J Biochem Technol (2021) 12(4): 94-98
https://doi.org/10.51847/bnyZig6kjI
ISSN: 0974-2328

The Function of Maintaining Body Balance in Students Involved in Various Sports

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Received: 06 August 2021 / Received in revised form: 05 December 2021, Accepted: 12 December 2021, Published online: 19 December 2021

Abstract

The vital activity of any organism is inevitably associated with the impact of many negative environmental factors on it that can impair its function. Eachreaction of the body to influence from the outside is accompanied by a specific reaction of its vegetative structures and muscles, contributing to the maintenance of homeostasis. Successful sports performance requires an impeccable ability to maintain body balance for a long time. Doing different types of sports, to varying degrees, develops the function of maintaining body balance in trainees. This is especially noticeable in case of shoulder girdle muscular fatigue, even as a result of short intense physical activity. For athletes in various sports, there have long been differences in ensuring that the body maintenancebalance in space after short muscular loads. The statokinetic stability of basketball players and gymnasts is higher than that of tennis players. This was indicated by the lower dynamics of their stabilographic characteristics after a power load, which characterizes the maintenance of body balance. People with low physical fitness are much inferior to athletes in their ability to maintain body balance in space. This is due to the fact that untrained individuals have weak mechanisms for restraining the onset of fatigue. In addition, they have small functional reserves of the organs of autonomic support of life, which additionally weakens the statokinetic stability.

Keywords: Gymnasts, Tennis players, Basketball players, Statokinetic stability, Muscle activity

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Introduction

The vital activity of any organism is inevitably associated with the impact on it of many negative environmental factors that can impair its functioning (Glagoleva & Medvedev, 2020; Glamazdin *et al.*, 2021). Each reaction of the body to the influence from the outside is accompanied by a certain reaction of its vegetative structures and muscles, contributing to the maintenance of homeostasis (Amelina & Medvedev, 2009; Bespalov *et al*., 2018b; Moubarez *et al*., 2019; Amiri *et al*., 2020). The leading role in this process is played by maintaining the position of the body in space, as well as maintaining the optimum biochemical and physiological processes occurring in all cells of the body (Karpov *et al*., 2018; Makhov & Medvedev, 2018a). The function of maintaining body balance in the environment is of great importance for successful sports activity (Vuillerme & Boisgontier, 2008). This function is very important in the practice of training performances of any athlete, regardless of his sports specialization and skill level (Makhov & Medvedev, 2018b).

It becomes clear that to maintain balance, a person needs optimal work, proprioceptive, vestibular, and visual mechanisms of interaction with external the world, integrated by the nervous system. The development of fatigue of each of these mechanisms reduces the overall stability of the body (Taylor & Gandevia, 2008).

For successful sports activity, it is especially important to maintain body balance in conditions of muscle fatigue development (Bespalov *et al.*, 2018a). At the same time, human stability inevitably deteriorates under conditions of general (Karpov *et al*., 2020) and local (Skoryatina & Medvedev, 2019) physical activity. The increase in the severity of fatigue leads to a decrease in the stability of the body in space due to the gradual weakening of the function of maintaining the balance of the body (Pinsault & Vuillerme, 2008; Makurina *et al*., 2020). At the same time, the peculiarities of the influence of physical fatigue against the background of a power load on the muscles that retain the stability of the body in representatives of different sports specializations have not been fully studied and require clarification (Raspopova *et al*., 2020).

Purpose of the work: To assess the ability to maintain body balance among young athletes involved in basketball, gymnastics, and tennis in conditions of fatigue of the shoulder girdle muscles.

Materials and Methods

The study was carried out on 67 completely healthy young men-athletes with a sports qualification not lower than the first adult sports category (average age 20.1±0.7 years). In the work, 24 basketball players, 21 gymnasts, and 22 tennis players were examined. The control group consisted of 32 completely healthy male volunteers (mean age 19.8±0.8 years), who had not been involved in sports in their lives.

The possibilities to maintain an optimum balance were found out using the stabilographic device "Stabilan 01-2" (made by Ritm, Russia). Oscillations in the center of pressure were recorded with this device. The success of maintaining body balance was assessed at baseline and after exercise. All subjects underwent the Romberg test in a state with open eyes for 52 seconds. After that, the subjects did push-ups in the supine position thirty times for 30 seconds. At the end of the exercise, the subjects were immediately placed on the surface of the stabilographic platform and passed the Romberg test with their eyes open. The values obtained in the Romberg test before exercise were compared with the level of this indicator after it.

The state of the function of maintaining the stability of the body was assessed by finding out some stabilographic parameters characterizing the fluctuations of the center of the exerted pressure: QX, mm - latitude of indicators in the frontal plane; QY, mm - the difference in parameters in the sagittal plane; VCP, mm / sec - the value of the linear average rate of dynamic change in the position of the center of pressure; SELLS, mm^2 is the area of the statokinesiological confidence ellipse; VS, mm^2/s - the rate of change in the size of the statokinesigram area; KFR,% - the quality of the function of the maintained equilibrium.

All the results of the study performed are presented as the arithmetic mean (M) ± the error of the mean (m). The statistical significance of the differences between the observed groups was determined by determining the Student's t-test.

