Ann Appl Sport Sci, 11(04): e1202, 2023.
http://www.aassjournal.com; e-ISSN: 2322–4479; p-ISSN: 2476–4981. 10.61186/aassjournal.1202

ORIGINAL ARTICLE

The Comparison of Postural Control in Pole Vaulters of Different Skill Levels

[1]Maria A. Gapicheva*, **[1]Anna V. Nenasheva**, **[2]Seyed Morteza Tayebi**

[1]Theory and Methods of Physical Education and Sport Department, the Institute of Sports, Tourism, and Service, South Ural State University (National Research University), Chelyabinsk, Russia. [2]Department of Exercise Physiology, Faculty of Sports Sciences, Allameh Tabataba'i University, Tehran, Iran.

Submitted March 22, 2023; Accepted in final form May 20, 2023.

ABSTRACT

Background. Individual qualities of posture control are crucial to success in many modern complex coordination sports disciplines. The data of the stabilometric test allows you to effectively monitor violations of the statokinetic stability appropriate adjustments to the individual training system. **Objectives.** The purpose of the study is to identify the relationship between the indicators of the statokinetic stability of athletes and their results. **Methods.** The jumpers were divided into two groups, the participants of one group had personal achievements in the pole vault from 3.20 to 4.20 meters, and the participants of the second group from 4.60 to 6.00 meters. Postural control was evaluated using the stabilographic hardware and software complex MBN "Stabilo" (Russia). **Results.** In our study, there were no statistically significant differences between the groups. However, we can observe a shift in the general center of pressure with the growth of sportsmanship in the frontal plane X (to the right) and the sagittal plane Y (forward) with open and closed eyes. **Conclusion.** The analysis of the indicators of statokinetic stability in athletes of various skill levels specializing in pole vaulting confirms that the speed of the general center of pressure of athletes of higher qualification is lower in all the positions considered, which indicates a better ability to maintain their postural stability and a more developed proprioceptive analyzer. In this study, we did not identify critical pathologies, and the results were within the normal range for healthy people.

KEYWORDS: ***Stabilometry, Postural Balance, Coordination, Technical Readiness, Pole Vaulters, Track and Field, Adaptation.***

INTRODUCTION

Stabilometry is a method of recording the projection of the total center of mass of the body on the plane of the support and fluctuations in the standing position of the subject, as well as when performing various diagnostic tests. (1-4). The force platform allows you to evaluate the control of the pose in the projection on the horizontal plane. At the same time, significant deviations often indicate a violation of the functionality of the musculoskeletal system or the system of coordination of movements (5-9). The data of the stabilometric test and its analysis make it possible to effectively monitor such violations and make appropriate adjustments to the individual training system (10, 11). Stabilometric indicators are quite significant for studies related to the age and skills of individual athletes (5, 12, 13).

Individual qualities of postural control and skills, both static and dynamic (especially movement correction and combination of skills) - are crucial for success in many modern coordination sports disciplines (5, 14). In track

*. Corresponding Author:
Maria A. Gapicheva, Ph.D.
E-mail: m.gapicheva@mail.ru

and field, the skills of vestibular balance are formed mainly in connection with the competitive activity in a particular form, and the period of sports. Testing athletes with their eyes closed showed that an athlete's balance and coordination abilities depend on their skills. The higher the skills and experience - the better the vestibular balance in the test (5).

L. V. Kapilevich, studying the physiological control of the technical readiness of athletes, concluded that regardless of the specialization, highly qualified athletes are better able to maintain balance when performing basic movements: "The growth of technical skill is expressed in a decrease in the vector indicators of the stabilogram, the values of deviation and the speed of movement" (13). The relationship between the growth of athletic performance and postural stability in pole vaulters was not considered earlier, this was the basis for our study. As the athletic performance of pole vaulters increases, the indicators of statokinetic stability will improve. The purpose of the study is to identify the relationship between the performance of athletes and their results.

MATERIALS AND METHODS

The study was conducted on the premises of the Research Center for Sports Science of South Ural State University (National Research University). Examination of athletes was carried out in the general preparatory period of preparation for competitions. Fourteen male jumpers aged 16 to 25 divided into two groups were examined. The participants of the first group had personal achievements in the pole vault from 3.20 to 4.20 meters, and the participants of the second group from 4.60 to 6.00 meters. At all stages of the study, the participants were previously acquainted with the algorithm of the procedure. The organization of the study was regulated by the protocol of the Council of Europe Convention on Human Rights and Biomedicine (1999) and the Helsinki Declaration of the World Medical Association (2013 edition). Before the study, the participants' informed consent was obtained.

