical Culture and Sports Rehabilitation of the National University of Physical Education and Sports, the Department of Theory and Methods of Physical Education of Vinnitsa State Pedagogical University named after M. Kotsyubinsky. The scientific pedagogical study was carried out with the consent of the parents and in compliance with the basic provisions of the "Rules of moral principles for



conducting scientific research involving human subjects” approved by the Declaration of Helsinki (1964–2013).

Subjects

The scientific study involved 150 athletes specializing in hand-to-hand combat aged 8–14 years. The pedagogical research took place at the comprehensive children's and youth sports school Arsenal (Kyiv).

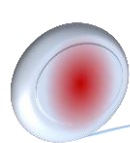
Theoretical – to determine the relevance of the problem of biomechanics of athletes’ posture as an indicator of the state of its health; empirical: pedagogical observation as a method of empirical research - to familiarize yourself with the process of organizing educational and training sessions. To determine the types of posture, the Torso program was used (Kashuba, et al., 2020); visual screening of the state of the biogeometric profile of the posture of young athletes specializing in hand-to-hand combat included an orientation to the tribal system and the use of a comparison method of individual posture on the photogram and graphic options on the standard. Consequently, it was accepted that a score of “1” corresponds to the assessment of “bad”, “2” – “satisfactory”, “3” – “good”. The maximum the athlete could receive was 33 points (such an integral assessment required the experimenter to receive 3 points out of all 11 indicators), the minimum was 11 points (all 11

indicators were scored 1 point) (Kashuba, et al., 2020). Taking this into account, the studied young athletes specializing in hand-to-hand combat were subject to distribution according to the levels of the state of the biogeometric profile, determined based on the analysis of 11 indicators regulated by screening in the frontal (5) and sagittal (6) planes; ascertaining pedagogical experiment.

Statistical data analysis

All data obtained in the empirical study were processed by methods of mathematical statistics. To describe the primary statistics, the mean, standard deviation, median, quartiles and extremes of the distributions were calculated. Comparison of independent samples was carried out using the Student's t-test in case of normal data distribution, the Mann-Whitney U-test or the Kolmogorov-Smirnov test in the absence of a normal distribution. In the case of multiple comparisons, one-way analysis of variance was used using Fisher's F test in cases where the data were normally distributed, or using the Kruskal-Wallace method if the distributions were non-normal.

The purpose of the study was, based on somatoscopic indicators, to substantiate the biological prerequisites for the introduction of corrective and preventive measures in the educational and training process of young athletes specializing in hand-to-hand combat.



Results of the study

Based on the results of videometry (the results were confirmed by an orthopedic doctor), it was found

that from the group of athletes 8-9 years old, 53.33% have normal posture, and 46.67% have functional disorders of the oral cavity (Table 1).

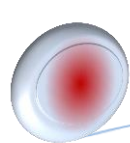
Table 1. Features of posture of athletes specializing in hand-to-hand combat aged 8–14 years (n=150), %

Athletes, age, years	Posture				
	normal	hunched back	scoliotic	round back	flat back
8-9 years old (n = 30)	53, 33	13, 34	16, 66	3, 33	13,34
9-10 years old (n = 30)	50, 0	16, 7	13, 35	6,60	13,35
10-11 years old (n = 26)	42,31	23,07	23,07	7,69	3,85
11-12 years old (n = 24)	45,84	8,33	12,5	25,0	8,33
12-13 years old (n = 20)	45,0	5,0	15,0	30,0	5,0
13-14 years old (n = 20)	40,0	--	15,0	30,0	15,0

Among athletes specializing in hand-to-hand combat for 9-10 years, 50.0% have a normal type of posture and 50.0% have poor posture. According to the data obtained, among martial arts athletes aged 10-11 years, 42.31% of athletes have normal posture, and 57.69% of athletes have poor posture. Among athletes aged 11-12 years, 45.84% of athletes have normal posture, and 54.16% of martial arts athletes have poor posture. An examination of young athletes specializing in hand-to-hand combat 12–13 to determine functional disorders of the musculoskeletal system was

struck by the fact that 45.0% of martial arts athletes have a normal type of posture and 55.0% have a posture disorder. It is interesting that among martial arts athletes aged 13-14 years, 40.0% of athletes have normal posture, and 60.0% of subjects have poor posture. Taking into account the above data, it is obvious that it is the age period of 12–13 and 13–14 years that should be considered potentially dangerous during the formation of the musculoskeletal system of young athletes specializing in hand-to-hand combat.

