Cerebral blood circulation and static balance in football players after paravertebral muscle relaxation in an aquatic environment

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Abstract. It was found out that the stability of the body is optimized with an increase in the statistical relationship with the parameters of cerebral circulation after the use of paravertebral muscle relaxation in the aquatic environment. A decrease in the length and area of the migration of the center of body mass is accompanied by an increase in the rate of blood filling of the brain vessels in football players. It was found out that in football players who underwent a course of paravertebral muscle relaxation in an aquatic environment, the stability of the body was accompanied, to a greater extent, by an increase in the time of rapid filling of the blood vessels of the brain, the time of the rise of the rheogram, the amplitude of the differentiated rheogram at the point characterizing the filling rate. In the football players of the second group, where the course of paravertebral muscle relaxation was not used, the maintenance of static balance was accompanied, with a lower share of statistical weight from the indicators of the speed and volume of blood filling of the brain vessels.

1. Introduction
Optimization of the recovery processes of athletes has always been an actual applied task of sports physiology and sports medicine. Recovery is an important part of sports activities. Recovery tools and techniques are used at different times during the training process. In athletes the state of overtraining manifests itself in different ways and it is an individual reaction of the organism to various training loads. The use of the most effective means of recovery, taking into account the individual features of the body of athletes when choosing the means of recovery, is an important task today. The complexity of this task is associated with the precise determination of the localization of fatigue and the main mechanisms leading to the state of overtraining [1]. The variability of the use of physical activity in sports practice is applicable for more effective adaptation to training and competitive loads [2, 3]. This approach, in our opinion, is also applicable in the choice of recovery tools. One of the powerful tools in optimizing recovery is the altered gravity environment. A promising means of recovery is paravertebral muscle relaxation in the aquatic environment. The authors studied the effect of paravertebral muscle relaxation in the aquatic environment on the indicators of external respiration and the level of physical performance of both athletes and students with disabilities. The resulting data
indicated that, following a special set of exercises in water aimed at normalizing the myotonus of paravertebral muscles, both volume and flux values increased at a reliable value level [4, 5]. Also after the paravertebral myoralaxis, the level of physical efficiency was increased both absolute and relative [5]. Recovery processes are an integral part of the training process as a whole, as recovery time and its nature influence the assessment of functional fitness of athletes [6, 7]. Physiological assessment of the recovery process is an important condition in the management of the functional state, especially in football players, since in this sport, competitive and training loads are associated with the maximum stresses of all energy-supplying systems of the body  [8-12]. A certain stability and efficiency of the cerebral circulation under various loads, both in terms of energy and kinematic characteristics, is an indicator of the optimal functional state. Also, many authors use postural tests to assess the integral state of athletes [13]. The combined assessment of the parameters of cerebral circulation and the stability of the body [14] in the effectiveness of the use of various means of recovery, including paravertebral muscle relaxation in an aquatic environment, is of scientific interest. The aim of the study was to determine the effect of paravertebral muscle relaxation in the aquatic environment on the parameters of cerebral circulation and body stability in football players.

2. Methods and organization of research
The study involved 29 qualified football players. The subjects were divided into two groups. The first group underwent a course of paravertebral muscle relaxation in an aquatic environment. The second group did not undergo a course of paravertebral muscle relaxation in an aquatic environment. The average age of the examined players was 19.1±2.1 years. Using automated stabilography, the following parameters were determined and processed: the area of the statokinesiogram, S, mm²; the length of the migration path of the pressure center, L, mm; the callorage for maintaining the stability of the body A, J. To register the parameters of rheoencephalography, we used the rheoanalyzer RA5-01. Amplitude indicators: ARG (Om); Al( Om); Am df. (Om/s); Al (Om). Time indicators: VDN (s); VPR (s); Tre (ms); Tri (ms); Trl (ms). Combined indicators: OIR ( % ); BS (Om). In order to optimize the functional state of the cardio-respiratory system of athletes, we used the method of optimizing the functional state of the respiratory system of athletes (copyright registration certificate No. 45351 of 28.08.2012; copyright belongs to Mametova O. B., Savina K. D., Syshko D. V., V. I. Vernadsky Crimean Federal University). The method for optimizing the functional state of the respiratory system is based on a set of exercises aimed at improving the functions of the respiratory system. This kit includes the Noodle Swimming Exercise, which is a lightweight flexible foam cushion that is used to increase buoyancy and provides additional support during water aerobics. The complex is aimed at stretching muscle groups in the area of reflex projections of the respiratory system, which are pathologically spastic. The method for optimizing the respiratory system included the relaxation of the traction muscles with local muscle hypertonia. First, palpation and myotonometry determine the localization of pathological hypertonicity of the paravertebral muscles in the C3-Th8 zones, then certain swimming positions were formed in the pool with the help of noodles, stretching the pathologically spastic muscles of the neck and trunk. in the field of reflex representation of the respiratory system. The causal relationship with this method is that when noodles are used, the buoyancy of individual body segments increases. At the same time, locally hypertensive muscles are selectively stretched in zones C3-Th8 in conditions of rhythmically symmetric aerobic swimming.

