

Maintaining postural balance in martial arts athletes depending on coordination abilities

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Abstract.

In martial arts, all movements from the standing position, as well as circular strikes require maintaining postural balance. A high level of postural control is a necessary condition for improving athletic performance. Motor-coordination abilities play a significant role in maintaining postural balance. The aim of the paper was to establish the conditions for maintaining postural balance in different situations depending on coordination abilities in martial arts athletes. The sample included male and female athletes involved in judo, combat sambo, Greco-Roman wrestling, kickboxing, sports karate, taekwondo with athletic experience of 4 to 15 years (n=221). The results of the experiment were processed with the Student's t-test for independent samples, which determines the level of significance between the variables of two groups of athletes with different coordination abilities. The significance of differences between two groups of martial arts athletes reveals that athletes have differences in the following indicators: general and special coordination abilities, dynamic orientation in space, consistency of movements, accuracy of dynamic and spatial characteristics, response quickness, timeliness of movements, and improvisation. Therefore, maintaining postural balance requires developing the above-mentioned coordination abilities. It can be assumed that symmetrical leg performance is also facilitated by a high level of coordination abilities, which is one of the conditions for maintaining postural balance. The level of athletic performance is significantly higher in the group of athletes with a high level of postural balance. The revealed differences indicate that maintaining postural balance in martial arts athletes depends on coordination abilities, which affect both athletic performance and symmetrical leg performance.

Keywords: postural control, position, balance, coordination, martial arts, symmetry, sports performance

Introduction

Maintaining postural balance in martial arts is determined by coordination abilities and symmetrical leg performance, which has a positive effect on sports results. Martial arts require complex coordination of movements. Such martial arts as taekwondo, boxing and karate, are characterized by the lack of movement patterns in terms of technical and tactical actions. The nature of movements that presume interaction with opponents is not predetermined and changes depending on the partner's movements, which are based on the dynamic situation. In martial arts, an athlete must be able to maintain his/her postural balance, effectively perform technical actions in a standing position (both supported and unsupported) and when jumping.

The position of the body is determined by its posture, orientation and location in space, as well as its relationship to support. Maintaining postural balance requires the athlete to prevent any changes in the center of pressure relative to the support area. Motor actions are associated with constant balance control (Kal, M., 2005; Ryabina, K.E., Isaev, A.P. 2015; Erlikh, V.V., Korableva, Yu.B., Epishev, V.V., Polyakova, O., 2018). The posture of the body is determined by the position of its elements relative to each other in a 3-dimensional space (Donskoy, D.D., 2019). In martial arts, a variety of body positions (stances) are distinguished. In martial arts, stance is the arrangement of body elements independent of its orientation and location in space and its relationship to support. Different stances are provided by tonic muscular activity, and more often by the activity of extensor muscles, which support the center of pressure. In martial arts, while maintaining the body position, an athlete is subjected to gravity forces, the opponent's body weight and ground reaction forces, which prevent free fall. All external forces are aimed at changing the position of the body and are divided into disturbing and balancing actions. Muscle traction usually serves as a balancing force.

Under certain conditions, combat actions can be classified as disturbing and aimed at changing the body position in space. The research of A.A. Savin, A.D. Vikulov, A.A. Melnikov, (2010) showed that highly skilled wrestlers were able to maintain a more stable vertical body position even in case of increasing fatigue. One of the reasons for the increased stability in highly skilled athletes is the lower accumulation of metabolites during exercise compared with low skilled athletes.

The mechanisms of maintaining postural balance in athletes are quite complex, since they are determined by the performance of various analyzers (visual, vestibular and tactile), organs, and body systems (vegetative organs, nervous and muscular systems). For example, maintaining balance after rotational movements requires much work from the vestibular analyzer. The participation of one or another analyzer is determined by a specific motor task associated with maintaining stability (Nazarenko, L.D., 2000).

Martial arts characterized by intensive shock load (especially, in the head area) contribute to pathological disorders caused by strong punches and excessive irritations of the otolith apparatus and the need to maintain postural balance (Strelets, V.G., Gorelov, A.A., 1995).

Stability is the ability of an athlete's body to maintain balance without falling under external forces applied by the opponent or environment (Kadochnikov, A.A., 2011).

