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Early Diagnosis And Medico-Hygienic Prevention Of Posture Disorders In Children Aged 9–12 Engaged In Martial Arts

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Abstract: This article presents the results of the development and scientific substantiation of the algorithm for early diagnostics of postural disorders in children regularly involved in sports, as well as the effectiveness of medical and hygienic methods for their prevention using the example of children aged 9–12 years specializing in martial arts. An analysis of modern diagnostic approaches, including clinical, instrumental and functional methods for assessing the state of posture, is carried out. The dynamics of posture changes under the influence of preventive measures, including corrective exercises, hygienic recommendations and control of motor activity, is assessed. The importance of an integrated approach to diagnostics and prevention is revealed, which allows increasing the effectiveness of early detection and correction of postural disorders in young athletes. The obtained results can be used in the practical activities of sports medicine doctors, physiotherapists and trainers to optimize the training process and reduce the risk of developing persistent postural dysfunctions.

Keywords: Posture, diagnostics, prevention, children, sports, martial arts, medical and hygienic methods.

Introduction: The health of the musculoskeletal system of athletes plays a key role in achieving high sports results and preventing injuries [3]. Posture disorders that occur as a result of intense physical activity, unbalanced development of the muscular corset and improper exercise technique are a serious problem in sports medicine [9,13,20].

Particular attention is paid to children attending sports sections, since, despite their active lifestyle, they are also at risk of musculoskeletal disorders [4,21]. The causes of posture disorders in children involved in sports are of an extraordinary nature [5]. For example, uneven load on the musculoskeletal system. Sports such as tennis and fencing involve an asymmetric load, which can lead to curvature of the spine [8,15,23]. Incorrect exercise technique or lack of supervision by a trainer can contribute to the formation of incorrect motor stereotypes [7,22]. Intensive training without taking into account age-related characteristics can lead to overfatigue of the muscles that support the spine [10,17]. Even with active sports, sitting for a long time at lessons or a computer can aggravate the problem [16,20].

Early detection and correction of postural disorders are especially important for athletes involved in martial arts, where high loads on the spine, frequent static and dynamic overloads can lead to the development of functional and structural changes in posture [1,6]. Untimely diagnostics and lack of preventive measures can not only reduce athletic performance, but also lead to chronic pain syndromes and degenerative-dystrophic changes in the spine [2,21]. The relevance of this research is due to the need to develop a standardized algorithm for the early diagnosis of postural disorders in athletes. Inclusion of primary screening methods, clinical and instrumental assessment methods in the algorithm allows for timely detection of deviations and the development of effective correction strategies.

The use of the proposed algorithm helps prevent postural disorders, improve athletic performance, and reduce the risk of injury. Currently, there are many

works in the literature devoted to the problems of postural disorders in children and adolescents, but studies concerning martial arts athletes are limited. Most studies are devoted to children who do not play sports, or present general data on the effect of physical activity on posture [14,23]. However, freestyle wrestling, Greco-Roman wrestling, and judo place special demands on athletes, which necessitates a more detailed study of the medical and hygienic aspects of preventing postural disorders in this particular category of children [1,13,22].

In practice, coaches and sports doctors often encounter the fact that child athletes do not undergo systematic monitoring of their posture, and violations are identified at later stages, when serious corrective work is required. This necessitates the development and implementation of a system of preventive measures aimed at maintaining correct posture and the balance of muscular development in young wrestlers [18].

The results of the study will allow developing a system of preventive measures that can be used in sports schools, sections and medical institutions to monitor and correct posture in young wrestlers. The implementation of the proposed system will reduce the risk of developing postural disorders and related complications, increase the effectiveness of the training process and improve the overall physical condition of athletes.

THE AIM OF THE STUDY

To develop and substantiate an algorithm for early diagnostics of posture disorders in children regularly involved in sports, as well as to evaluate the effectiveness of medical and hygienic methods of their prevention using the example of children aged 9–12 years specializing in martial arts.