A study aimed at establishing the



types of posture of young martial arts athletes allowed us to state that among athletes 8-9 years old, the most common postural disorder is scoliotic posture – 16,66%, hunched and flat back – 13,34% and round back – 3,33% respectively. At the age of 9-10 years, the largest number of athletes with postural disorders are martial arts athletes with a slouched back – 16,7%, scoliotic posture and a flat back: 13,35%, respectively; at the age of 10-11 years, the most common types of postural disorders a hunched back and scoliotic posture remain – 23,07%, respectively. From the calculations it follows that among athletes aged 11–12 years, the most common postural disorder is a round back – 25,0%, scoliotic posture – 12,5% and a hunched and flat back – 8,33%, respectively. A much worse situation was found among experimental athletes specializing in hand-to-hand combat at the age of 13–14 years. Thus, in the contingent of martial arts athletes aged 13–14 years, the most common postural disorder is a round back – 30,0%, scoliotic posture and a flat back – 15,0%, respectively. It seems to focus on the fact that among the 13-14 year old martial arts athletes, not a single athlete with a hunched back was found.

Subsequently, the results of visual screening of the level of state of the biogeometric profile of posture of young athletes specializing in hand-to-hand combat were used to establish the

expressiveness of functional changes in the latter (Table 2).

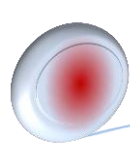
It has been established that among athletes aged 8–14 years who specialize in hand-to-hand combat with functional disorders of the musculoskeletal system, there are no martial arts athletes with a high level of biogeometric profile of posture.

Based on the results of screening the biogeometric profile of the posture of an experimental contingent of young athletes specializing in hand-to-hand combat, a general tendency was traced towards a decrease in the average values of the number of points at high and medium levels of the state of the biogeometric profile of posture of martial arts athletes with normal posture, and at low and medium levels – the state of the biogeometric profile of the posture of athletes with a hunched back, flat back, round back and scoliotic posture.

In addition, a generalized examination of these results showed that some of the subjects who had a normal type of posture received the same scores (from 19 to 21 points) as those who had a certain type of posture disorder.

This fact raises the question of determining the risk zone for the development of postural disorders. We understand it as a certain area of signs that may indicate the formation or deterioration of posture, but at the moment have not led to a pronounced





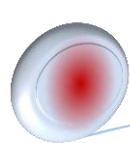
violation, i.e. Improving posture and ensuring optimal musculoskeletal health and functionality.

Therefore, we define the risk zone as the zone of overlap of assessments of the level of the

biogeometric profile of posture, although theoretically it may appear wider if it is determined by values below the center of distribution for athletes with normal posture.

Table 2. Distribution of athletes aged 8–14 years specializing in hand-to-hand combat according to the level of the biogeometric profile of posture (n=150)

Posture type	Level of state of the biogeometric profile of posture						Total athletes
	low		average		high		
	n	%	n	%	n	%	
8-9 years old (n = 30)							
Normal posture	---	---	10	62,50	6	37,50	16
Hunched back	2	50	2	50	---	---	4
Round back	1	100	---	---	---	---	1
Scoliotic posture	3	60	2	40	---	---	5
Flat back	3	75	1	25	---	---	4
9-10 years old (n = 30)							
Normal posture	---	---	9	60	6	40	15
Hunched back	3	60	2	40	---	---	5
Flat back	3	75	1	25	---	---	4
Round back	2	100	---	---	---	---	2
Scoliotic posture	2	50	2	50	---	---	4
10–11 years old (n = 26)							
Normal posture	---	---	7	63,63	4	36,37	11
Hunched back	4	66,66	2	33,34	---	---	6
Flat back	1	100	---	---	---	---	1
Round back	2	100	---	---	---	---	2
Scoliotic posture	4	66,66	2	33,34	---	---	6
11–12 years old (n = 24)							
Normal posture	---	---	7	63,63	4	36,37	11
Hunched back	2	100	---	---	---	---	2