Functional changes associated with different orientation of the body and maintaining stability affect all physiological systems. Changes in body position are accompanied by changes in blood circulation, arterial pressure, heart rate, etc. (Gurfinkel, V.S., Kots, Ya.M., Shik, M.L., 1965). Body balance is determined by various factors. The most important of them are posture, mechanical disturbances aimed at loss of stability, location of the center of pressure (Donskoy, D.D., 2019), the angle of stability (Eganov, A.V., 2014), motor asymmetry (Eganov, A.V., 2021; Eganov, A., Cherepov, E., Bykov, V., Tselishcheva, E., 2020), amplitude and period of oscillations when countering mechanical disturbances, resistance force (Perrin, P., Deviternie, D., Hugel, F., Perrot, C., 2002), body length, body weight (Kazilov, M.M., Frolov, V.G., Zhrebkin, N.N., 2021; Bădău et al., 2018; Zamchiy, T.P., Lozhkina-Gametskaya, N.I., Spataeva, M.Kh., 2014) and lower-extremity muscle fatigue (Gribble, P.A., Hertel, J., 2004; Harkins, K.M., Mattacola, C.G., Uhl, T.L. et al., 2005). Maintaining postural balance is especially significant in case of physical fatigue (Litvinenko, Y.V., Sadowski, J., Niznikowski, T., Boloban, V.N., 2015).

According to Lephart et al. (1998) joint perception of body position by a person is defined as a specialized sense that is regulated by almost all physiological systems of the body, including neuromuscular control.

There is an opinion (Ergen, E., Ülkar, B., Eraslan, A. (2007)) that the perception of the relative position of body parts and their movements is performed consciously and associated with motor coordination, which is provided by the central nervous system by means of visual, vestibular and somatosensory receptors.

The more an athlete pays attention to postural control, the more opportunities he/she has for mastering techniques (Ovchinnikov, V.A., 2009).

According to M.M. Kazilov, V.G. Frolov, and Zhrebkin N.N., (2021) taller and heavier athletes are characterized by increased maximum resistance force and the period of oscillations in an irreversible position.

In martial arts, throws and kicks are associated with the rotation of the trunk or other complex movements, which result in loss of balance. Therefore, maintaining postural balance requires an athlete to prevent any deviations of the center of pressure with respect to the support area.

When fighting an athlete provides postural control by choosing an individual way of posture adjustment and using his/her coordination abilities (Sadowski J., 2000).

Postural balance is manifested in the ability to maintain a uniform distribution of the center of pressure in front stance or to shift it somewhat to the forward leg. This feature is associated with athletic performance that provides specific stability and prevents unnecessary falls (Zamchiy, T.P., Lozhkina-Gametskaya, N.I., Spataeva, M.Kh., 2014). Maintaining postural balance when fighting is connected with postural control. The sharper the movement and the faster the rotation of the trunk, the longer is the time of simultaneous activity of multidirectional muscles.

When it comes to postural control in an athlete under attack, the center of pressure is projected onto the center of the area of its support resulting in a constant movement of this point. This indicates natural spontaneous fluctuations in the center of pressure. This position can be considered as the most stable and the most favorable for an athlete under attack. The area of support and the amplitude of movement are significantly reduced, which indicates a more rational activity of athletes for maintaining this position. The dependence of postural balance on anthropometric measurements should be also noted: with the increase in weight, a number of significant indicators of postural balance increases (Kazilov, M.M., Frolov, V.G., Zhrebkin, N.N., 2021).

Maintaining postural balance in different conditions is one of the requirements for improving technical and tactical skills, developing punch force, preserving dynamic balance (Sadowski, J., 2000) and stability in general (Litvinenko, Y.V., Sadowski, E., Niznikowski, T., Boloban, V.N., 2015).

Coordination abilities can be considered as a muscular synergy, which manifests itself in solving complex motor tasks in dynamic conditions that arise unexpectedly. Coordination abilities are regulated by the central nervous psychophysiological mechanisms. The main components of coordination abilities include: special coordination abilities, space orientation, postural balance control, etc. Nowadays, Issurin, V.B. et al. (2019) identify more than 20 components of coordination abilities.