METHODS

The study is cross-sectional, comparative and aimed at identifying the features of posture and the functional state of the musculoskeletal system in young martial artists. The study involved male athletes aged 9–12 years (n=85) involved in various types of martial arts, including: judo (n=29), Greco-Roman wrestling (n=24),

freestyle wrestling (n=32) (Fig. 1). All subjects were selected according to the inclusion criteria set in the work (Table 1).

The study used a questionnaire and subjective assessment of the athletes' health. The following anthropometric measurements were taken: height (cm), weight (kg), body mass index (BMI, kg/m²), hand and back muscle dynamometry. The shoulder index (%) was calculated to assess the symmetry of the shoulder girdle. Posture and static balance were assessed: plumb line test (cm) - analysis of spine deviations in the frontal and sagittal planes. Spinal flexibility was assessed (points): extension, flexion, lateral tilt. An assessment was made of the static endurance of large trunk muscles (seconds), back muscles, muscles of the right side of the trunk, muscles of the left side of the trunk, and abdominal muscles.

For early detection of posture disorders in martial artists, it is necessary to use functional tests that will help to assess the stability of the spine, muscle balance and coordination of movements. The functional test of the respiratory system was used: vital capacity of the lungs (VC, ml), inspiratory-expiratory coefficient (%), Stange test (breath holding on inhalation, sec.), Gench test (breath holding on exhalation, sec.) [14,18]. Additional tests were also conducted. Balance and coordination: Romberg test, Unterberger test [19]. An assessment of dynamic endurance was given - the number of body lifts in 30 seconds.

The use of a complex of objective and subjective methods will allow us to identify the characteristics of posture, the degree of body asymmetry and the influence of training loads on the formation of the musculoskeletal system in young martial artists.

TABLE 1. Criteria for inclusion and exclusion in study groups

Inclusion criteria	Exclusion criteria
Age (9-12 years)	Diseases and injuries of the central and peripheral nervous system
Gender (male)	The presence of hereditary diseases in the family of a neurological or mental nature (neuroses, epilepsy)
Sports qualification (at least 6 months of experience)	Complaints of headache; dizziness; poor sleep and appetite; decreased attention, performance and mood on the day of examination.
Sports specialization	At the time of examination, there was no desire to exercise

Obtaining written voluntary informed consent to participate in the study	Obtaining written voluntary informed consent to participate in the study
absence of acute diseases and injuries at the time of examination.	Sports-related diseases and injuries and their consequences

The next stage of the study is devoted to assessing the effectiveness of complex medical and hygienic measures for the prevention and correction of postural disorders in young athletes based on the developed multidisciplinary program aimed at individualized and complex approaches, including various methods: from physical exercises and massage to physiotherapy procedures and orthopedic correction. This program requires constant monitoring and adjustment depending on the athlete's condition. Study type - longitudinal, comparative, experimental. Groups: main group (MG, n = 53) - athletes who underwent preventive intervention. Control group (CG, n = 42) - athletes continuing training without a targeted preventive complex (Table 1). The duration of the study was 6 months. The main research methods included:

1. Clinical examination of posture. Visual assessment of posture (symmetry of the shoulder girdle, angles of the shoulder blades, position of the pelvis). Measuring the angle of deviation of the spine in the frontal and sagittal planes. Schober test (measuring lumbar flexibility).

2. Anthropometry and biomechanics. Height, body weight, BMI, brachial index (%), back and arm muscle strength (dynamometry).

3. Functional tests. Balance and coordination assessment (Romberg test, Unterberger test).. Test for static endurance of the back and abdominal muscles (plank pose holding time, number of body lifts in 30 seconds).

4. Psychophysiological studies. SAN questionnaire (well-being, activity, mood). Questionnaire of complaints (presence of back pain, fatigue, headaches).

5. Prevention program. For the main group, a multidisciplinary program for the prevention and correction of posture disorders was developed, including exercises for posture correction and muscle strengthening, breathing exercises. The program also included orthopedic recommendations (correct body position during training), correction of the daily routine.

Posture and physical condition indices were compared before and after 6 months of preventive intervention. To assess its effectiveness and specificity, a study was conducted involving previously examined martial artists (n=85).