The complex consisted of the following exercises:
1. Swimming on the back in flippers, in 3 minutes - 200m. For those who cannot swim, they can do it with a board in their hands. Hands are stretched upwards, the head is on hands, the chin is on the surface of the water. Foot movements are in the style «rabbit» with a large amplitude. The intensity is moderate. Respiration is free.
2. «Armchair». Swimming with a noodle forward, in a seated position. (Swinging noodle in front of the swimmer on water). For 4 minutes - 150m. The hands are straightened, the grip of the noodle is on top. The legs are performing counter movements in the style of «rabbit», the knees are not
bending. The amplitude of movements is medium. To maintain the correct position, monitor the position of the noodle above the legs. Breathing is free.

3. «Seat in Swallows». Swimming in swallows with back forward, sitting. (Nuddling in front on water). In 6 minutes - 300m. Your hands are relaxed, and you can see behind the noodle. Your knees don’t bend. Medium amplitude is of moderate intensity. To maintain the correct position of the body at all distances, monitor the position of the noodle over the tibia. Focus on muscle stretching in the neck and thorax. To increase the stretching effect, a continuous calm exhale is performed in water.

4. «Koromyslo». Swimming on the back in swallows, hands are along the torso. (The position of the noodle is behind the head). In 6 minutes - 300m.

5. «Cart». Swimming on the back in flippers with two noodles. For 6 minutes - 300m. One noodle is behind the back of the head, another at the level of the waist. One noodle is under the head, the chin pressed against the chest. The head: the back of the head is being pushed by the noodle forward. The other noodle is located on the extended arms on the surface of the water at the level of the belt of the submerged body. The legs’ work on the surface style «rabbit» is done with the average amplitude.

6. Swim on the back in swallows with the noodle held on the edges with both hands. (Noodle bent is in the form of a noose on the water in the tibia). In 6 minutes - 300m. Take the noodle by the edges and connect them together. The noodle, lying on the water surface, forms a loop over the torso. The movement of the legs is free with an average amplitude. Control the location of the cervical spine in the water. Breathing is free.

7. «Anchored chair». Swimming in flippers with noodle in a seating position near the side. (Noodle is in front at the level of feet and tied to the side). 4 minutes (4 45sec. 15 sec). The noodle is fastened to the pool wall with a rope. The swimmer takes up the position when seated face to the side. Hands are straight, grasp is behind the noodle. Watch the position of the noodle above the feet. The legs move with a medium amplitude, free. To increase the stretching effect, the swimmer performs prolonged exahles in water. The rope that holds the noodle creates the conditions for additional muscle stretching by external resistance. In these conditions, the active trajectory of the paravertebral muscles increases.

8. «Oblique chair». Navigation with the noodle in the swallows in a seated position with the back forward behind the symmetrical position of the hands. (Noodle is in front at the level of the feet). Six minutes – 300m. A straight arm extended forward from the concave side of the scoliotic deformation of the spine holds the noodle and the other arm is along the torso. The legs perform counter movements in the style of «rabbit». Follow the position of the noodle near the stop. The intensity is medium, breathing is free.

9. «Crooked chair». Swimming in the swallows in a seated position with back forward with two noodles. (Noodles are: 1) forward at foot level; 2) behind the back). 6 minutes - 300m. The arm, extended forward, is on the side of the concave of the scoliotic deformation of the spine, it lies on the groove above the feet, the other one is stretched back and lies on the other. The legs perform counter movements in the style of «rabbit». Follow the position of the noodle near the feet. The breath is free.

10. Swimming on the back. 4 minutes - 200 m. Free swimming is without fins and noodles, changing different arm positions every 25 m: Hands straight up; arms along the torso; right top - left along the torso; left up - right along the torso. Intensity is moderate. The method of static characterization of the variation series was applied, defining the arithmetic mean (x) and the arithmetic mean (Sx) error. Valid differences were statistically characterised by the value p of not more than 0.05.

3. Research results and their discussion

The study of the kinetics of body balance in the orthograde position and indicators of cerebral circulation in the first group of football players was carried out after using a course of paravertebral muscle relaxation. For comparative analysis, a second group was formed, where the course of paravertebral muscle relaxation was not performed (Table 1).

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Table 1. Indicators of cerebral circulation and body stability in paravertebral muscle relaxation in an aqueous medium.

| Indicators of cerebral circulation and body stability | 1st group (n=14) using a course of paravertebral muscle relaxation | 2nd group (n=15) the course of paravertebral muscle relaxation was not used |
|------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| VBN (с)                                              | 0.036                                                         | 0.030                                                         |
| AADR (Om/s)                                          | 1.05                                                          | 0.95                                                          |
| VPR(с)                                               | 0.107                                                         | 0.096                                                         |
| S, mm²                                               | 305.4±9.5                                                     | 316.3±11.6*                                                   |
| L, mm                                                | 10.5±1.2                                                      | 14.8±1.3*                                                     |
| A, Joule                                             | 4.7±0.2                                                       | 6.6±0.1*                                                      |