Flat back	2	100	---	---	---	---	2
Round back	4	66,66	2	33,34	---	---	6
Scoliotic posture	3	100	---	---	---	---	3
12–13 years old (n = 20)							
Normal posture	---	---	6	66,66	3	33,34	9
Hunched back	1	100	---	---	---	---	1
Flat back	---	---	1	100,0	---	---	1
Round back	3	50	3	50	---	---	6
Scoliotic posture	2	66,66	1	33,34	---	---	3
13–14 years old (n = 20)							
Normal posture	---	---	5	62,50	3	37,50	8
Hunched back	---	---	---	---	---	---	---
Flat back	2	66,66	1	33,34	---	---	3
Round back	4	66,66	2	33,34	---	---	6
Scoliotic posture	3	100	---	---	---	---	3

Since the distribution of all three indicators according to the test data in the group of athletes with normal posture and with various types of musculoskeletal disorders does not correspond to Gauss’s law, its center was determined by the median (Table 3), which in this case was equal to 22 points.

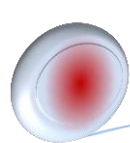
Consequently, the risk zone for functional disorders of the musculoskeletal system among athletes aged 8-14 years, specializing in hand-to-hand combat, according to our confirmed data, covers the range from 19 to 21 points using the method of visual screening of the level of state of the biogeometric profile of posture, and it can hypothetically be expanded in

side increasing up to 22 points.

Accordingly, posture can be considered impaired if the results of visual screening of the state level of the biogeometric profile of posture are below 19 points, which is confirmed by expert assessment data from medical specialists. Diagnostic scores greater than 22 may indicate normal posture if appropriately confirmed by an orthopedic specialist.

This zone includes 71,4% of athletes with normal posture who were examined. These are persons who, according to the total score of the level of state of the biogeometric profile of posture in the sagittal plane, received the same scores (11 and 12 points) as children in whom the expert classified a





functional disorder of posture.

Let us also add that the upper limit of this range corresponds to the median of the distribution, that is, there is no doubt that a result exceeding 12 diagnostic points can indicate a normal state of posture in the sagittal plane, of course, subject to appropriate confirmation by a specialist. And, accordingly, a result below 11 points probably indicates poor posture, especially if this is confirmed by an expert opinion.

71.4% of athletes with normal posture also fall into the zone that may indicate potential postural problems in the frontal plane. This applies to persons who received the same scores on the total score of the level of state of the biogeometric profile with athletes

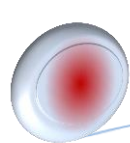
with impaired posture (from 9 to 10 points). Due to the fact that the upper limit of this range corresponds to the median of the distribution, there is no doubt that a score exceeding 10 points on the diagnosis may indicate a normal state of posture in the frontal plane, and a result less than 19 points reliably indicates poor posture, especially if this is confirmed by expert opinion.

The data presented above indicate that among athletes with normal posture, only 37.1% demonstrate a high level of its biogeometric profile. At the same time, 62.9% have an average profile level, and they can be considered at risk of developing functional disorders of the oral organs.

Table 3. Primary statistics and quartiles of distribution of indicators of the level of state of the biogeometric profile of posture of athletes 8–14 years old with normal and impaired posture

Characteristics of	Indicators of the level of state of the biogeometric profile of posture	Primary statistics				Distribution quartiles		
		min	max	\bar{x}	S	Me	25%	75%
Normal (n=70)	Sagittal plane	11	18	12,76	2,15	12	11	13
	Frontal plane	9	15	10,89	2,09	10	9	13
	Level of state of the biogeometric profile of posture	19	33	23,64	4,11	22	20	27
Impaired (n=80)	Sagittal plane	7	12	9,51	1,31	10	9	10
	Frontal plane	5	10	6,85	2,14	6	5	9
	Level of state of the biogeometric profile of posture	13	21	16,36	2,47	15	14	19

Note. Here and below: n – number of subjects in the group; min – the lowest and max – the highest value of the indicator; \bar{x} – arithmetic mean value; S – standard deviation; Me, 25%, 75% – median and distribution flats.