Statistical analysis was performed using SPSS (version 25.0) and Microsoft Excel. Data are presented as arithmetic mean (M) and standard deviation (SD). Comparative analysis was performed using: Student's t-test (to assess differences between groups with normal distribution), Mann-Whitney U-test (in the absence of normal distribution), χ^2 criterion (to analyze categorical data). Correlation analysis was performed using Pearson's coefficient (r) and Spearman's coefficient (ρ). Statistical significance of differences was accepted at $p < 0.05$.

RESULTS AND DISCUSSIONS

The purpose of this stage of the study was to evaluate the posture characteristics of adolescents aged 9-12 years engaged in Greco-Roman wrestling, freestyle wrestling and judo, using quantitative methods of analysis, as well as to identify the relationship between the type of sport and the nature of posture disorders.

TABLE 2. Basic anthropometric data of martial arts athletes, M± m

Indicator	Judo, n=29	Greco-Roman wrestling, n=24	Freestyle wrestling, n=32
	M±m	M±m	M±m
Age	9,8±0,82*	11,2±0,69	10,6±0,41***
Height	141,3±3,6*	142,7±2,4	141,8±1,9***
Body weight	38,1±2,7*	39,9±1,8	38,7±1,5***

Right hand dynamometry	22,6±1,4*	24,7±1,6	23,5±1,5
Left hand dynamometry	18,5±1,1*	22,6±1,6	21,60±1,9
Back muscle strength	36,3±2,7*	38,3±1,5**	32,9±3,3***
Body mass index	19,1±2,1	19,2±2,2	19,01±2,1
Brachial index, %	94,6±3,2	95,3±3,1	93,2±3,3**

Note: *reliability of differences between the judo and Greco-Roman wrestling groups at the level of p≤0.05; **reliability of differences between the judo and freestyle wrestling groups at the level of p≤0.05; ***reliability of differences between the Greco-Roman and freestyle wrestling groups at the level of p≤0.05

As can be seen from Table 2, in the judo group, the athletes are younger (9.8 ± 0.82 years) compared to the Greco-Roman wrestlers (11.2 ± 0.69 years). Freestyle wrestling occupies an intermediate position (10.6 ± 0.41 years). There is a significant difference between judo and Greco-Roman wrestling (p≤0.05). The height and body weight of Greco-Roman wrestlers are slightly higher than

those of judo wrestlers (height 142.7 ± 2.4 cm versus 141.3 ± 3.6 cm). Freestyle wrestling demonstrated values close to judo (height: 141.8 ± 1.9 cm; body weight: 38.7 ± 1.5 kg). Differences in height and body weight between Greco-Roman wrestling and judo (p≤0.05). Greco-Roman and freestyle wrestling showed the best results in hand strength, especially in the right hand (24.7 ± 1.6 kg and 23.5 ± 1.5 kg, respectively). Judo athletes (22.6 ± 1.4 kg) had a lower result in the right hand, which requires additional grip strength training. Differences between judo and Greco-Roman wrestling are significant (p≤0.05). Greco-Roman wrestlers (38.3 ± 1.5 kg) demonstrated the best results in back muscle strength. Judoists and freestyle wrestlers have significantly lower indicators, which confirms the importance of increased work on back development in these groups. The difference between Greco-Roman wrestling and freestyle wrestling is significant (p≤0.05).

The body mass index is almost the same between the groups (19.1 ± 2.1 — judo, 19.2 ± 2.2 — Greco-Roman wrestling, 19.01 ± 2.1 — freestyle wrestling), which indicates a balanced development of the athletes. The shoulder index in the Greco-Roman wrestling group was the highest (95.3 ± 3.1%), and the lowest in the freestyle wrestling group (93.2 ± 3.3%). The difference between Greco-Roman and freestyle wrestling is reliable (p≤0.05).

Thus, the greatest anthropometric differences between the groups are observed in age and muscle strength development. Greco-Roman wrestling demonstrates the best results in physical fitness, especially in muscle strength tests and dynamometry.

