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SHORT REPORT

Comparative Analysis of Peripheral Blood Circulation Parameters in Long-Distance Swimmers at Middle Altitude and Under the Conditions of a Hypoxic Gas Environment

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Abstract

Competitive activity at middle altitude creates increased demand on the cardiovascular system of long-distance swimmers. The state of their cardiovascular system and its readiness for such activities at middle altitude can be evaluated according to haemodynamic parameters. At the same time, state-of-the-art strategies for cardiovascular disorder prevention in long-distance swimmers during training for competitive activity at middle altitude are mostly based on the assessment of systemic haemodynamics, with no reference to microcirculation. The process of adaptation and changes in the functional parameters of long-distance swimmers that characterize their physical performance and the function of external respiration mainly occurs by broadening the range of training tools and methods. The unrestricted broadening of these tools and methods can cause severe disturbances in the functioning of the cardiovascular system. At the same time, existing methods for assessing the state of the cardiovascular system in long-distance swimmers do not allow performing a qualitative evaluation of the peripheral circulation haemodynamic parameters. The studies conducted have shown that microcirculation parameters in long-distance swimmers at different training loads have similar dynamics at middle altitude and under the conditions of a hypoxic gas environment, which allows for higher quality assessment of the cardiovascular system state in athletes and for the more accurate evaluation of their bodily reaction to different training loads at middle altitude.

Keywords: *long-distance swimmers, peripheral blood circulation, haemodynamic parameters, conditions of a hypoxic gas environment and at middle altitude*

Introduction

Expanding the conditions of competitive activity and conducting it at middle altitude creates increased demand on the cardiovascular system of athletes (Bakayev, Bolotin, & You, 2018; Bakaev, Bolotin, & Aganov, 2016; Bohuslavska, Furman, Pityn, Galan, & Nakonechnyi, 2017; Radovic, & Kasum, 2008; Leko, Siljeg, & Greguranic, 2019). The state of their cardiovascular system and its readiness for such activities at middle altitude can be evaluated by haemodynamic parameters (Bolotin, & Bakayev, 2017; Bunevicius et al., 2016; Vogiatzis et al., 2007). At the same time, state-of-the-art strategies for the prevention of cardiovascular disorders in long-distance swimmers during training for competitive activity at middle altitude are mostly based on the assessment of systemic haemodynamics, with reference to the micro-circulation of the working muscles (Murray, & Horscroft, 2016;

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Bakayev, Vasilyeva, Kalmykova, & Razinkina, 2018; Bolotin, Bakayev, & You, 2018).

Broadening of these training tools and methods can cause severe disturbances in the functioning of the cardiovascular system and the body in general. At the same time, existing methods for assessing the state of the cardiovascular system in long-distance swimmers do not allow performing the qualitative evaluation of the peripheral circulation haemodynamic parameters (Dempsey, Amann, Harms, & Wetter, 2012; Martin et al., 2009).

The studies conducted have shown that microcirculation parameters in long-distance swimmers at different training loads have similar dynamics at middle altitude and under the conditions of a hypoxic gas environment (Bolotin, & Bakayev, 2017). This phenomenon allows for higher quality assessment of the cardiovascular system state in athletes and for the more accurate evaluation of their bodily reaction to different training loads at middle altitude.

Study objectives:

1) To assess the dynamics of microcirculation in long-distance swimmers after ten hours of staying in a hypoxic gas environment;

2) To evaluate the peripheral circulation in long-distance swimmers at middle altitude;

3) To reveal the differences in the dynamics of microcirculation in long-distance swimmers at middle altitude and under the conditions of a hypoxic gas environment.

Methods

Eight long-distance swimmers from the Russian swimming team, in the age group of 17 to 23, were examined at middle altitude. The athletes underwent competition preparation and competed at the altitude of 1,300 m above sea level. For six weeks, the group swam for 17 to 19 km daily with a total weekly distance of 115 to 120 km. Balanced and repeated training methods were used.

The same subjects were examined in a hypoxic gas environment before the start of the training process at middle altitude. For that, they stayed in a hypoxic chamber with 16% oxygen content for 720 min. The conditions similar to those of the middle altitude were created in the hypoxic chamber. The air temperature was +24 degrees; the air humidity was 70%. The subjects in the hypoxic chamber were at rest. Peripheral blood circulation was studied using Laser-Doppler flowmetry at the distal phalanx of the second finger of the right hand. The microcirculation parameter (M) and the root-mean-square deviation of the fluctuation of red blood cells flow (b) (in peripheral units (p.u.)) were measured in all subjects. The coefficient of variation (CV) was used to assess the intensity of the microvessels' vasomotor reactions.

