



The effects of medium oxygen concentration on physical and mental exercise.

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Oxygen therapy is a well-established integral medical treatment of cardiovascular disease and respiratory disorders. However, the use of oxygen is not limited to treatment. Oxygen therapy has enormous potential and can contribute to increasing mental and physical abilities of the human body[1]. After finishing resting and starting physical exercise, a rapid demand for ATP occurs, which due to the lack of availability of oxygen, can not be meet in a cycle of oxidative phosphorylation. Another substrate necessary for muscle contraction is creatinine. ATP is needed to phosphorylate creatinine in muscle cells, producing phosphocreatine, necessary for muscle contraction during the initial stages of exercise. Lack of oxygen forces the muscle cells to set to anaerobic respiration; less effective and leading to the accumulation of lactate and muscle acidification. The difference between the required levels of oxygen delivered to the body and is called oxygen deficit [2].

Summarising oxygen supply is necessary to carry out the energetic processes such as muscle contraction and regeneration.

Increased concentration of oxygen in the tissues is called hyperoxia. There are several possibilities of increasing the concentration of oxygen in the body, one of them is placing the

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patient inside a hyperbaric chamber or inhaling air with a higher oxygen concentration than the ambient air  $FiO_2 > 20.93\%$ . Hypoxia leads to synthesis of hypoxia inducible factor 1- $\alpha$  (HIF-1  $\alpha$ ). The increase of HIF-1 $\alpha$  results in the formation of new blood vessels, vascularization and glycolysis. HIF-1 $\alpha$  is also activated after the injuries sustained eg. during sports. That factor increases: the blood flow by widening blood, partial pressure of oxygen in the blood and accelerates the synthesis of proteoglycans and fibronectin and collagen production. Unfortunately, with increasing blood flow comes swelling, and the increase of collagen synthesis and proteoglycans can lead to scar formation. Increasing the concentration of oxygen in the blood will therefore decrease the synthesis of HIF-1 $\alpha$ , consequently, more rapid healing of injuries, decrease in swelling and pain. The essence of the therapeutic mechanism behind thermotherapy and massage is the increased availability of oxygen in the tissues [3, 4].

Recently, metal canisters containing oxygen at a concentration of 95% -99.5% appeared on the market. As is apparent from the work of Prof. Suchet and dr. Sikora's inhaling oxygen from containers Oxywatt® leads to a concentration of 30.62% [5]. Such concentration is safe as when oxygen was inhaled no symptoms of respiratory alkalosis, such as muscle cramps tachycardia or fainting were reported [6]. Inhalation of oxygen increases the maximal rate of O<sub>2</sub> delivery in rowers [7], cyclists of 10 % [8] as well as in runners. In a group of runners, breathing 40% oxygen has been shown to decrease in pH (acidosis) physiologically occurring during exercise. [9] Inhalation of 30% oxygen results in increased exhalation of CO<sub>2</sub> what is interpreted as increase in production of ATP in the process of oxidative phosphorylation [10]. One of the first study investigating the influence of inhaling oxygen on exercise consisted of administering the test group with different concentration of oxygen during maximal running on a treadmill. After inhalation of 40% oxygen, followed by a run, the length of maximal run increased to 300 seconds compared with 250 seconds when inhaled atmospheric air [11].

Another study showed that inhaling 30% oxygen during rowing ergometer exercise raises the maximal rate of O<sub>2</sub> uptake (VO<sub>2</sub>max). Also, oxygen-administration group obtained higher pH values and higher blood concentration of oxygen [7]. In addition, inhalation of 30% oxygen reduces the average heart rate by 5 beats per minute as compared to the inhalation of oxygen in the atmospheric air. The increase in the concentration of oxygen in the body, slows

down metabolism in the myocardium which enables more effort [12]. By lowering both respiratory rate and heart rate, it is possible to increase the frequency and length of effort. In another study, athletes breathed 30% oxygen through resting intervals during the Wingate test consisting of carrying out maximum effort on the ergometer. After warming up, followed 30 seconds Wingate test then came a period of relaxation which lasted 8 minutes. At this time, they render 8 breaths lasting about 2 seconds. The study group inhaled the oxygen from the single canister similar to Oxywatt® while the control group the atmospheric air in canister (placebo). After the resting time was over, another exercise commenced. The study showed a reduction in maximum power difference between the first and second test in a group of breathing 30% oxygen. Also, the average power during the exercise was higher in the study group. Less fatigue was also shown among people breathing oxygen as well as reduced plasma lactate and reduced number of average heartbeats [6]. Another effect of inhaling higher concentration of oxygen is a reduction of oxidative stress and plasma free radicals produced during exercise. A blood test of professional athletes running on a treadmill while inhaling oxygen, showed a decrease in the concentration of lactate dehydrogenase and malondialdehyde; (MDA) while inspiring 30% oxygen. Lactate dehydrogenase is a biomarker synthesized during oxygen deficit and moves pyruvate to lactate contributing to acidification of the muscles. Decrease in MOD means that the administration of 30% oxygen reduces the concentration of free radicals further damaging the muscles during exercise [13].

