Impact of breath-hold diving on selected adaptive and cardioprotective mechanisms

Summary

Physical training leads to adaptation of the respiratory system, which is mainly responsible for maintaining balance between the demand and supply of oxygen during exercise. The adaptation of ventilation to the consumption of oxygen in tissues may be disturbed by the course of many restrictive or obstructive diseases, which may result in developing hypoxia and hypercapnia. Breathing in conditions of reduced oxygen access also occurs in freedivers who swim long distances under water or perform a static breath hold for several minutes (Hong et al. 1970, Landphier et al. 1963, Liner et al. 1993).

Breathing is a physiological reaction that results in a lot of adaptive mechanisms that protect the organism against hypoxia. The most important reaction is the diving reflex, whose function is to ensure adequate O_2 supply to the brain and heart. The components of the diving reflex are: apnea, bradycardia combined with a decrease in cardiac output, narrowing of blood vessels, an increase in mean arterial pressure and spleen contract (Schagatay et al. 2001, 2005; Lemaitre et al. 2015; Hoiland et al. 2017). The stimulation of sensory fibers of the trigeminal nerve of the face further enhances the diving reflex response (Andersson et al. 2009, Jay et al. 2007). Holding your breath can also cause adverse changes resulting from too long exposure to hypoxia and hypercapnia. The organs most sensitive to hypoxia and ischemia include the brain and heart, for which it is important to activate protective mechanisms during ischemia and reperfusion.

The ability to tolerate hypoxia and hypercapnia in freedivers is an increasingly discussed topic of research. The observed trend of improving world records in this discipline indicates high adaptation of the body to such specific effort (Ostrowski et al. 2012). Breathing techniques that are particularly important are those that increase the volume of air you draw in and extend your apnea time (Tetzlaf et al. 2008).

The aim of the dissertation is to demonstrate the effect of breath holding diving on adaptive changes in the respiratory and cardiovascular systems and to show if there are mechanisms responsible for exercise-induced cardioprotection.

The subjects of the study were athletes participating in pool breath-holding diving (freediving). Four women and 11 men (GFD) representatives of Poland, finalists, medalists

and record holders of the world and European championships were included in the study. The control group (GK) consisted of 15 healthy people, including 4 women

and 11 men, in similar age range (GK 35.8 ± 3.8 vs. GFD 35.8 ± 5.7) recreational swimming.

The research was carried out in three stages. The first one took place at the Physiology Department of the Academy of Physical Education in Katowice and included anthropometric measurements (InBody), assessment of the adaptation of the circulatory system to breath holding (12-lead ECG System RScribe5, MDS Cardio, USA) during two static tests in gas environment (STA -D1 and STA-D2) and an ergospirometric test (BH Exercycle SL, Spain, 2018).

In the second stage, all subjects underwent spirometry, bodyplethysmography and lung diffusion test (Elite Platinum No. 232000063, Med. Graphics 2010). The tests were carried out at the Clinic of Lung Diseases and Tuberculosis of the Silesian Medical University in Zabrze, in cooperation with the Silesian Medical University in Katowice. In the last stage, measurements related to adaptation to breath holding under water immersion in GFD were made. STA-I and DNF-I tests were carried out. Venous blood was collected for biochemical measurements before and immediately after the trials.

One of the most important results of this study is to demonstrate greater respiratory efficiency that affects more favorable adaptation to breath holding during static and dynamic diving competition in the freedivers tested. There was no negative impact of freediving on lung functions and heart rate at rest and during the ergospirometric exercise test. Another significant result is the demonstration of increase in the heat shock protein HSP 27 level in response to breath holding and the relationship between induction of these proteins and oxidative stress, and oxygen availability and lung capacity. Physiological responses resulting from apnea training demonstrated in freedivers can help improve athletic performance.