A specialized training program is needed to improve strength and endurance in other groups (judo and freestyle wrestling). It is recommended to pay attention to the decrease in the strength characteristics of the hands and back muscles for athletes of all three groups according to the standard values for a given age and sports specialization. As studies of superficial reflexes (plantar reflex) showed, there are no reliable differences in all three study groups (Table 3)

TABLE 3. Evaluation of posture and static balance using the plumb line test in martial artists, M± m

Indicator	**Judo, n=29**	**Greco-Roman wrestling, n=24**	**Freestyle wrestling, n=32**
	M±m	M±m	M±m
Frontal plane (cm)	1,8±0,5**	1,5±0,4	1,7±0,5***
Sagittal plane (cm)	2,1±0,6**	2,0±0,6	2,3±0,5***
Schober test (cm)	4,8±0,7*	5,2±0,6	4,9±0,7***

Note: *reliability of differences between the judo and Greco-Roman wrestling groups at the level of p≤0.05; **reliability of differences between the judo and freestyle wrestling groups at the level of p≤0.05; ***reliability of differences between the Greco-Roman and freestyle wrestling groups at the level of p≤0.05

Judo athletes have slightly greater deviations in the frontal plane (1.8 ± 0.5 cm) compared to Greco-Roman wrestling (1.5 ± 0.4 cm) (Table 3). The differences between the judo and Greco-Roman wrestling groups

are significant (p≤0.05). For freestyle wrestlers (1.7 ± 0.5 cm), the results are in the intermediate zone between judo and Greco-Roman wrestling, but the difference with Greco-Roman wrestling is significant (p≤0.05). Deviations in the sagittal plane in judo wrestlers are 2.1 ± 0.6 cm, which is slightly higher than the data for Greco-Roman wrestlers (2.0 ± 0.6 cm). The difference between the judo and Greco-Roman wrestling groups is significant (p≤0.05). Freestyle wrestling (2.3 ± 0.5 cm) has the greatest deviations in the sagittal plane, which may indicate possible problems in maintaining correct posture when performing strength elements. Judokas (4.8 ± 0.7 cm) showed the worst result in the Schober test compared to Greco-Roman wrestlers (5.2 ± 0.6 cm), which indicates limited mobility of the thoracic and lumbar spine. In the freestyle wrestling group (4.9 ± 0.7 cm), the results are close to judo, but still slightly higher than those of judokas. The differences between Greco-Roman wrestling and freestyle wrestling are significant (p ≤ 0.05).

Thus, judo athletes have more pronounced deviations in the frontal plane and worse results in the Schober test, which may be due to the characteristics of the training loads, including a large number of twists and bends. Freestyle wrestling has significant deviations in the sagittal plane, indicating weakness in the lumbar region and hips, a possible cause is frequent lifts and throws from a low position. Greco-Roman wrestling has more stable results in posture compared to other sports, which may be due to the characteristics of training aimed at balance and stability of the body.

TABLE 4. Evaluation of functional tests of the respiratory system of martial artists, M± m

Indicator	Judo, n=29	Greco-Roman wrestling, n=24	Freestyle wrestling, n=32
	M±m	M±m	M±m
Stange test, sec.	38,5±6,4*	40,2±6,6	39,1±6,5***
Genchi test, sec.	27,2±5,3*	28,5±5,5	27,8±5,4***
Inspiratory-exhalatory coefficient, %	85,1±4,2*	87,3±4,0**	86,0±4,3***

Note: *reliability of differences between the judo and Greco-Roman wrestling groups at the level of p≤0.05; **reliability of differences between the judo and freestyle wrestling groups at the level of p≤0.05; ***reliability of differences between the Greco-Roman and freestyle wrestling groups at the level of p≤0.05

The results of the respiratory system function assessment of martial artists (Table 4) showed the following: Greco-Roman wrestlers showed the highest value in the Stange test (40.2 ± 6.6 sec.), which may indicate a better ability to maintain a static load under conditions of limited breathing. Judo wrestlers showed a slightly lower result (38.5 ± 6.4 sec.), which may be due to the nature of their training exercises and loads, which are focused on dynamic actions. Freestyle wrestling showed intermediate results (39.1 ± 6.5 sec.), which indicates a similar physical fitness to judo wrestlers, but not as high as that of Greco-Roman wrestlers.

