Effects of acute hypoxia and endurance training under hypoxic state on the physiological condition of the cardiac muscle

Jakub Goliniewski

Summary

Physical effort causes a number of beneficial adaptive changes in the human body, especially in the area of the cardiac system, including the reduction of the risk of cardiovascular diseases. Nevertheless, in the case of competitive sports, where the body is subjected to very high loads, there is also a risk of negative changes, distinguishing these against the structural and functional background. One of the leading research issues in this field is to determine the impact of exercise on the physiological state of the heart muscle by analyzing the activity of cardiac markers.

For several decades, the positive effect of training under hypoxic conditions on the achieved sports results has also been known. Thanks to the development of technology, the model of intermittent hypoxic training (IHT) is also becoming more and more popular, assuming the implementation of a training unit in conditions of hypoxia, while staying in normoxic conditions during the rest of the day. The assumption is that IHT conditions cause additional stress to the body, which, along with exercise-induced stress, contributes to an increase in adaptive changes in the body. However, there is still a lack of research that would answer the question of how the increased training stress caused by training under hypoxic conditions affects the physiological state of the heart muscle.

Therefore, the aim of the study was to analyze the effect of interval exercise and a four-week high-intensity endurance training in conditions of moderate normobaric hypoxia on the activity of cardiac markers: troponin I (cTnI) and T (cTnT), cardiac fatty acid binding protein (H-FABP), isoenzyme cardiac creatine kinase (CK-MB) and myoglobin (Mb) in swimmers and the comparison of the obtained results with the effects of the same exercise carried out under normoxic conditions.

16 swimmers participated in the study, selected according to the criterion of having at least the 2nd sports class, at least 6 years of training experience and a six-year grace period from carrying out training in hypoxic conditions. The participants of the study were randomized into the experimental (H) and control (N) groups and underwent a 4-week training program. Group H performed swimming training under normoxic conditions and additionally, twice a week, high-intensity training on land under normobaric hypoxia, at a simulated altitude of 2,500 m above sea level. (FiO2 = 15.5%). Group N followed an identical training program entirely under normoxic conditions. Training loads for training on land were selected on the basis of% VO2max determined in the given conditions, in the case of the N group - in normoxia, in the H group - in hypoxia (% VO2maxhyp). Training on land involved performing a two-stage training circuit 4 times (in the first two microcycles) or 5 times (in the next two microcycles). The first station, focused on the work of the upper limbs and performed on the rotor, contained 30 seconds of effort with maximum intensity with a load of 0.4 Nm / kg. Then the work was continued on the cycloergonometer according to the following schedule: 3 minutes - 50%

VO2max / VO2maxhyp, 2 minutes - 90% VO2max / VO2maxhyp, 3 minutes - 50% VO2max / VO2maxhyp.

During the first research series (S1), before and immediately after the first two training units (carried out in normoxic and hypoxic conditions), venous blood was collected from the antecubital vein in order to determine the effect of interval exercise on the activity of cardiac markers (CK-MB, cTnI, cTnT, H -FABP, Mb). The second research series (S2) was carried out during the last training unit in the conditions in which individual groups trained and assumed the collection of venous blood and determination of cardiac markers according to the standards adopted in S1.

The results of the study showed a statistically significant effect of a single effort on the concentration of troponin T ($F = 30.64$; $p < 0.001$), myoglobin ($F = 35.65$; $p < 0.001$), CK-MB ($F = 4.18$; $p < 0$) , 05) and hFABP ($F = 17.29$; $p < 0.001$). Further analysis showed a statistically significant increase in blood troponin T concentration immediately after exercise in normoxia by 120.3% ($p < 0.01$) and in hypoxia by 116.5% ($p < 0.01$). There was also an increase in blood myoglobin concentration by 112.9% ($p < 0.01$) after exercise under normoxia and by 125.0% ($p < 0.001$) after exercise under hypoxia. The concentration of hFABP in the blood also increased significantly ($p < 0.05$) immediately after exercise, by 14.4% in normoxia and 16.4% in hypoxia, respectively. Moreover, an increase in the concentration of CK-MB by 31.1% on the border of the accepted significance level ($p < 0.07$) was demonstrated after exercise in normoxia. At the same time, there was no statistically significant interaction between exercise and the conditions of its implementation for the concentrations of the analyzed heart markers in the blood.

The four-week IHT training resulted in a significant decrease ($p < 0.001$) of resting CK-MB concentration by 55.2%. Similar changes were not registered after normoxic training. Moreover, a significant decrease ($p < 0.05$) of resting myoglobin concentration after training in normoxia by 50.0% was demonstrated. The resting concentration of troponin I, troponin T and hFABP did not change significantly after the four-week training, regardless of the conditions of its implementation.

In addition, it was shown that the change in troponin I concentration following interval exercise in normoxia was significantly greater ($T = 3.00$; $p < 0.05$) after four weeks of training in normoxia (Group N) compared to the change recorded before training. Similar changes were not recorded after training in hypoxia (IHT group). At the same time, no similar changes were noted for the other analyzed heart markers.

In summary, the most important result of the study is the demonstration that both a one-time exercise under moderate hypoxia (2500 m) and a four-week IHT training did not increase the activity of heart markers in swimmers compared to changes that occur under normoxic conditions. The lack of significant differences in the physiological response of the myocardium to the given stimulus proves the lack of a negative influence of exercise in hypoxia on the heart muscle and the safety of the IHT method in athletes.