The study was performed using the stabilographic hardware and software complex MBN "Stabilo" (Russia). The study was conducted in the "European" setting, each position was recorded for 30 seconds. The stability of the pose was evaluated in six positions: "European" setting (E. S.) eyes open; E. S. eyes open, head turning to the left; E. S., head turning to the right; E. S., eyes closed; E. S. eyes closed, head turned to the left; E. S. eyes closed, head turned to the right. The independent t-test was used to compare the dependent variables between groups. Statistical significance was established when $p < 0.05$.

RESULTS

When adequately assessing the indicators of postural stability, it is necessary to take into account the actual size of the human body. The size of the support surface (size of the foot), is also important, as well as the distance between the main joints and the distance between both upper anterior iliac spines (interosseous size) (15-17). These data for the two groups are presented in Table 1. Table 1 shows the calculation of the Romberg coefficient, QR (%) for both groups.

The results of the study of the indicators of statokinetic stability in athletes of various skill levels, specializing in pole vaulting, in the position of the E. S. with closed eyes and open eyes, are presented in Table 2. The results of the study of the indicators of statokinetic stability of pole vaulters of various skill levels, in the position of the E. S., with the head turned to the left with closed and open eyes are presented in Table 3 and turned to the right with closed and open eyes are presented in Table 4.

Table 1. Anthropometric indicators, Romberg coefficient of the studied groups

Indicator	I (n = 7)	II (n = 7)	P
Body length (mm)	1859 ± 21	1863 ± 12	> 0.05
Foot length (mm)	275 ± 4	271± 3	> 0.05
Ankle-toe distance (mm)	225 ± 7	220 ± 5	> 0.05
Foot width (mm)	104 ± 5	97 ± 5	> 0.05
Interosseous size (mm)	268 ± 7	270 ± 5	> 0.05
Romberg coefficient, QR (%)	214 ± 42	179 ± 70	> 0.05

*Note:** – $p < 0.05$ reliability of measurements of the results of the first group relative to the second.

DISCUSSION

The data presented in Table 1 illustrate that the anthropometric data of the two groups are not statistically significant. The indicators of the first and second groups are within the normal range for healthy people (9, 18). The average Romberg coefficient in the group of athletes with results of 3.20 to 4.20 is 35% more than in athletes of a higher class. This suggests a greater influence of the proprioceptive system in maintaining balance in the strongest pole vaulters.

Table 2. Indicators of statokinetic stability of groups in the main stance with open and closed eyes

Indicator	Eyes open		Eyes close	
	I (n = 7)	II (n = 7)	I (n = 7)	II (n = 7)
The standard deviation of the COP in the frontal plane, mm	15.08 ± 5.12	31.85 ±16.5	23.75 ± 7.05	33.86 ± 14.34
The standard deviation of the COP in the sagittal plane, mm	20.28 ±5.01	36.18 ± 18.45	30.77 ±11.46	42.68 ±17.14
COP speed, V (mm/s)	18.72 ± 2.81	18.16 ± 3.34	31.45 ± 7.48	26.61± 2.44
Statokinesiogram area, mm^2	229.74 ±56.61	337.9 ±106.6	543.13±216.19	367.27± 71.57
Stability indicator, %	89.28± 2.05	88.82 ±1.87	86.19± 3.04	87.45± 1.15
Stability index, (un)	24.31± 4.2	25.43 ±3.84	16.33± 3.33	15.63± 1.27
The dynamic component of balance, (un)	65.81 ± 9.36	74.57± 3.84	83.67± 3.33	84.37 ±1.27
P	> 0.05	> 0.05	> 0.05	> 0.05

*Note:*COP - the center of pressure.

Table 3. Indicators of statokinetic stability of groups in the main stance with head turn to the left, with open and closed eyes

Indicator	Eyes open		Eyes close	
	I (n = 7)	II (n = 7)	I (n = 7)	II (n = 7)
The standard deviation of the COP in the frontal plane, mm	30.11 ± 24.82	23.97± 9.26	41.18 ±15.12	29.14 ±10.87
The standard deviation of the COP in the sagittal plane, mm	24.82 ±10.64	25.12 ±13.89	30. 91 ±14.58	23.28 ±6.18
COP speed, V (mm/s)	22.85 ± 3.8	17.35± 3.1	30.21± 8.74	23.31± 1.55
P	> 0.05	> 0.05	> 0.05	> 0.05

Table 4. Indicators of statokinetic stability of groups in the main stance with head turning to the right with open and closed eyes