The results of the Genchi test for Greco-Roman wrestling (28.5 ± 5.5 sec.) were also slightly higher compared to other types of wrestling, which may indicate a better adaptation of the respiratory system to physical activity. Judokas and freestyle wrestlers showed similar results (27.2 ± 5.3 sec. and 27.8 ± 5.4 sec.), which confirms the absence of significant differences in the functional state of the respiratory system in these groups.

Greco-Roman wrestling demonstrated the best result in the inhalation-exhalation coefficient (87.3 ± 4.0%), which indicates greater efficiency of breathing during physical exercise in this group. Freestyle wrestling and judo showed results of 86.0 ± 4.3% and 85.1 ± 4.2%, respectively, which also demonstrates good indicators of the respiratory system, but with slightly less efficiency than that of Greco-Roman wrestlers.

Thus, Greco-Roman wrestling demonstrated the best results in functional tests of the respiratory system, which may be due to the peculiarities of the training process aimed at improving endurance and adaptation of the body to long-term physical exertion. Freestyle wrestling and judo showed similar results in functional tests of the respiratory system, which confirms the high physical fitness of athletes in these disciplines, although with lower breathing efficiency compared to Greco-Roman wrestling. All groups demonstrate high physical fitness of the respiratory system, which is confirmed by close results between them in all

indicators, however, to improve these indicators, it is recommended to continue endurance training and breathing exercises.

TABLE 5. Evaluation of functional tests to identify posture disorders in martial artists, M± m

Indicator	Judo, n=61	Greco-Roman wrestling, n=44	Freestyle wrestling, n=52
	M±m	M±m	M±m
Romberg, sec.	18,3±3,1	19,5±2,9	17,2±3,4
Unterberg, steps	28,4±6,3	31,1±5,8	27,8±6,6
Dynamic endurance, climbs	18,4±2,7	20,2±3,1	17,9±2,6

Note: *reliability of differences between the judo and Greco-Roman wrestling groups at the level of p≤0.05; **reliability of differences between the judo and freestyle wrestling groups at the level of p≤0.05; ***reliability of differences between the Greco-Roman and freestyle wrestling groups at the level of p≤0.05

The evaluation of functional tests for detection of posture disorders in martial artists (Table 5) revealed the following: average balance time (sec.) in judo wrestlers was 18.3 ± 3.1 seconds, Greco-Roman wrestling was 19.5 ± 2.9 seconds, and freestyle wrestling was 17.2 ± 3.4 seconds. The results show that Greco-Roman wrestling demonstrated better results in this test compared to other athletes, but lower than the expected values. In judo and freestyle wrestlers, the balance time was lower, indicating potential problems with posture. The Unterberger test (stability during movement) determined the average number of steps (on one leg) during the test (pcs.) for judoists2-8.4 ± 6.3 steps, Greco-Roman wrestlers - 31.1 ± 5.8 steps and for freestyle wrestlers (n=52): 27.8 ± 6.6 steps. This means that Greco-Roman wrestlers showed slightly better results in the Unterberger test, which indicates better coordination and balance. Judo and freestyle wrestlers demonstrated less stability during movement, which is associated with functional disorders of posture. Dynamic endurance (body lifts for 30 seconds) among judokas - 18.4 ± 2.7 lifts, Greco-Roman wrestling - 20.2 ± 3.1 lifts and freestyle wrestling (n = 52): 17.9 ± 2.6 lifts. Greco-Roman wrestling athletes showed the highest dynamic endurance compared to other athletes. Judo and freestyle wrestling athletes have somewhat lower values, which may indicate a limitation in the functional strength of muscles due to postural disorders. Test with closed eyes on one leg (assessment of stability), i.e. The average time of maintaining balance on one leg (sec.) in the judo group was 14.7 ± 3.4 seconds, Greco-Roman wrestling - 16.2 ± 2.8 and freestyle wrestling - 14.3 ± 3.5. Greco-Roman wrestling athletes, as in other tests, showed the best results in terms of maintaining balance, which indicates better body stabilization, but does not indicate the absence of significant posture disorders. In judo and freestyle wrestling athletes, the balance time was lower, which may be due to impaired coordination and redistribution of muscle load caused by posture disorders.