Results

A reduction in microcirculation during short-term exposure (360 min), followed by its compensatory increase (720 min) was determined in swimmers under the conditions of a hypoxic gas environment (Figure 1).

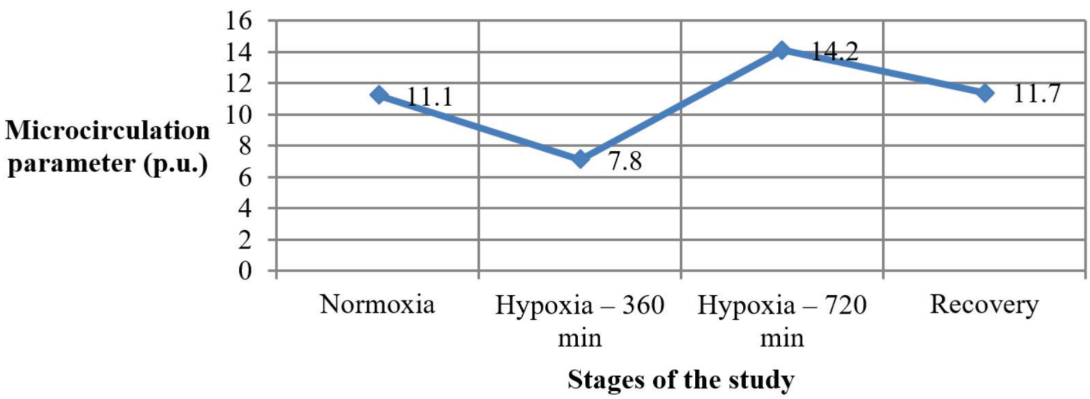

FIGURE 1. Microcirculation parameters in long-distance swimmers under the conditions of a hypoxic gas environment

Baseline data that characterize the reduction of peripheral blood circulation were obtained using biomicroscopy in athletes at middle altitude (Table 1).

With that, the coefficient of variation showed reverse dynamics in the form of an increase in the vasomotor activity of microvessels from 12.5 to 18.3% at the stage of performing the maximum training load for a month at middle altitude under the conditions of exposure to a hypoxic environment, which was then followed by a reduction at the stage of preparation for the start.

Table 1. Dynamics of Microcirculation Parameters in Long-Distance Swimmers at Middle Altitude

Microcirculation	Stage of the study		
	Baseline level	Stage of performing training load at middle altitude	Stage of competition preparation
Microcirculation parameter (p.u.)	11.3±1.1	8.1±1.2*	14.3±1.1*
Coefficient of variation %	12.5±0.84	18.3±0.91*	12.4±0.83

Legend: * – p<0.05

Discussion

In the course of this research, it was established that the peripheral vascular resistance of the arterial bed is determined by arterioles. Depending on the diameter of these vessels, it was revealed that various regulatory mechanisms might predominate (Martin et al., 2009). Arterioles of a larger diameter

(70 to 100 μm) are characterized by pronounced endothelium-dependent vasoreactivity. This type of reactivity is characterized by a direct relationship between changes in the vascular lumen in response to changes in the blood flow. Arterioles with a diameter of 40 to 70 μm are largely regulated by smooth muscle cells' stretch receptors. This regulation is determined by the narrowing of the arteriolar lumen at an increase in pressure, as well as the expansion of microvessels at a decrease in pressure. The tone of arterioles with a diameter of less than 40 μm is characterized by the metabolic activity of tissues, which undergo specific changes in swimmers under the influence of the training load at middle altitude. It was determined that the expansion of arterioles is caused by an insufficient amount of incoming oxygen following a decrease in metabolic activity and short-term suppression of microcirculation. This occurs against the background of the accumulation of under-oxidized metabolic products, which causes a decrease in pressure in arterioles. We have revealed an increase in the coefficient of variation, which characterizes the enhancement of the vasomotor reactions of microvessels. This discovery confirms the above-described mechanisms.

Under the conditions of a hypoxic gas environment, two-step change dynamics of microcirculation parameters in athletes were recorded: an initial reduction with a subsequent increase to the baseline level. Similar results were recorded in swimmers during competitions at middle altitude. This suggests that the assessment of peripheral circulation in a hypoxic gas environment may be critical in evaluating the degree of readiness of the cardiovascular system in long-distance swimmers for competitions at middle altitude.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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