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Original Article

Biomechanical assessment of statnamic stability of rhythmic gymnasts of the stage of specialized basic training

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Abctract
In rhythmic gymnastics at the stage of specialized basic training, along with a stable demonstration of contest compositions, there are technical mistakes related to an insufficient level of development of sensorimotor coordination, orientation in space and time, statnamic stability of the body. The indicators of the biomechanical analysis of stabilograms while persons under test are fixing the basic balance stands, suggest that stability control is achieved by macro-oscillations, as well as by micro-oscillations of the body, due to the emerging mechanisms of regulation of body positioning in conditional sectors of space, as well as a controlled ratio of the length of the trajectory of the general centre of pressure on a support on frontal and sagittal, which may indicate that athletes have motor and technical capabilities to successfully develop and improve the performance of balance stands of increasing difficulty.
Keywords*: rhythmic gymnastics, body stability, posturography, technique.*

Introduction

The statnamic stability of the gymnast's body and a body system "gymnast-object" is the basis of technical readiness, which has a positive effect on the quality of performance of a contest composition. Given the scientific fact that a person's standing is a special case of movement, sports exercises are considered as statnamic physical actions.

The term "stability" describes one of the most important features of the system's behaviour and is a fundamental concept used in physics, mechanics, biomechanics and other sciences (Lytvynenko Yu., 2016). Scientists consider the static stability of a body as a person's ability to resist every, even the slightest, imbalance. Dynamic stability is the ability of a person to return to the position of balance with the cessation of the effect of forces upsetting the balance of a body upon it. In the literature the importance of developing criteria for assessing the static and dynamic stability of 2 an athlete's body and a body system as global criteria for assessing body balance in sports with a complex coordination structure of moves, including rhythmic gymnastics, has been repeatedly pointed out (Boloban, V., 2005; Viner-Usmanova I. A., 2013). Balances in rhythmic gymnastics are performed under conditions that require a developed skill of retention of stability (Sadowski J., 2012; Shynkaruk O., 2017).

The greatest difficulties are related to one leg balance, requiring active flexibility, special strength, well-developed equilibrioception in the conditions of work with objects (a body system) and changing orientation in space. Recent studies have shown that the highly specialized criteria for the assessment of sports exercises characterizing the statnamic stability of an athlete's body and a body system, include the following: force of limb pressure on a support, N; amplitude of body oscillations, mm; the length of the trajectory of the general centre of pressure of the body (limbs) on a support on frontal and sagittal planes and their ratio, mm, cu; the length of the trajectory of the displacement of point on the body in the region of the sacrum in a system of interacting bodies, mm; frequency of oscillations of a body, Hz; period of body oscillations, s; the ratio of the amplitude and frequency of body oscillations, ≥, ≤; symmetry and asymmetry of regulation of body positioning, mm; time of body balance fixation.

It is known that the indicators of amplitude and frequency of oscillations of the general centre of pressure on a support are of great importance. It has been established that with an increase in the amplitude of oscillations, the stability of a body decreases, that is, the smaller the amplitude of oscillations is, the better the

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stability is, because it decreases the probability that the projection of the general centre of mass of the body at some point passes the edge of the support area of an athlete's body.

This is confirmed by literary data. The systems of the body responsible for controlling movements have a great sensitivity, which allows to solve complex motor tasks at the level of micro-oscillations, and increasing the frequency of oscillations allows to make appropriate adjustments to the nature and structure of a movement in time.

The literature contain the data that indicate that gymnasts, acrobats, divers, etc., including the champions and medal winners of the Olympic Games, world champions, and others, have not only a decrease in the amplitude of oscillations of the general centre of pressure of feet on a support when performing control equilibrium tests, but also a decrease of the frequency (Boloban, V. 2012, 2013; Kovalenko Y.O., 2017).

This indicates a high readiness of the corresponding systems of a body to make timely metered corrections when performing sports exercises. It is important to take into account the length of the trajectory of the general centre of pressure on a support, which is a derivative of amplitude and frequency. In case of a significant amplitude and frequency of oscillations of the general centre of pressure of an athlete on a support, the length will also increase. The shorter this length is, the less mechanical work is performed by an athlete, the movements become more economical. It is also important to take into account the ratio of this indicator in different planes (sagittal and frontal).

When these indicators approach the 1 : 1 ratio (or close to this) the quality of stability control increases. The goal of the research was to assess the indicators of statnamic stability of the body of rhythmic gymnasts by means of posturographic measurement, biomechanical analysis of basic control tests for balance in the structure of the stage of specialized basic training, with the usage of a computer force plate with biological feedback “Stabilan 01-2”.

Materials and methods

The research involved young gymnasts of the Children and Youth Sports School "Avant-garde" of the city of Kyiv, aged 12-15 years (n = 20), having a Candidate Master of Sports category. There was recorded the interaction of young gymnasts with a support, in particular, the movement of the general centre of pressure (GCP) of feet on a support, that is coordinates at different moments in time, reflecting the features of statnamic stability as the basis for analysing and assessing the athlete’s body's oscillating processes (in mm.).