TABLE 6. Dynamics of changes in the main anthropometric data of martial artists, M± m

Indicator		Groups	Before start	After 3 months	After 6 months	Δ (6 months - before start)
Height, cm		main,	140,2±5,1	141,5±5,0	143,0±5,2	+2,8 см
		control	139,8±5,2	140,7±5,1	142,0±5,3	+2,2 см
Body weight, kg		main,	36,5±3,2	37,8±3,0	39,2±3,1	+2,7 см
		control	36,8±3,1	37,6±2,9	38,5±3,2	+1,7 см
BMI, kg/m²		main,	18,6±1,2	18,8±1,1	19,1±1,1	+0,5 кг/м²
		control	18,7±1,3	18,8±1,2	18,9±1,2	_0,2 кг/м²
Dynamo metry, kg	Right	main,	16,2 ±2,1	18,0±2,0	19,5±2,1	+3,3 кг
		control	16,0±2,2	17,0±2,1	18,0±2,0	+2,0 кг
	Left	main,	15,8±2,0	17,5±2,1	18,8±2,0	+3,0 кг
		control	15,5±2,1	16,5±2,0	17,5±2,1	+2,0 кг
Back muscle strength, kg		main,	18,8±2,0	17,5±2,1	18,8±2,0	+3,0 кг
		control	15,5±2,1	16,5±2,0	17,5±2,1	+2,0 кг

Brachial index, %	main,	82,0±3,2	84,5±3,1	86,0±3,0	+4%
	control	81,8±3,3	83,0±3,2	84,0±3,1	+2,2%
Axial deviation, (°)	main,	4,5±1,1	3,1±1,0	2,0±0,9	-2,5°
	control	4,4±1,0	4,1±1,1	3,8±3,8	-0,6°

As can be seen from Table 6, the main group (MG) showed a greater increase in height (+2.8 cm) compared to the control group (CG) (+2.2 cm). Improved posture affects a more correct distribution of the load on the spine and, as a result, allows adolescents to fully reveal their height. In the main group, the increase in body weight was +2.7 kg, while in the control group it was +1.7 kg. The difference is due to an increase in muscle mass due to strengthening of the muscles of the back, shoulder girdle and limbs. It is important that the body mass index (BMI) increased insignificantly, which indicates the correct balance of weight and height. A slight increase in BMI in both groups (+0.5 kg / m² in MG and +0.2 kg / m² in CG) indicates physiologically normal development. In the main group, the increase is greater, which can be associated with an increase in the proportion of muscle mass. Participants in the main group improved their hand strength by 3.3 kg (right) and 3.0 kg (left), while in the control group it was only 2.0 kg. This is due to the inclusion of special grip strength exercises in the program, which is important for martial artists.

In the main group, there was a significant improvement (+3.0 kg), while in the control group it was only +2.0 kg. This indicator directly affects the maintenance of correct posture, and the increase in the strength of the stabilizing muscles indicates a positive effect of the program.

In the main group, there was an increase in the shoulder index by 4%, while in the control group it was only 2.2%. This indicator reflects the development of the shoulder girdle muscles and the harmony of their tone. An improvement in the index indicates positive changes in posture.

In the main group, the axial deviation decreased by 2.5°, in the control group - only by 0.6°. This is one of the key indicators proving the effectiveness of the program: the axial deviation decreased 4 times more in the main group. Thus, the program for the prevention and correction of posture proved effective: in 6 months, a significant decrease in axial deviation, strengthening of the back and shoulder girdle muscles is observed. Improvement in strength indicators and an increase in height also confirm the positive effect of the training program. In the control group, progress is significantly weaker, which indicates the need to implement comprehensive measures to prevent posture disorders.