Results and Discussion

During the Romberg test without physical activity, the main stabilographic characteristics, which made it possible to determine the state of the balance function in representatives of different sports, did not differ **(Figures 1-5)**. The absence of statistical differences in the leading stabilographic parameters among gymnasts, tennis players, and basketball players should be associated with the obvious non-specificity of this research method, which does not reveal the features of the parameters of maintaining body balance during any training and competition.

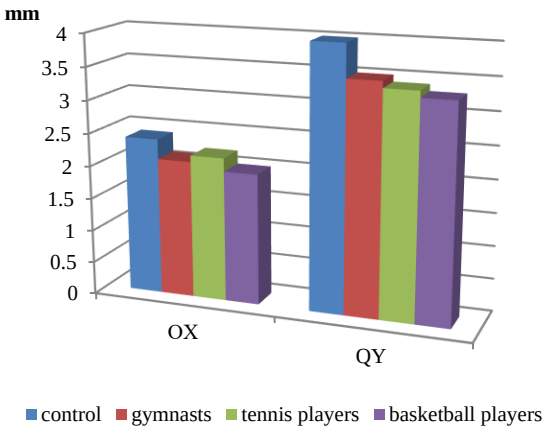

Figure 1. Scatter of the values of the oscillation values of the center of pressure in the frontal and sagittal planes without power load

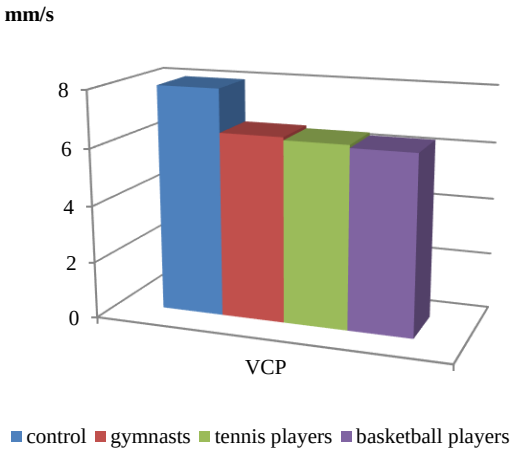

Figure 2. Levels of the linear average velocity of the center of pressure oscillation without power load

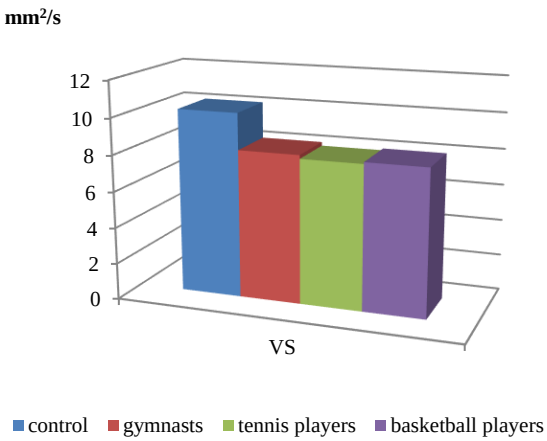

Figure 3. Dynamics of the area of the statokinesigram without power load

A high level of stabilographic characteristics: QY, VCP, SELLS, and a slightly reduced value of the integral parameter "quality of the equilibrium function" were noted in representatives of the control group. This indicates their lower ability to maintain the body in an upright position compared to athletes of any specialization **(Figures 1-5)**.

In the opinion of earlier researchers, physical load and sensory load affect body balance due to a pronounced contribution in this process of the work of the visual and vestibular analyzers (Nazarenko *et al*., 2014; Mal *et al*., 2018a) and the processing of information by the sensory zones of the brain, primarily from muscles, joints, and bones (Mal *et al*., 2018b; Medvedev, 2018a).

In the course of the study performed against the background of physical fatigue of the shoulder girdle of all examined, there was a change in the recorded stabilographic characteristics, leading to a decrease in the level of the integral value "quality of the equilibrium function". The onset of physical activity inevitably increases the activity of the cardiorespiratory system, contributing to the rationalization of blood flow and increased tissue trophism (Medvedev, 2021; Makhov & Medvedev, 2021). Undoubtedly, this affects the fluctuation of the center of pressure (Makhov & Medvedev, 2019) and the efficiency of maintaining the balance of the whole body (Medvedev, 2018c; Makhov & Medvedev, 2018d).

It is believed that the development of pronounced muscle fatigue in any part of the body affects the implementation of central integration, the analysis of sensory information entering the brain, and also weakens proprioceptive reception in the muscles that provide the vertical posture of a person (Medvedev, 2018e; Makhov & Medvedev, 2020a). It is known that the development of physical fatigue phenomena inhibits the process of proprioceptive impulses from tired muscles, contributing to a decrease in the level of general somatic stability (Vorobyeva & Medvedev, 2019; Makhov & Medvedev, 2020b). When basketball players and gymnasts were compared, no statistically significant differences in recorded stabilographic characteristics were found after the test muscular activity. The intensity of the increase in the VCP, SELLS indices and the severity of the decrease in the value of the "quality of the balance function" during the test physical fatigue in tennis players were higher than in basketball players and gymnasts **(Table 1)**. This can be explained by the fact that the sports actions of tennis players mainly include a set of standard movements with a small force load on the limbs and a low level of training of the autonomic nervous system (Medvedev, 2018b). The use of test physical activity in tennis players led to more significant physical fatigue in the autonomic nervous system and the muscles of the upper extremities and shoulder girdle (Makhov & Medvedev, 2018c). This contributed to a more pronounced fluctuation of the center of pressure in tennis players against the background of physical fatigue and a weakening of the ability to maintain general body balance (Medvedev, 2018d; Mal *et al*., 2020).