Three basic equilibrium tests were performed: test 1 - vertical stand, feet closed, hands up; test 2 - standing balance, leg back into the splits, grab with one hand, another one is up; test 3 - standing balance on a half toe, leg back into the splits, grab with one hand, another one is up. The tests were recorded during 20 s.

Theoretical analysis and compilation of scientific literature data; methodical and practical experience of coaches participating in the training of gymnasts at the stage of specialized basic training; method of expert assessment with the usage of video analysis of the technique of basic balance performance; force plate “Stabilan 01-2”. Data collection was performed in the gyms’ reception areas where the lead researcher approached and recruited the participants. Participants were given details about the study and the procedure of participation.

Results

The results of the statnamic stability of the body of rhythmic gymnasts of the stage of specialized basic training are presented in table 1, in fig. 1, and described in the text. During the comparative analysis the following indicators were taken into account: the displacement of the general centre of pressure of the feet on a support in the conditional sectors of space (spatial assessment of the body scheme, in mm) of the relative vertical position of a gymnast's body; body oscillations amplitude, mm; the length of the trajectory of the general centre of pressure of the feet of a body on a support in the frontal and sagittal planes and their ratio, mm, c.u.

When recording the basic test 1 - vertical stand, feet closed, hands up, the scatter of displacement indicators in the frontal plane are from - 4.31 mm to 5.07 mm, in the sagittal plane are from -8.29 mm to 8.73 mm; in test 2 - standing balance, leg back into the splits, grab with one hand, another one is up, the scatter of displacement indicators in the frontal plane are from -2.96 mm to 10.36 mm, in the sagittal plane are from - 9.12 to 5.96 mm; in test 3 - standing balance on a half toe, leg back into the splits, grab with one hand, another one is up, the scatter of displacement indicators in the frontal plane are from -10.2 mm to 6.49 mm, , in the sagittal plane are from - 81.4 mm to 48.65 mm .

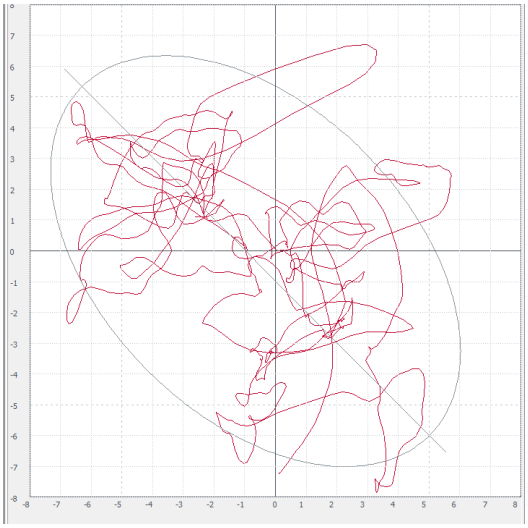
The gymnast E.K. has a frontal displacement of 0.04 mm, and a sagittal one of 0.34 mm. In test 2, the frontal displacement is 2.29 mm, the sagittal one is 0.99 mm. In test 3, the frontal displacement is 6.49 mm, the sagittal one is 14.42 mm. The indicators of the length of the trajectory of the general centre of pressure on the frontal and sagittal of the athletes are as follows: test 1 - 165.8; 151.6 mm; test 2 - 798.7; 886.9 mm; test 3 - 765; 942.4 mm.

Table 1. Indicators of statnamic stability of the bodies of the Candidates Master of Sports in rhythmic gymnastics of the stage of specialized basic training, when performing basic balances (n = 10)

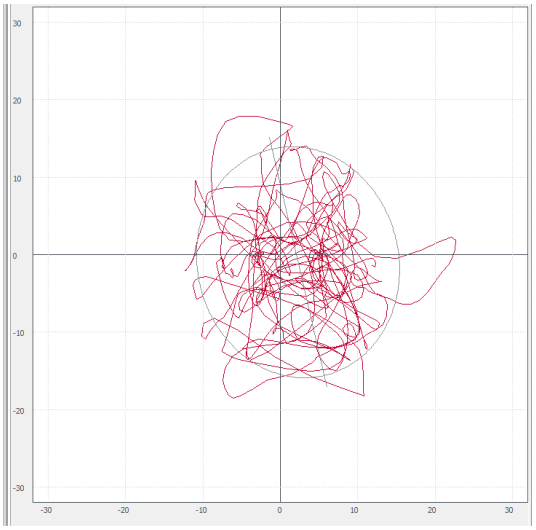
No.	Athletes	Values of posturographic indicators (mm)											
		Test 1				Test 2				Test 3			
		1	2	3	4	1	2	3	4	1	2	3	4
1	K.M.	1,44	-0,56	154,5	168,7	-0,7	-6,94	563,8	593,5	-5,6	24,8	455	650
2	M.M	-0,15	-8,29	172,8	185,2	1,27	-9,12	702,2	942,1	-1,81	28,69	755,9	592,8
3	T.M.	-2,56	-5,05	120,6	172,1	-2,96	5,96	841	794,8	-1,26	19,69	528,8	782,9
4	E.Ie.	1,41	7,45	224	203,9	3,46	3,87	925,8	908,5	1,36	48,65	896,2	773,8
5	K.A.	-0,89	1,77	166,3	182,3	0,13	-6	649,9	621,6	3,27	1,56	525,6	478,2
6	E.K.	-0,04	-0,34	165,8	151,6	2,29	-0,99	798,7	886,9	6,49	14,42	765,1	942,4
7	S.S.	5,07	-0,71	217,9	259,7	10,36	1,92	835,9	957.8	3,81	41,53	1014,3	963,3
8	K.A.	1,46	-0,16	212	245,2	8,03	-0,27	744	866	-10,2	-81,4	967,7	1086,5
9	B.A.	1,14	5,41	205	178,9	-0,56	-8,64	1107	1108	-6,61	32,02	54,5	78,4
10	A.D.	-4,31	8,73	246,6	290,8	-2,01	2,86	1081	962,5	-7,76	42,44	440,1	814,1