Indicator	Eyes open		Eyes close	
	I (n = 7)	II (n = 7)	I (n = 7)	II (n = 7)
The standard deviation of the COP in the frontal plane, mm	49.45 ± 29.95	25.99 ±11.86	34.62 ± 10.87	27.77 ± 10
The standard deviation of the COP in the sagittal plane, mm	33.16 ± 17.98	30.72 ±12.11	53.18 ± 6.18	36.74 ± 14.28
COP speed, V (mm/s)	22.05 ± 4.04	20.23 ± 2.42	36.24 ± 1.55	25.74 ± 2.15
P	> 0.05	> 0.05	> 0.05	> 0.05

As can be seen from Table 2, there were no statistical differences between the values shown in the two groups in the E. S. with open and closed eyes. But we can observe a shift in the general center of pressure with an increase in sports skill in the frontal plane x (to the right) by 16.77 mm with the eyes open, and by 10.11 mm with the eyes closed. There is also a shift in the general center of pressure in the sagittal plane y (forward) by 15.9 mm open eyes, and 11.91 mm eyes closed. Based on the results of a study of postural balance in middle-distance athletes (8), as well as the formation of the functional sports adaptation of the skeletal system of pole vaulters that we identified earlier: "Jumpers form a functional sports adaptation, as a result of which, there is a forward tilt of the projection of the cervical spine, as well as a forward tilt of the projection of the lumbar spine and a turn of the pelvis to the right in the sagittal plane" (19). So, a specific asymmetric load during a long period of training and competitive activity affects the movement of the projection of the general center of pressure to the right forward.

The speed of the general center of pressure with closed eyes was lower by 4.84 mm/s in athletes of higher qualification. The area of the statokinesiogram with open eyes was larger in the athletes of the first group. But with the eyes closed, this indicator was higher in the second group. The stability indicators, the stability index, and the dynamic component of the balance component were very similar in both groups.

Table 3 shows that the performance of athletes in the E. S. with the head turned to the left, with their eyes open and eyes close, did not have statistically significant differences. However, the standard deviation of the general center of pressure in the frontal and sagittal planes, in highly qualified athletes, is less, by 6.14 mm and 12.04 mm, respectively. The rate of the general center of pressure in the stronger group was also lower, in the positions of open eyes and closed eyes.

In Table 4, the performance of athletes in the E. S. with the head turned to the right, with open and closed eyes, also had no statistically significant differences. The tendency that the standard deviation of the general center of pressure in the frontal sagittal planes is less in athletes of higher qualification is confirmed in this position, by 23.46 mm and 6.85 mm in the frontal and sagittal planes, respectively. The rate of general center of pressure in the stronger group was also lower, in the positions of open eyes and closed eyes. The stability indicators, the stability index, and the dynamic balance component when turning the head to the left and the right, as in the E. S., had very similar values in both groups.

CONCLUSION

The analysis of statokinetic stability indicators in track and field athletes of different skill levels specializing in pole vaulting did not reveal statistically significant differences in the indicators of the two groups. However, the speed of the general center of pressure of athletes of higher qualification is lower in all the positions considered, which indicates a better ability to maintain their postural stability and a more developed proprioceptive analyzer. Thus, the hypothesis put forward by us is confirmed. In addition, the results confirm previous studies that consider the improvement of vestibular balance in connection with the growth of skills and experience of the athletes.

It should be noted that the general center of pressure shifts with the growth of sportsmanship in the frontal plane X (to the right) and the sagittal plane Y (forward) in the main stand with open and closed eyes. We consider that a specific asymmetric load during a long period of training and competitive activity affects the movement of the projection of the pressure center point to the right-forward-the formation of functional sports adaptation.

The stability indicators, the stability index, and the dynamic balance component were very close in terms of values in both groups, which means that these data do not correlate with the growth of the athletic skills of the pole vaulters. In this study, we did not identify critical pathologies, the results obtained were within the limits of the physiological norm for healthy people. Further research will help to expand the understanding of the specific adaptive mechanisms in pole vaulters.

APPLICABLE REMARKS

- The results obtained can be used by coaches to understand the level of fitness of athletes and to regulate the complex coordination load.
- The results can also be useful for research in the field of physiology when working with force platforms since they indicate the parameters that characterize the degree of development of the vestibular apparatus.

ACKNOWLEDGMENTS

The authors thank Ksenia Andreevna Naumova, translator, and junior researcher at the Center for Sports Science SUSU, for her help in preparing the article.

AUTHORS' CONTRIBUTIONS

Study concept and design: Maria A. Gapicheva. Acquisition of data: Maria A. Gapicheva. Analysis and interpretation of data: Maria A. Gapicheva. Drafting the manuscript: Maria A. Gapicheva. Critical revision of the manuscript for important intellectual content: Anna V. Nenasheva. Statistical analysis: Maria A. Gapicheva. Administrative, technical, and material support: Seyed Morteza Tayebi. Study supervision: Anna V. Nenasheva.

