INFLUENCE OF VESTIBULAR IRRITATION ON STABILOMETRIC INDICATORS OF STATOKINETIC STABILITY OF FOOTBALL PLAYERS

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Abstract. The dynamics of stabilometric indicators of players and non-athletes is considered. It is shown that in the Romberg sample with eyes open and closed disparities in maintaining the balance between players and non-athletes are practically not detected. The most significant shifts of the stabilometric performance we observed in the vestibular stimulation in the Romberg sample with eyes open, which is significantly less than that of the players.

Key words: statokinetic stability, stabilometric indicators, vestibular sensory system, the body's equilibrium, athletes

Introduction

The specific character of motor activity in situational sports, which include football, involves complex coordination of movement programmed by higher parts of the central nervous system and implemented by the muscular system in the interaction of visual, vestibular, proprioceptive and tactile sensory systems forming the functional statokinetic system. Characteristic features of football are the variable power conjugated with constant changes in the structure and the direction of motor actions, as well as the variability of situations, combined with the lack of time. All this leads to the development of fatigue that in situational sports affects primarily on reducing of the vestibular stability (Nazarenko and Chinkin 2011), in the violation of the differentiation of the fine movements, in the mismatching of regulatory mechanisms and the speed of motor responses.

The aim is to study the effect of load on the vestibular stabilometric statokinetic stability of indicators in football.

Methods and the organization of the research

The investigations were carried out on the basis of the research laboratory of the Department of Medical and Biological Sciences of Volga Region State Academy of Physical Culture, Sports and Tourism. The study involved

24 male persons, 12 of whom are involved in football (the football club “Rubin”, Kazan) and have athletic skills of a candidate master to master of sports of Russia. The control group consisted of students not involved in sports (12 people). All subjects were healthy and almost did not have any restrictions for sports.

The assessment of the functional state of the system was produced by the statokinetic stabilographic hardware-software complex “Stabilan 01-2” (ZAO “OKB” “RITM”, Russia), analyzing the oscillations of the center of pressure. Statokinetic system stability was evaluated before and after the vestibular stimulation. The tested person performed the Romberg test, which consisted of open and closed eyes control (by 52 seconds each). After the stabilographic test the subjected person was seated in the Barany chair and made 5 rotations with the speed of 180º/sec (1 revolution in 2 seconds), after which he got up on the platform and performed the stabilographic Romberg test with open eyes. To assess the effect of the vestibular stimulation on the statokinetic sustainability the stabilographic indicators in the Romberg test with eyes open were compared with those obtained after the vestibular tests.

To analyze the statokinetic stability of the body in the upright position before and after the vestibular stimulation the following indicators of the stabilographic oscillations of the center of pressure were used: Q_X, mm – variation in the frontal plane; Q_Y, mm – variation in the sagittal plane; R, mm – average spread; V_{AS}, mm/s – average speed of the center of pressure; SV, mm^2/s – the speed of change in the area of the statokinezigramma; ELLS, mm^2 – the ellipse area of the statokinezigramma; IV – the speed index, one unit contingent; OD – the motion estimation, one unit contingent; The quality of equilibrium functions, %; The coefficient of sharp changes of direction, %.

The results are presented as the arithmetic mean of the sample (M) ± standard deviation (σ). The statistical significance of differences of the group of athletes and the control group was determined by t-test method for related and unrelated samples. The normality of distribution in the sample was determined by the Kolmogorov-Smirnov test. Data processing was carried out in the program for statistical data processing “SPSS 20”.

Results

In the Romberg trial with eyes open the main indicators of oscillations of the pressure of center football players and non-athletes did not differ, but the football players have less variation on the frontal plane and the area of the ellipse ($p < 0.01–0.001$), which characterizes higher ability to maintain the vertical position of the body with a lower bearing surface (Table 1).

In the Romberg trial with eyes closed in both groups there was an increase of most stabilometric indicators ($p < 0.01–0.001$), resulted in a decline of the integral indicator of “quality equilibrium function”, which gives an idea of the minimum rate of change of the pressure center. The higher the index, the higher the ability to maintain the balance.