In complex coordination sports, orientation is aimed at the development and improvement of coordination abilities and postural balance. Authors (Botyaev, V.L., 2010; Sadowski, J., Boloban, V.,

Niznikowski, T., Mastalerzh, A., 2011; Litvinenko, Y.V., Sadowski, E., Niznikowski, T., Boloban, V.N., 2015; Eganov, A.V., Bykov, V.S., Pozdniakov, G.P., 2021) claim that postural control is ensured by improving technical skills and athletic performance. A high level of coordination abilities affects the asymmetry of attacking and defensive actions (Eganov, A.V., 2021).

In martial arts, athletes perform various complex coordination motor actions. All this requires thinking, reacting, concentrating and switching attention, as well as demonstrating spatial, temporal, dynamic accuracy of movements and their biomechanical rationality (Ovchinnikov, V.A., 2009). Decrease in coordination abilities has a negative impact on athletic performance enhancement (Botyayev, V.L., 2010).

Maintaining postural balance is of critical importance as one of the components of coordination abilities, the development and improvement of which is necessary in any athlete. Consequently, the inability to maintain postural balance in static and dynamic situations is associated with an insufficient level of coordination abilities.

Thus, a high level of postural control is a necessary condition that determines sports performance. Significant role in maintaining postural balance, especially in rotational movements, belongs to coordination abilities.

However, the conditions for maintaining postural balance, which determines the requirements to coordination abilities, have not yet been determined. Therefore, it is necessary to determine and substantiate each of the structural elements of postural balance, which influence postural control in martial arts.

The aim of the paper was to find the conditions for maintaining postural balance in different sports situations depending on coordination abilities in martial arts athletes.

Materials and methods.

Experimental data were obtained between 2014 and 2021 in Chelyabinsk on the premises of South Ural State University and Ural State University of Physical Culture. The sample included male and female athletes involved in judo, sambo, Greco-Roman and freestyle wrestling, hand-to-hand fighting, mixed martial arts, kickboxing, sports karate, kyokushinkai, boxing, taekwondo with athletic experience of 4 to 15 years.

The assessment of sports performance was carried out using a 100-point scale from a beginner to a world champion (Eganov, A.V., 2021). The level of coordination abilities was measured by a special test with a ten-point scale. Before the test all athletes were provided with instructions on test performance. The example of our assessment scale for the ability to maintain postural balance in a difficult sports situation is given below.

1	2	3	4	5	6	7	8	9	10
low			average				high		

All expert assessments were checked by the trainers. This test meets the metrological requirements for reliability, validity and objectivity. The data obtained were subjected to mathematical and statistical processing. The integral level of coordination abilities was determined by the sum of all indicators characterizing coordination abilities. This test was used to diversify two groups of martial arts athletes aged from 17 to 26 (n=221). The first group consisted of athletes engaged in martial arts with a high level of coordination abilities estimated as 8-10 points.

The second group involved athletes with coordination abilities at a level of 3-6 points. The average level of coordination abilities estimated as 7 points was not taken into account. At the same time, there were no statistically significant differences ($P \geq 0.14-0.90$) between the groups in terms of body length, body weight, age and athletic experience.

The results of the experiment were processed with the Student's t-test for independent samples, which determines the level of significance between the variables of two groups of athletes. In addition, the arithmetic mean (\bar{x}) and standard error of the general population ($\pm m$) were determined. Calculations were carried out using the Microsoft Excel software.

Results and discussion.

The significance of differences between two groups of martial arts athletes is shown in Table 1. It can be seen from the table that athletes with a high level of coordination abilities compared with low-skilled athletes ($t = 2.86-6.58$, $p \leq 0.01-0.001$) have differences in the following indicators: general and special coordination abilities, speed of shifting between movements, dynamic orientation in space, consistency of movements, dynamic transformation of movements, accuracy of dynamic and spatial characteristics, response quickness, dynamic adaptation, timeliness of movements, vestibular static and dynamic performance, improvisation, hand-foot coordination.