As evidence, we present comparative data on the severity of individual signs of posture and generalized indicators of the level of state of the biogeometric profile of

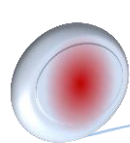
posture in athletes with normal posture, who are at risk of its violation, and whose posture undoubtedly corresponds to the norm (Table 4).

Table 4. Statistically significant differences in the state of the biogeometric profile of posture of young athletes 8–14 years old with high and average (3L) levels of normal type posture

Signs and indicators of the biogeometric profile of posture	Groups according to the level of biogeometric profile of posture										Reliability of differences	
	with a high level (n=26)					from the risk zone (n=44)					U	p
	\bar{x}	Me	25%	75%	S	\bar{x}	Me	25%	75%	S		
Head tilt angle (α_1)	2,46	2	2	3	0,51	2	2	2	2	0	308	p<0,01
Thoracic kyphosis (distance l1)	2,46	2	2	3	0,51	2	2	2	2	0	308	p<0,01
Torso angle (α_2)	2,46	2	2	3	0,51	2	2	2	2	0	308	p<0,01
Abdomen (distance l2)	2,46	2	2	3	0,51	2	2	2	2	0	308	p<0,01
Lumbar lordosis (distance l3)	2,46	2	2	3	0,51	1,57	2	1	2	0,5	175	p<0,01
Knee joint angle (α_3)	2,46	2	2	3	0,51	2	2	2	2	0	308	p<0,01
Position of the pelvic bones (α_4)	2,77	3	3	3	0,43	1,57	2	1	2	0,5	75	p<0,01
Shoulder symmetry (α_5)	2,46	2	2	3	0,51	2	2	2	2	0	308	p<0,01
Triangle waist	2,69	3	2	3	0,47	2	2	2	2	0	176	p<0,01
Symmetry of the lower angles of the blades (α_6)	2,69	3	2	3	0,47	2	2	2	2	0	176	p<0,01
Placement of the feet	2,50	2,50	2	3	0,51	2	2	2	2	0	286	p<0,01
In the sagittal plane	14,77	14	13	17	2,37	11,57	12	11	12	0,5	75	p<0,01
In the frontal plane	13,12	14	13	14	1,84	9,57	10	9	10	0,5	75	p<0,01
General indicator	27,88	27,5	27	31	3,89	21,14	22	20	22	1	75	p<0,01

Note: 1. Hereinafter: U – value of the Mann-Whitney test; p – level of significance of differences. 2. $U_{cr}(26; 44; 0,01) = 380$.





The analysis of variance carried out showed that the different age groups of athletes do not differ in any of the indicators (Table 5).

As can be seen from the table, for three indicators the sums of variances within groups significantly exceeded the combined (between-group) variance. Hence, the assumption that athletes' posture deteriorates with age, which was tested by comparing children of all ages ranging from 8 years to 14 years, is refuted.

And, at the same time, high rates of intragroup variation raise the question of the significant heterogeneity of each of these groups in terms of the severity of the studied indicators, which, of course, we see in the fact that the studied, regardless of age, but with different types of postural disorders, as well as levels of severity of this distortions differ significantly not only from athletes with normal posture, but also from each other.