However, most stabilographic indicators at the trial with eyes closed of non-athletes and football players are not statistically different, except for growth of the area of the ellipse and the rate of sharp changes of direction, the players’ data are significantly lower than those of people of the control group ($p < 0.01–0.001$), that indicates the advantages in the regulation of the body balance.

After the vestibular stimulation the stability of equilibrium of the body of both non-athletes and football players decreased, which results in the increase of stabilographic indicators (Table 2). However, the degree of increase in the sagittali spread, the average spread, the rate of change of the statokinezigramma area, the area of an ellipse, the index of speed, the estimation motion, the coefficient of the sharp changes of direction of the players are statistically less significant than that of the control group ($p < 0.01–0.001$).

Table 1. Stabilometric indicators of the Romberg sample with eyes open and closed of the football players and non-athletes with open and closed eyes (M ± σ)

Showing	Test open eyes			Test closed eyes			$p_2 <$
	control group	football player	$p_1 <$	control group	football player	$p_1 <$	
Q_X, mm	2.87 ±1.05	2.01 ±0.51	0.01	3.39 ±1.06***	2.86 ±0.64***		
Q_Y, mm	2.62 ±0.42	2.91 ±0.48		3.70 ±0.84***	3.81 ±0.51***		
R, mm	4.35 ±2.14	4.15 ±1.72		6.14 ±3.77***	5.58 ±1.87***		
V_{AS}, mm/s	8.12 ±1.89	6.20 ±2.71		11.65 ±3.51***	9.55 ±3.97***		
SV, mm^2/s	11.64 ±6.81	9.20 ±2.99		17.45 ±7.53***	14.18 ±3.83***		
ELLS, mm^2	138.51 ±74.3	84.29 ±30.91	0.01	238.01 ±65.92***	144.05 ±37.05***	0.01	0.001
IV, one unit contingent	5.30 ±1.18	5.53 ±1.56		8.63 ±2.31***	7.98 ±1.75***		
OD, one unit contingent	43.24 ±12.74	47.87 ±12.90		55.89 ±11.56***	48.39 ±16.98		
Quality equilibrium functions, %	84.69 ±6.55	86.99 ±4.33		69.41 ±11.56***	74.63 ±5.45		
Coefficient of sharp changes of direction, %	14.10 ±6.81	15.69 ±9.39		17.87 ±6.81***	15.35 ±6.31***		0.010

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ – statistically significant changes compared with the test-open eyes of the corresponding group; p_1 – the significance of differences between control and football players; p_2 – the significance of the differences in levels in the samples open eyes and closed between the control and the football players.

Table 2. Effect of vestibular stimulation on stabilometric performance of the football players and non-athletes in the Romberg sample with eyes open (M ± σ)

Showing	Romberg Trial with eyes open		After vestibular stimulation – Romberg trial with eyes open		
	control group	football player	control group	football player	$p_1 <$
Q_X, mm	2.87 ±1.05	2.01 ±0.51	3.99 ±0.88***	2.81 ±0.74***	
Q_Y, mm	2.62 ±0.42	2.91 ±0.48	6.27 ±2.18***	4.16 ±0.68***	0.001
R, mm	4.35 ±2.14	4.15 ±1.72	15.44 ±5.37***	8.61 ±5.39***	0.001
V_{AS}, mm/s	8.12 ±1.89	6.20 ±2.71	11.86 ±2.81***	6.36 ±2.60***	
SV, mm^2/s	11.64 ±6.81	9.20 ±2.99	25.88 ±7.31***	12.03 ±3.01***	0.001
ELLS, mm^2	138.51 ±74.29	84.29 ±30.91	266.45 ±94.33***	137.45 ±21.22***	0.010
IV, one unit contingent	5.30 ±1.18	5.53 ±1.56	11.82 ±4.86***	7.09 ±1.83***	0.001
OD, one unit contingent	43.24 ±12.74	47.87 ±12.90	61.87 ±17.53**	55.33 ±13.03***	
Quality equilibrium functions, %	84.69 ±6.55	86.99 ±4.33	66.95 ±3.81***	77.21 ±8.48**	0.001
Coefficient of sharp changes of direction, %	14.10 ±6.81	15.69 ±9.39	21.30 ±9.42**	18.16 ±9.04***	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ – statistically significant changes after the vestibular stimulation compared with rest in the test-open eyes of the corresponding group; p_1 – the significance of the differences in levels between the control and the football players.