Notes: *Test 1 - vertical stand, feet closed, hands up; Test 2 - standing balance, leg back into the splits, grab with one hand, another one is up; Test 3 - standing balance on a half toe, leg back into the splits, grab with one hand, another one is up. 1 - Frontal displacement; 2 - Sagittal displacement; 3 - The length of the trajectory of the general centre of pressure on a support in the frontal plane; 4 - The length of the trajectory of the general centre of pressure on a support in the sagittal plane

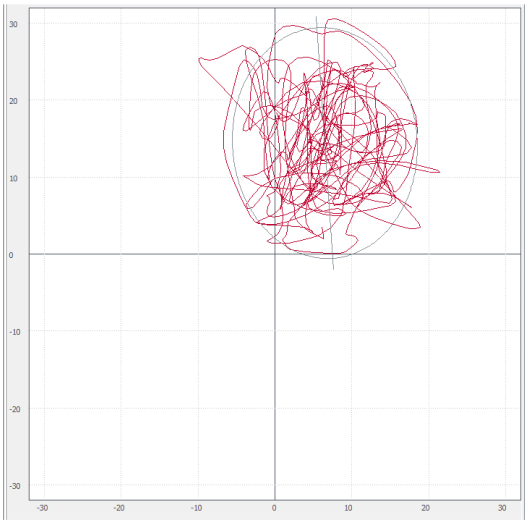
With the increase of difficulty of the test, the gymnast searched for “comfortable” sectors of space, both in the body scheme and on the supporting surface of the force plate. Comparative analysis has shown positive dynamics of indicators; in test 1, the indicators of frontal and sagittal displacements were 4 times reduced, the indicators of the length of the trajectory of the general centre of pressure on a support on frontal and sagittal planes were halved. In test 2, the indicators are saved. Test 3 in the second experiment was more complicated due to the fact that the gymnasts performed the equilibrium on a half toe and the indicators were averaged. The indicators of the length of the trajectory of the general centre of pressure are mainly located in the front-right conditional sector. The gymnast maintained stability consistently during 20 s (fig. 1).



Test 1



Test 2



Test 3

Figure 1. The indicators of stabilograms of the general centre of pressure of the feet on a support while the gymnast E.K. was maintaining statnamic stability in the process of performing basic tests 1,2,3, on balance

Note: Test 1 - vertical stand, feet closed, hands up; Test 2 - standing balance, leg back into the splits, grab with one hand, another one is up; Test 3 - standing balance on a half toe, leg back into the splits, grab with one hand, another one is up

Discussion

The analysis of the research and methodological literature, of the experience of coaches, and of the results of the participation of rhythmic gymnasts in sports competitions has shown that, along with a stable demonstration of good and excellent contest compositions by the gymnasts aged 10-14 years old, there are some problems and technical errors: during the preliminary basic and specialized basic training the accelerated athletic training of gymnasts is carried out, the acquired skills of sensorimotor coordination and agility are implemented ineffectively in competitive programs, the defects of controlling statnamic stability of a body (statnamic stability of a body) in the process of performing exercises without and with objects are revealed.

Conclusion

The indicators of biomechanical analysis of stabilograms, while recording basic balance tests, indicate that statnamic stability management is achieved due to the emerging mechanisms of body posture regulation in conditional sectors of space (central, front-left, front-right) and due to the controlled ratio of the length of the trajectory of the general centre of pressure on a support on frontal and sagittal, which may indicate that athletes have motor and technical capabilities to successfully develop and improve the performance of balance stands of increasing difficulty.

There have been recorded technical errors in the management of body stability, caused by insufficiently formed motor skills and those of the regulation of posture in the process of moving the body backwards (in the back-left and back-right conditional sectors of space). Managing stability in the process of leaning backward, performing various body movements in leaning backward is one of the most meaningful, spectacular, but also difficult motor actions in the contest composition of a female athlete.

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