Note: * p<0.05

When studying the stabilometric indicators, we took into account the spontaneity of the movements of the center of mass of the body, which allows us determining the constant displacement of the vertical projection of the center of gravity on the horizontal plane of the support [15]. Studies of football players of the first and second groups showed that as a result of the use of paravertebral muscle relaxation in an aquatic environment, only the indicators of body stability, such as the length of the migration path of the center of mass of the body (L, mm), the area of migration of the center of mass of the body (S, mm²) and energy consumption for maintaining the pose (A, J), were statistically significantly changed. Football players who underwent a course of paravertebral muscle relaxation in an aquatic environment showed more effective indicators of body stability, as they were found to have lower indicators of L, mm; S, mm²; A, J, in comparison with similar indicators in football players who did not pass that course. Such changes in the functioning of the musculoskeletal system of football players who have undergone a course of paravertebral muscle relaxation in an aquatic environment are primarily associated with the effect of relieving hypertonus of the paravertebral muscles, which reduces, first of all, the values of support asymmetries and somatic compensations. When analyzing rheoencephalographic parameters, we studied the magnitude of the amplitude and shape of rheographic waves (anacrot), which are determined by the degree of blood filling in the studied area of the vascular bed, at the time of development of the ascending and descending parts of the wave, the additional wave, their severity and location on the descending part of the main wave [16, 17]. The indicators of cerebral blood circulation, such as the time of rapid filling (VB, с) and the time of reorgram elevation (VPR, с), only tended to increase, this indicates more effective conditions for filling the brain vessels and a decrease in their tone in football players after paravertebral muscle relaxation in an aquatic environment. ADR (Om/s) – the amplitude of the differentiated rheogram at the point M (M), which characterizes the maximum rate of blood filling, was higher in football players who underwent a course of paravertebral muscle relaxation in an aqueous medium, which indicates a decrease in the tone of large arteries. In general, this reflects the ability of the major arteries of the brain to stretch during systolic blood flow, and this indicator increases with the growth of elasticity and decrease in the vascular tone. Thus, paravertebral muscle relaxation in an aquatic environment increased the body's stability in maintaining an orthograde posture and optimized the hemodynamic conditions of blood flow of brain vessels in qualified football players. Using correlation and factor analysis, we obtained the weight of the hemodynamic factor of the brain in providing support kinetics in maintaining an orthograde posture after the course of paravertebral muscle relaxation in an aqueous medium (Table 2).
Table 2. The weight of the hemodynamic factors of the brain in maintaining the orthograde posture in football players of the first and second groups.

| Indicators, D, % | VBN  | VPR  | ADR  |
|-----------------|------|------|------|
|                 | Group 1 | Group 2 | Group 1 | Group 2 | Group 1 | Group 2 |
| L               | 49.6%  | 33.2%  | 48.6%  | 32.6%  | 45.5%  | 30.2%  |
| S               | 38.7%  | 31.7%  | 39.5%  | 31.7%  | 46.4%  | 33.5%  |
| A               | 48.6%  | 35.6%  | 47.3%  | 34.6%  | 40.7%  | 34.3%  |

This made it possible to assess the influence of the factors’ combination of the speed and volume of blood filling, the tone of various vessels of the brain, as well as vascular peripheral resistance in ensuring the maintenance of the pose from the positions of deviations from the center of body mass and energy costs. As a result, we found out that in the first group of football players who underwent a course of paravertebral muscle relaxation in an aqueous environment, the maintenance of an orthograde posture or static balance was provided in less energy-consuming conditions and with a greater weight of the factor of the cerebral circulation efficiency, in comparison with the players who did not take that course. The weight of the hemodynamic factor in maintaining the pose in the first group of football players was in the range of 38.7-49.6%, while in the second group of football players it was in the range of 30.2-34.6%. Thus, the course of paravertebral muscle relaxation in the aquatic environment due to the specifics of the exercises used in the course affect the coupling of the cerebral circulation systems with the motor and vestibular analyzers in providing postural reactions. It is known that the effect of physical exercises on the circulatory system as a whole is great, but exercises in an aquatic environment, in the conditions of the horizontal position of the body of the student, the effects of the viscous properties of water and changes in gravity, and aimed at relieving hypertonus of the paravertebral muscles, primarily have a positive effect on cerebral hemodynamics. Thus, in the pattern of ensuring posture maintenance, cerebral hemodynamics is one of the key factors.

4. Conclusions
1. Paravertebral muscle relaxation in an aquatic environment significantly (at p<0.05) reduced the length and area of migration of the center of the body mass, as well as energy consumption for maintaining static balance in the orthograde position.
2. Paravertebral muscle relaxation in an aqueous environment affected the parameters of cerebral hemodynamics, so that the time of rapid filling, the time of lifting the rheogram and the amplitude of the differentiated rheogram at the point of rapid filling tended to increase, this indicates more optimal hemodynamic conditions.
3. The maintenance of orthograde posture or static balance was provided in less energy-consuming conditions and with a greater weight of the factor of cerebral circulation efficiency in football players who underwent a course of paravertebral muscle relaxation in an aquatic environment, in comparison with football players who did not take that course.

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