Administration of 50% Oxygen at both medium and strenuous exercises, leads to a constant oxygen saturation. [14]. Inhalation of 30% Oxygen increases minute ventilation of 21%. [15]. Breath of oxygen for two minutes causes a transient hyperoxia lasting three times longer than the time of administration of oxygen.[16] Hyperoxia in rowers shortened the time it takes to cross the 2500 m by 11 seconds. Rowers also used more energy (375 W compared to 352 W used during the inhalation of atmospheric oxygen) [17]. Inhalation of 30% oxygen while riding on a cycle ergometer showed a decrease in heart rate compared with 21% breathable oxygen. The researchers observed no change in the level of oxygen saturation which is associated with decreased blood flow in patients breathing oxygen. This effect was visible both during exercise and at rest. [18]

Furthermore, inhalation of oxygen can affect mental abilities. During the administration of 30% oxygen, study participants were instructed to perform adapted visual-

spatial tasks. At the same time high resolution magnetic resonance imaging of the brain was conducted. Seven out of eight participants demonstrated improved visual spatial abilities during the administration of 30% oxygen. Research in MRI revealed increased activity within areas of the brain responsible for memory and spatial orientation, as well as visual coordination [19]. Inhaling oxygen from the disposable container directly before the task consisting of memorizing a list of words showed a statistically significant increase in the number of memorized words both 10 min and 24 h after the start of the exercise. The effect of increased assimilation of information after the administration of oxygen was noticeable, but the participants who did not inhale oxygen directly before looking at a list of words and only before recollection did not show increased skills. The researchers believe that the increased concentration of oxygen before mental effort, activates areas of the brain responsible for memory consolidation and concentration [20].

The administration of 30% oxygen during words reading leads to a 22% increase in memorized words compared with breathing atmospheric air. The reaction time was slightly shorter in patients breathing a higher oxygen concentrations [21].

Similarly, oxygen influences the reduction of response time, the time required to recognize the image and to make a decision, the time required for mathematical calculations. Also, researchers have shown a positive effect of oxygen on long-term memory [22]. Similar conclusions can be drawn from a study conducted by Chung et al. Oxygen reduces the response time associated with the pattern recognition. [23] Winder and Borrill has compared the effects of oxygen and glucose to a group of 104 healthy adults. It turns out that only oxygen contrary to glucose affects long-term memory [24]. Scholey et al. attempted to estimate the optimal time required to obtain a better memory skills while breathing oxygen. It turns out that this effect is visible 5 minutes and 2 min before remembering as well as directly before the reading of words to memorize. While breathing oxygen 10 min before reading the words had no effect on memory. [16]

#### Summary.

The influence of oxygen on the effectiveness of physical activity is well documented in numerous scientific studies. The oxygen inhaled in the concentration of 30% decreases the levels of lactate and heart rate while it accelerates muscle regeneration and reduces the

concentration of free radicals. Inhalation of oxygen causes an increase in the maximal rate of O<sub>2</sub> delivery. In addition, use of oxygen helps to increase both the power and duration of maximum effort. What's more visible are the effects of oxygen on mental abilities. Inhalation of oxygen affects memory skills, concentration and reaction speed, which can be used in sports requiring reflexes. Oxygen has the properties of promoting wound healing and rapid healing effect on the fatigue. Fatigue is caused by the depletion of energy resources, the accumulation of breakdown products and abnormalities in metabolism. Providing high levels of oxygen promotes the ATP production and transformation of metabolites.

A drop in heart rate and breathing can be used during breaks between exercises, yielding a more effective relaxation. Also, taking a few breaths for 20 minutes before sleep contribute to the increase in regeneration. This effect is confirmed by observations of individual players.

"I was running during training for a couple of times a day, very brief episodes of intense exercise, I breathed oxygen during breaks about 5 breaths on each. I felt as if my lungs were better oxygenated, it calmed my breath and accelerates the regeneration of leg muscles. I also noticed that my attention was greater on the exercises performed. I have been using oxygen during long distance trails. After running a few kilometers I took 3-5 deep breaths. I felt that it improves my respiratory system, affects the muscle performance and strength. I have observed a decrease in heart rate and calming breath. "

Based on the research presented and the literature, about 5 breaths should inhaled from the Oxywatt® container lasting 1-2s to get positive results.

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