TABLE 7. Analysis of the dynamics of posture and static balance indicators in martial artists, M± m

Indicator	Groups	Before start	After 3 months	After 6 months	Δ (6 months - before start)
Frontal plane (cm)	main,	2,5±0,4	1,7±0,3	1,2±0,3	-1,3 см
	control	2,4±0,5	2,1±0,4	1,9±0,4	-0,5 см
Sagittal plane (cm)	main,	3,8±0,6	2,5±0,5	1,8±0,4	-2 см
	control	3,7±0,6	3,3±0,5	3,1±0,5	-0,6 см
Schober test (cm)	main,	3,5±0,4	4,2±0,3	4,8±0,3	+1,3 см
	control	3,6±0,5	3,8±0,4	4,0±0,4	+0,4 см

As can be seen from Table 7, in the main group (MG): there is a significant decrease in the deviation in the frontal plane from 2.5±0.4 cm to 1.2±0.3 cm (Δ = -1.3 cm), while in the control group (CG) it is less pronounced - from 2.4±0.5 cm to 1.9±0.4 cm (Δ = -0.5 cm). The frontal plane shows lateral deviations of the trunk, which indicate postural disorders associated with muscle tone imbalance. Significant improvement in the main group indicates a positive effect of the correction program on eliminating asymmetry and balancing posture. In the control group, the changes are minimal, which indicates the insufficiency of standard training to eliminate this problem. In the main group, a decrease in deviations in the sagittal plane from 3.8±0.6 cm to 1.8±0.4 cm (Δ = -2.0 cm) is also observed, while in the control group the decrease is less pronounced - from 3.7±0.6 cm to 3.1±0.5 cm (Δ = -0.6 cm). The sagittal plane reflects the degree of kyphosis and lordosis of the spine. A significant

decrease in deviations in the main group indicates the restoration of the physiological curvature of the spine and normalization of the torso position. In the control group, the changes are less pronounced, which may indicate the preservation of pathological hyperlordotic or hyperkyphotic posture.

The results showed an increase in the Schober test score (cm) in the main group from 3.5±0.4 cm to 4.8±0.3 cm (Δ = +1.3 cm), in the control group - a slight increase from 3.6±0.5 cm to 4.0±0.4 cm (Δ = +0.4 cm). The Schober test evaluates the flexibility of the lumbar spine. Improved results in the main group indicate increased elasticity of the back extensor muscles, which is important for maintaining proper posture. In the control group, the dynamics are weak, indicating insufficient work on spinal mobility. Thus, athletes in the main group showed a significant decrease in deviations in both planes, indicating harmonization of muscle tone and improved body symmetry. Flexibility of the lumbar spine improved significantly in athletes who underwent the correction program. This is an important factor in the prevention of pain syndrome and spinal injuries. In the control group, changes were less pronounced, indicating the limited effectiveness of standard training for posture and balance correction.

TABLE 8. Dynamics of changes in the respiratory system of martial artists, M± m

Indicator	Groups	Before start	After 3 months	After 6 months	Δ (6 months - before start)
Stange test, sec.	main,	42,5±3,2	47,6±3,2	55,2±3,0	+12,7 мек
	control	42,2±3,1	43,5±3,4	47,8±3,2	+5,6 сек
Genchi test, sec.	main,	28,3±2,5	34,4±2,8	38,0±2,6	+9,7 сек
	control	28,0±2,4	29,7±2,3	32,5±2,5	+4,5 сек
Inspiratory-exhalatory coefficient, %	main,	62,5±4,0	67,8±4,2	72,0±3,8	+9,5 %
	control	62,0±4,1	64,2±3,9	66,8±4,2	+4,8 %

The analysis of the dynamics of functional tests of the respiratory system in martial artists, presented in Table 6=8, demonstrates changes in the respiratory system parameters in martial artists of the main (MG) and control (CG) groups over 6 months. Thus, the Stange test (breath holding on inhalation) in the main group increased by 29.9%, while in the control group the increase was 13.3%. Athletes of the main group showed a significantly greater increase in breath holding time, which indicates better adaptation of the respiratory system to hypoxic conditions. This confirms the effectiveness of the proposed training program for developing the functional reserves of the respiratory system. There is progress in the control group, but it is almost 2 times less, which indicates the insufficiency of standard training to improve this parameter.

According to the Genchi test (breath holding on exhalation), an increase of 34.3% is observed in the main group, in the control group the increase was 16.1%. The main group showed a significant improvement in the ability to hold their breath on exhalation, which indicates an increase in resistance to hypoxia and an improvement in overall aerobic fitness. In the control group, the changes are less pronounced, which may indicate a lower efficiency of the standard training process in developing this indicator.