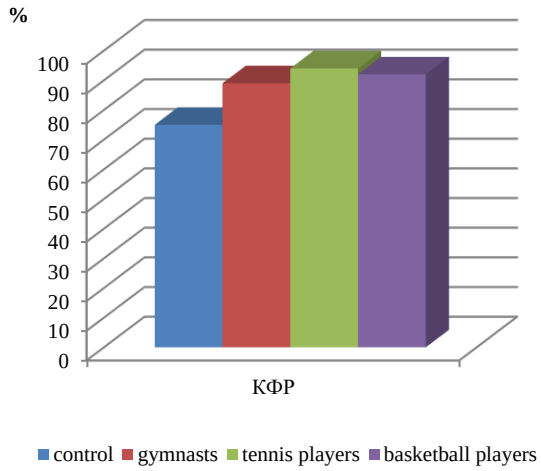

Figure 4. Quality of the balance function without power load

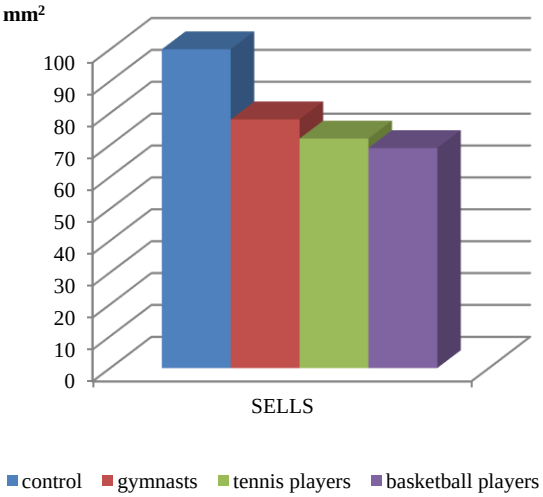

Figure 5. Area of confidence statokinesigraphic ellipse without sludge load

Table 1. Indicators of the function of maintaining the balance of the body against the background of a power load

Stabilographic indicators	control, n=32	gymnasts, n=21	tennis players, n=22	basketball players, n=24
Q_X, mm	1.36±0.39	0.91±0.42**++	1.29±0.44	0.94±0.35**++
Q_Y, mm	1.94±0.87	1.32±0.41**++	1.57±0.36*	1.45±0.58**+
V_{CP}, mm/s	7.75±1.52	3.49±1.37**++	4.62±1.46**	3.37±1.48**++
V_S, mm^2/s	7.62±2.92	4.38±1.86**++	5.52±2.27**	4.42±2.46**++

S_{ELLS}, mm^2	135.94±9.75	62.20±14.18**++	84.34±10.44**	59.33±10.26**++
The quality of the balance function, %	-7.32±2.40	-3.36±2.23**++	-5.29±2.24**	-3.24±1.97**++

Note. The statistical significance of the differences between the control and the level of indicators in the observed athletes: * –p <0.05, ** - p <0.01. Significance of differences between the parameters of gymnasts and basketball players from the parameters of tennis players: + p <0.05, ++ - p <0.01.

In persons with low physical fitness, the recorded indicators of body balance with the development of muscle fatigue turned out to be higher than in athletes. This was indicated by the values of their VCP, VS, SELLS indicators, and the quality of the equilibrium function. These differences were based on the more pronounced fatigue in the control of the vegetative part of the nervous system and muscles under load conditions due to the greater accumulation of lactic acid in them, which lowers the level of receptor sensitivity and inhibits impulse from receptors to the subcortex and cerebral cortex (Boldov *et al*., 2018; Stepanova *et al.*, 2018).

Conclusion

The ability to maintain body balance can be significantly impaired with the development of shoulder fatigue, even as a result of short intense physical activity. In athletes of different sports specializations, differences are recorded in ensuring the maintenance of body balance in space after short muscular loads. The state of statokinetic stability of basketball players and gymnasts is higher than that of tennis players. This was indicated by the lower dynamics of their stabilographic characteristics after a power load, which assessed the degree of preservation of body balance. Persons with low physical fitness are significantly inferior to athletes in their ability to maintain body balance in space. This is because untrained persons have less developed mechanisms for restraining the onset of fatigue and small functional reserves of the organs of vegetative support of life.

Acknowledgments: The team of authors thanks to the administration of the Russian State Social University for the opportunity to research its basis.

Conflict of interest: None

Financial support: None

Ethics statement: The study was approved by the local ethics committee of the Russian State Social University on September 15, 2018 (protocol №11).

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