CONFLICT OF INTEREST

The authors claim that there is no known conflict of interest.

REFERENCES

1. Vitenzon A.S. D.V. Skvortsov. [Diagnostics of movement pathology with instrumental methods: an analysis of gait, stabilometry M. 2007; 640] Журнал неврологии и психиатрии им. С.С. Корсакова. Москва. 2009; 109 (1), 92. Russian
2. [Posturographic express diagnostics in vestibulology] Luchihin L.A., Skvorcov D.V., Kononova N.A. Вестник оториноларингологии. 2006; (1), 13-17. Russian
3. Some approaches for stabilometry and posture biofeedback training Skvortsov D.V., Nekrasova T.S., Alekseev I.G., Svirida D.N. Gait & Posture. 1999; 9 (1), 47.
4. Gait and posture in patients with low back pain compare with clinical form Skvortsov D.V., Larina V.N. Gait & Posture. 1995; 3 (2), 85. [doi:10.1016/0966-6362(95)93463-M]
5. T.V. Krasnoperova, N.B. Kotelevskaya, T.F. Abramova, Physiological value of stabilometric studies in complex coordination sports. Theory and Practice of Physical Culture. 2020; 7, 56-58.
6. Comparative analysis of vertical posture control in athletes differing in expertise Melnikov A.A., Savin A.A., Emelyanova L.V., Nikolaev R.Y., Vikulov A.D. Human Physiology. 2011; 37 (5), 615-620. [doi:10.1134/S036211971105015X]
7. Murphy, D. F. Connolly D.A.J., Beynnon B.D. Risk factors for lower extremity injury: a review of the literature. Br. J. Sports. Med. 2003; 37, 13–29. [doi:10.1136/bjsm.37.1.13] [PMid:12547739]
8. Postural balance in middle-distance runners V.V. Epishev, K.E. Ryabina, A.P. Isaev, V.V. Erlikh Russian Journal of Biomechanics. 2017; 21 (2) 166–177.
9. Effect of postural balance on changes in the electrocardiography parameters of wrestlerse V.V. Erlikh, Yu.B. Korableva, V.V. Epishev, O. Polyakova Human. Sport. Medicine. 2018; 18 (S); 13–18. [doi:10.14529/hsm18s02]
10. The role of visual information in maintaining postural stability after the maximum exercise for the upper and lower limb muscles Melnikov A.A., Vikulov A.D., Nikolaev R.Y. Human Physiology. 2016; 42 (4), 385-391. [doi:10.1134/S0362119716030117]
11. Semchenko A. A. Influence of long-term movement specialization in hurdling on the biokinematic parameters of normal statics of the locomotor system / A. A. Semchenko, A. V. Nenasheva // Human. Sport. Medicine. 2017; 17 (S), 66–72. [doi:10.14529/hsm17s07]
12. Functional condition of athletes with various indicators of quality function balance Bykov E.V., Kuzikov M.M., Zinurova N.G., Denisov K.G. South Ural state university Journal. 2012; 21 (22-25).
13. Kapilevich L. V. [Physiological control of technical readiness of athletes] Theory and practice of physical culture. Москва. 2010; 11, 12-15. Russian
14. Semchenko A. A. Tendency of changes in exercise tolerance in hurdlers at different stages of training and competitive conditioning. A. A. Semchenko, A. V. Nenasheva. Human. Sport. Medicine. 2017; 17, (2), 89–93. [doi:10.14529/hsm170209]
15. Sensorimotor reactions in psychophysiological studies (a review). Nekhoroshkova A.N., Gribanov A.V., Deputat I.S. Brazilian Journal of Medical and Biological Research. 2015; 1, 38. [doi:10.17238/issn2308-3174.2015.1.38]
16. Nashner L. M. Analysis of stance posture in humans. Handbook of Behavioral Neurobiology. Vol. 5. Motor Coordination. New York, 1981; 5, 527–565. [doi:10.1007/978-1-4684-3884-0_10]
17. Winter D. A. Biomechanics and Motor Control of Human Movement, 4th Edition N.Y.John Wiley Hoboken, 2009. – 384 p. [doi:10.1002/9780470549148]
18. The dynamic effect of trx training on the morphofunctional status of female students. K.Yu. Lobastova, E.V. Zadorina, Ya.A. Plotnikova. Human. Sport. Medicine. 2021; 21, (1), 29–37.
19. Features of the spatial position of the spine in pole vaulters. M.A. Gapicheva, A.A. Pletnev, A.S. Ushakov. Human. Sport. Medicine 2020, 20, (S2), 20–25.