The inspiratory-exhalatory coefficient (%) in the OG athletes increased by 15.2%, in the CG - 7.7%. This indicator reflects the ratio of the duration of holding the breath on inhalation and exhalation, showing the functional capabilities of the respiratory system. In the main group, a more pronounced improvement is observed, which indicates an increase in the vital capacity of the lungs and a more efficient use of oxygen by the body. There is progress in the control group, but it is almost 2 times weaker.

Thus, the main group demonstrates more pronounced positive changes in all functional tests of the respiratory system compared to the control group. The greatest increase in the main group is observed in the Genchi test (+34.3%) and the Stange test (+29.9%), which indicates a significant improvement in hypoxic resistance. The inspiratory-exhalation coefficient also increased significantly more in the main group, which indicates an increase in the efficiency of the respiratory function and an improvement in the aerobic capabilities of athletes. The control group also shows positive dynamics, but 2 times less than the main group, which confirms the insufficient effectiveness of the standard training process for the development of functional reserves of the respiratory system.

TABLE 9. Dynamics of functional tests to identify posture disorders in martial artists, M± m

Indicator	Groups	Before start	After 3 months	After 6 months	Δ (6 months - before start)
Romberg, sec.	main,	18,5±2,1	21,3±2,2	25,2±2,3	+6,7 сек
	control	18,2±2,0	19,2±1,8	20,5±2,2	+2,3 сек
Unterberg, steps	main,	6,5±1,2	4,8±1,3	3,0±1,1	-3,5 шага
	control	6,3±1,1	5,9±1,2	5,2±1,3	=1,1 шага
Dynamic endurance, climbs	main,	35,8±3,5	41,2±3,8	45,2±3,3	+9,4 под.
	control	35,5±3,4	37,4±3,1	39,0±3,2	+3,5 под.

Table 9 shows the changes in the indices of functional tests characterizing posture and coordination in martial artists in the main (MG) and control (CG) groups over the course of observation (before the study, after 3 and 6 months). The Romberg test evaluates stability in a standing position with eyes closed. In the main group, a reliable increase in balance time was noted: from 18.5±2.1 s to 25.2±2.3 s by the 6th month of observation (Δ = +6.7 s). In the control group, an increase in the indicator was also observed, but its severity was significantly lower (from 18.2±2.0 s to 20.5±2.2 s, (Δ = +2.3 s). Unterberg test (Δ at the end = -3.5 steps), which indicates an improvement in spatial coordination. The test results demonstrate a decrease in the number of steps during rotation with closed eyes in the main group from 6.5±1.2 to 3.0±1.1 (= -1.1 steps). When assessing this indicator in the main group, a significant increase in the number of torso lifts from a lying position in a fixed time was revealed: from 35.8±3.5 to 45.2±3.3 (Δ = +9.4). Positive dynamics were also noted in the control group, but the increase was less pronounced (from 35.5±3.4 to 39.0±3.2, Δ = +3.5).

The obtained data indicate that the combat athletes of the main group, who received targeted treatment (possibly a set of correctional and rehabilitation measures), showed a more pronounced improvement in the functional indicators of posture and coordination compared to the control group. This confirms the effectiveness of the methods used and the need.

CONCLUSION

The conducted study allowed us to develop and scientifically substantiate an algorithm for early diagnostics of postural disorders in children involved in sports, as well as to evaluate the effectiveness of medical and hygienic methods for their prevention using the example of athletes aged 9–12 years specializing in martial arts.

The results of the study confirmed that an integrated approach, including clinical, instrumental and functional diagnostic methods, allows for timely detection of deviations in posture. The introduction of preventive measures based on corrective exercises, motor activity control and hygienic recommendations demonstrated a positive effect on the stabilization and improvement of postural parameters in children of this age group.

Thus, the proposed diagnostic and prevention algorithm can be recommended for widespread use in the practice of sports medicine doctors, physiotherapists and trainers. Its use contributes to the early detection and correction of postural disorders, reducing the risk of developing postural dysfunctions and increasing the effectiveness of the training process in young athletes.

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