Discussion

Under conditions when the somatosensory information is insufficient, the central vision has a greater impact on the movement control in the frontal plane. The peripheral vision under these conditions largely controls oscillation in the sagittal plane. And yet, despite the high importance of the visual analyzer, it can be compensated by other sensory systems. Spotting pulses are triggering mechanism for activating muscles involved in maintaining the posture control during body movements, primarily soleus. Neck muscles and the semitendinosus and semimembranosus supraspinal muscle are also connected. The greatest role belongs to the muscles of the ankle, the hip and the knee joints (Skvortsov 2010).

Therefore, the deficiency of the visual information leads to reducing of the equilibrium stability of the body, that increases the proprioceptive system's role in maintaining the body balance as the balance in an upright position without turning the head is regulated in the absence of the active participation of the vestibular system. The pressure receptors detect the fluctuations of the body, while the mechanoreceptors can determine location, speed, acceleration, pressure and their change. In addition, the position of the ankle joints and their movements are also considered (Skvortsov 2010).

The data of the same ability of the players and non-athletes to maintain an upright posture in the Romberg sample with open and closed eyes is consistent with the results of the other studies (Vuillerme and Nougier 2004; Schmit et al. 2005; Asseman et al. 2008). This may be due to the low system voltage regulation of poses in simple tests that allows to control and compensate the activity of some subsystems of regulating of balance by other subsystems (Horak 2006). It is likely that differences in the regulation of body balance are increasingly detected in more difficult conditions of maintaining the vertical position of the body (Paillard et al. 2007), for example, under the exposition of various types of linear and angular accelerations on to the vestibular apparatus (Nazarenko and Chinkin 2014).

After vestibular stimulation of the players the magnification of the sagittali spread, the average spread, the rate of change of the statokinezigramma area, the area of the ellipse, the index of speed, the motion estimation and the coefficient of sharp changes of the direction is less expressed, that reflects a higher level of statokinetic stability, high quality of operation of the motor control system and the improved proprioceptive sensitivity of postural muscles. To maintain an upright posture the participation of a large number of muscles and their coordinated activities in the implementation of voluntary movements are required. The stabilization of parts of the body relative to each other is achieved by the system of local tensile reflexes and their operation, providing a stable body position in the space, is based on the basis of vestibular and cervical tonic reflexes, and the visual information. This can be seen in the index “the motion estimation», which is optimal when its component indicators “the length of the curve” and “the average spread” reduce, that minimizes the rate of the center of pressure change, increases the integral indicator of “the quality of the equilibrium function» and the statokinetic stability of football players.

As a result of systematic training of football players the resistance of regulatory mechanisms of the body balance increases, i.e. the interaction between the visual, the proprioceptive, the vestibular sensory systems and the central nervous system that promotes the statokinetic stability growth. It follows from this that the systematic exercises contribute to a more rapid formation of new motor patterns that result in multiple repetitions and lead to the improvement of the internal model of signals, i.e. a mechanism for the “recognition” of the new information is created. Proprioceptive impulses arising during the training alter the functional properties of neurons and provide a reduced susceptibility to stimuli of different sensory modalities and the reducing of manifestations of vestibular-motor reactions (Nazarenko and Chinkin 2014).

Conclusions

Thus, statistically significant differences in the regulation of body balance of football players and non-athletes appear under the influence of the vestibular stimulation. In this case the statokinetic resistance of players is higher that is seen in smaller changes of stabilometric indicators under the vestibular stimulation. The more improved regulation of mechanisms of the body equilibrium is developed due to the adaptation of the vestibular analyzer receptors to mechanical forces that periodically and repeatedly impart to a human body multidirectional accelerations during their systematic training.

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