Table 5. Results of one-way analysis of variance (ANOVA) of indicators of the state level of the biogeometric profile of posture in groups of athletes of all ages specializing in hand-to-hand combat

Indicators of the state level of the biogeometric posture profile	Type of dispersion	Sum of squared deviations	df	Average square	F	p
Sagittal plane	Intergroup	5,985	df ₁ =5	1,197	0,205	p>0,05
	Inside groups	841,908	df ₂ =144	5,847		
Frontal plane	Intergroup	15,057	df ₁ =5	3,011	0,345	p>0,05
	Inside groups	1256,28	df ₂ =144	8,724		
General indicator	Intergroup	38,525	df ₁ =5	7,705	0,309	p>0,05
	Inside groups	3586,835	df ₂ =144	24,909		

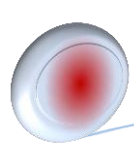
Note: df – degrees of freedom; F – Fisher's F-test value; r – level of confidence; F_{cr}(5; 144; 0,05)=4,4.

Discussion.

Today, researchers are unanimous in their vision of a significant component of modern sports theory as the problem of the health of athletes, and then the issues of the effectiveness of the process of long-

term sports training (Cakmakci et al., 2020; Byshevets et al., 2022; Ivchenko et al., 2023).

Processing of professional literature (Augustsson et al., 2021; Radu et al., 2022) allows us to state that it is the high information content of



indicators of physical development of young athletes that is the determinant of their inclusion in a number of information and analytical systems of a biomechanical monitor.

The relevance today of the problem of unfixed disorders of the musculoskeletal system of athletes is revealed by the results of scientific research devoted to determining the characteristics of violations of the biomechanics of posture and foot of young athletes representatives of various sports (Danyshchuk et al., 2020; Shelikhova, et al., 2021; Alvero-Cruz et al., 2022; Barczyk-Pawelec et al., 2022; Krykun et al., 2024).

Today, scientists (Grabara, 2012) agree that the stages of initial training and preliminary basic training in martial arts (Vako et al., 2024) (mainly and other sports) occur in the prepubertal and pubertal periods, which is characterized by heterochronicity of formation individual systems and organs, that is, they become more complex in both social and biological aspects. During this period of development, the children's spine is influenced by heavy loads arising during the training process, which can lead to adaptive changes in the musculoskeletal system of young athletes (Krykun et al., 2024).

We share the beliefs of experts (Kashuba, et al., 2020; Byshevets et al., 2022; Radu et al., 2022; Krykun et al., 2024) in the importance of developing

an athlete's health-saving methodology for:

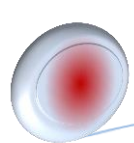
- ✓ transformation of the plan into a consistently implemented series of pedagogical influences designed for target settings to obtain a specific result;

- ✓ practice of health-saving technology as an interdependent activity of a physical education and sports rehabilitation specialist, coach, young athletes, their parents and society with the optimal implementation of human resources;

- ✓ introduction of diagnostic techniques to determine the range of health indicators of athletes to health-saving technology;

- ✓ step-by-step design and subsequent implementation of elements of health-saving technologies, reproduced by any children's sports school.

Conclusions. It has been shown that poor posture of various types is common among athletes aged 8-14 years, specializing in hand-to-hand combat, covering a contingent of 46.7 to 60% in different age groups. In addition, a significant portion of young martial artists with normal posture (62.9% among them) can be classified as at risk for poor posture, primarily due to a noticeable deviation from the norm in the position of the pelvic bones, waist triangles, and symmetry of the lower angles shoulder blades in the frontal plane, as well as due to



deviations in lumbar lordosis in the sagittal plane. Differences (at the level of trends) between athletes of all ages have been identified, which indicate a certain deterioration in the state of the biogeometric profile of posture with increasing age, but such differences have not received statistical confirmation.

Theoretical and practical aspects of the scientific work presented above will be the basis for the theoretical substantiation of the biological prerequisites for the introduction of corrective and preventive measures into the educational and training process of young athletes specializing in hand-to-hand combat.

Author's contribution

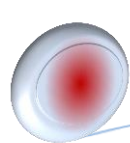
Conceptualization, V.K.; methodology, V.K.; software, Y. R.; check, I.V.; formal analysis, A. R.; investigation, Y. R.; re-sources, B.B.; data curation, I.V.; writing – rough preparation, A. R.; writing – review and editing, V.K.; visualization, G.D.; supervision, I.V.; project administration, I.V. All authors have read and agreed with the published version of the manuscript.

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