Effect of high-intensity interval training in normobaric hypoxia on the level of selected hormones and lipid profile in swimmers

Summary

Intermittent hypoxic training (IHT) is increasingly popular as an effective method to improve exercise capacity in athletes. The concept of the IHT training is based on the assumption that hypoxia-induced stress combined with that induced by physical exercise can lead to greater adaptations in the human body compared to the effects of training in normoxia. Scientific reports have shown that IHT training improves aerobic and anaerobic capacity, and these changes result from a number of adaptations occurring mainly at the muscle tissue level. Since endogenous hormones are an important factor in the course of exercise and training adaptations, one can presume that the beneficial effect of IHT training on exercise capacity in athletes is related to its effect on the hormone profile of the body. Testosterone (T), cortisol (C) and growth hormone (GH) are important hormones that regulate anabolic and catabolic responses in the body and play an important role in adaptation to physical exercise. However, few studies in the literature have examined changes in the levels of these hormones in response to IHT training to date. Therefore, research in this area is needed.

Furthermore, no research has been done to establish the effect of IHT training on blood lipid profile in athletes. It has been observed that the exposure to high altitude or prolonged stay at altitude leads to a decrease in total cholesterol (tChol), LDL cholesterol (LDL-C) and triglyceride (TG) levels and an increase in blood HDL cholesterol (HDL-C) levels. Currently, the research is being conducted in the literature on the effect of intermittent passive exposure to normobaric hypoxia or training under these conditions on the improvement of lipid profile. However, studies in this field have been carried out mainly with the participation of non-athletes. There is a lack of research on the effect of IHT training on the lipid profile in athletes with high training adaptation.

Therefore, the first aim of the study was to analyze the effect of four-week high-intensity interval training in normobaric hypoxia (IHT) on resting blood T, C and GH levels, and the T/C ratio in swimmers, and to compare the observed changes with the effects of identical training in normoxia. Furthermore, the effect of high-intensity interval exercise in normoxia and hypoxia on the levels of the above-mentioned hormones was also analyzed. The second aim of the study was to analyze the effect of IHT training on the lipid profile in swimmers.

Eighteen male swimmers participated in this study. The basic criteria for participating in the study were a minimum of six years of training experience and at least a six-months washout period from previous altitude training. The participants were randomly divided into an experimental group (H; n = 9) and a control group (N; n = 9) and underwent a 4-week training program. The athletes from group H performed the swimming training program in normoxia, complemented with the land high-intensity training sessions (two sessions a week) performed in normobaric hypoxia (FiO_2=14.5%, which corresponds to an altitude of 3,000 m above sea level). Group N followed an identical training program performed entirely in normoxia. Each high-intensity interval training session was composed of 10 to 15 minutes of general warm-up, 45 to 55 minutes of the main part, and 10 minutes of the final part. The workloads during these training sessions were determined based on %VO_{2max} evaluated in normoxia for group N or in hypoxia (%$VO_{2max\ hyp}$) for group H. In the main part, the athletes performed the training circuit several times, including the exercises for upper and lower limbs. Each circuit was composed of 60 seconds of work (50 W) at a fixed cadence of 80 rpm, followed by 30 seconds of maximum exercise (at 0.4 Nm/kg) on the rotor for upper limbs. After a 30-second rest for changing the ergometer, the athletes continued to exercise on the cycle ergometer. This exercise included 3 minutes at 50% VO_{2max}/$VO_{2max\ hyp}$, 2 minutes at 90% VO_{2max}/$VO_{2max\ hyp}$, and 3 minutes at 50% VO_{2max}/$VO_{2max\ hyp}$. For the first two microcycles, the training circuit was performed four times, whereas in the third and fourth weeks, the circuit was repeated five times.

Before and immediately after the training program, two research series were conducted: initial (S1) and final (S2) tests. In the research series, venous blood was collected in fasting conditions to determine the resting blood hormone levels (T, C, and GH) and the lipid profile of the participants. Furthermore, exercise tests (ramp test to exhaustion to evaluate aerobic capacity) and swimming tests (100 m and 200 m) were also carried out. During the first two training sessions, venous blood samples were obtained before and immediately after the exercise to determine the level of the above-mentioned hormones.

The results showed a significant ($p<0.05$) increase in resting blood T levels following the training in normoxia and hypoxia. The IHT training caused a significant ($p<0.05$) increase in the resting T/C ratio by 32%, which was not observed after training in normoxia. Regardless of training conditions, resting blood C and GH levels did not change significantly. In group H, who trained in hypoxia, the improvement in T/C ratio was accompanied by improved exercise capacity. The analysis of the swimming test results showed that the IHT training resulted in a significant ($p<0.01$) improvement in 200 m swimming by 3.7%, which was not observed in the group who trained in normoxia. Furthermore, the training program contributed to a significant increase in the maximal workload (WR_{max}) during the test to exhaustion in both groups. WR_{max} increased by 2.7% in group N ($p<0.05$) and by 5.6% in group H ($p<0.001$). The improvement in WR_{max} was significantly ($p<0,05$) greater after training in hypoxia compared to normoxia. No statistically significant changes in lipid profile were demonstrated in any of the groups. Furthermore, the results of the study demonstrated that the interval exercise performed during a high-intensity training session in normoxia and hypoxia contributed to a significant ($p<0.001$) increase in blood T, C, and GH levels and a decrease in T/C ratio. Exercise conditions did not differentiate the magnitude of exercise-induced changes in T, C, T/C, and GH levels.

In conclusion, the biggest achievement of the study is to demonstrate that a four-week high-intensity interval training (IHT) in normoxia contributes to an increase in resting blood testosterone (T) levels and improvements in the T/C ratio, indicating the formation of the hormonal anabolic *milieu* in the blood of the athletes. An identical training program carried out in normoxia did not induce beneficial changes in the anabolic-catabolic state in athletes' blood. Furthermore, the results of the study indicated that IHT training does not modify the blood lipid profile in athletes with normal lipid metabolism. The results also represent a valuable complement to previous studies on the hormonal response to high-intensity exercise under normoxia and hypoxia. The study showed, that with the use of the same relative load, i.e. when exercise intensity is adjusted to the conditions of its performance, exercise-induced changes in blood hormone levels do not differ in normoxia and hypoxia. This leads to the conclusion that during exercise in hypoxia it is not hypoxia itself but physical exercise intensity performed in these conditions that is the main determinant of the dynamics of hormonal response.