Table 1 – The significance of differences between two groups of martial arts athletes ($\bar{x}\pm m$)

Indicator	Level of coordination abilities		t	P
	high (n=103)	low (n=69)		
1. Maintaining postural balance in different conditions	8.66±0.08	5.44±0.15	20.99	≤0.01
2. General coordination abilities	7.52±0.12	6.78±0.15	3.98	≤0.01
3. Special coordination abilities	7.73±0.13	7.11±0.17	2.86	≤0.01
4. Speed of shifting between movements	7.64±0.14	6.67±0.20	4.08	≤0.01
5. Dynamic orientation in space	8.07±0.15	6.99±0.19	4.53	≤0.01
6. Arrangement of movements	7.62±0.14	6.29±0.17	6.14	≤0.01
7. Consistency of movements	7.94±0.13	6.46±0.20	6.63	≤0.01
8. Dynamic transformation of movements	7.93±0.15	6.85±0.19	4.50	≤0.01
9. Accuracy of dynamic and spatial characteristics	8.31±0.15	6.82±0.22	5.78	≤0.01
10. Response quickness	7.96±0.14	6.87±0.18	4.88	≤0.01
11. Dynamic adaptation	7.69±0.14	6.26±0.17	6.58	≤0.01
12. Timeliness of movements	7.69±0.15	6.36±0.18	5.71	≤0.01
13. Vestibular static and dynamic functions	7.82±0.16	6.16±0.23	6.19	≤0.01
14. Improvisation	7.96±0.17	7.07±0.20	3.43	≤0.01
15. Creative thinking	7.74±0.14	6.82±0.18	4.06	≤0.01
16. Hand-foot coordination	7.72±0.13	6.74±0.17	4.67	≤0.01
17. Integral indicator of coordination	317.9±3.8	269.18±4.8	8.08	≤0.01
18. Foot ambidexterity	6.78±0.21	5.57±0.24	3.78	≤0.01
19. Athletic performance, absolute scale	58.29±1.70	52.06±2.46	2.03	≤0.04

Note: $\bar{x}\pm m$ – mean value \pm standard error of the mean; t – two-sample t-test; P – level of significance between groups; \leq – differences between groups are statistically significant; f – the number of degrees of freedom (103+69=172), at f=172, t=1,98, P≤0,05; at t=2,62, P≤0,01.

The revealed differences indicate that the conditions for maintaining postural balance depend on coordination abilities. Consequently, their development will contribute to postural control in martial arts athletes. Similar differences were found by Nagaeva, E.I. et al. (2020) in a group of young karate athletes. The data obtained indicate that karate athletes have effective mechanisms for maintaining postural balance compared to non-athletes. Such changes in the system of postural balance are associated with the features of the training process in karate, when special attention is paid to the development of coordination abilities, proprioceptive sensitivity and motor accuracy.

These patterns are confirmed by a significantly ($t = 8.08$, $p < 0.0001$) higher integral indicator of coordination in a group of highly skilled athletes compared to low-skilled ones. It was also established ($t = 3.78$, $p < 0.001$) that the ability to perform technical actions with both legs was also associated with coordination abilities.

Aydın R, Ersöz G, Özkan A., (2021) studied the correlation between some factors associated with balance. The authors write that the main factors that prevent athletes from maintaining postural balance are connected with the errors associated with angular movements in the leg joints. Moreover, special attention should be paid to the left leg as far as the coordination abilities of the left leg are usually less pronounced. Special attention should be paid to significant differences between the groups in terms of the integral indicator of athletic performance, which turned out to be ($t = 2.03$, $p < 0.04$) higher in the group of athletes with a high level of coordination abilities. Therefore, one of the conditions for improving athletic performance in general is maintaining postural balance, which requires the development of the above mentioned characteristics indicated in the Table.

Conclusion.

In martial arts, an athlete must be able to maintain postural balance and effectively perform technical actions regardless of the body position. Sports performance in martial arts, as well as the ability to maintain postural balance in different sports situations, depends on the level of coordination abilities. The following skills can be considered as of utmost importance for martial arts: general and special coordination abilities, speed of

shifting between movements, dynamic orientation in space, arrangement of movements, consistency of movements, dynamic transformation of movements, accuracy of dynamic and spatial characteristics, response quickness, dynamic adaptation, timeliness of movements, vestibular static and dynamic functions, improvisation, creative thinking, hand-foot coordination, integral indicator of coordination, foot ambidexterity.

The data obtained should be considered as patterns that must be taken into account in sports training. Further research should be aimed at developing training means for maintaining postural balance in difficult sports situations.

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