OXYroom

**Normobaric chambers**

**1. Health benefits of using normobarism and hyperbarism**

**1.1. What is hyperbarism?**

Hyperbaric oxygen therapy involves inhalation of increased amounts of oxygen in a hyperbaric chamber at a pressure which exceeds the atmospheric pressure defined as 1 atmosphere absolute (1 ATA) [1,2]. Under normal conditions, the oxygen is transported inthe blood only with haemoglobin in red blood cells and the blood oxygen saturation isapprox. 98 %[3]. Crucial feature of the hyperbarism is the fact that the pressure increase to 3 ATA, the amount of oxygen delivered by the blood ranges from 10 to 15 times above normal,which makes it possible to maintain life even in case of total dysfunction of haemoglobin [3]. Scientific research shows that the range of pressure used most frequently oscillates between 1.5 and 3 ATA, while the duration of treatment is from 30 to 120 minutes [2, 4, 5, 6, 7], although in tests on animal models, the chambers have ATA value above 3. The oxygen inhalation at 3 ATA increases the partial pressure of oxygen in the blood to 200 kPa andmore, which leads to an increase in the concentration of oxygen in arterial blood from 6.6 to 6.8 ml ($O_2$/ 100 ml) [8].

Compared to hyperbarism, the normobarism involves the exposure to relatively lower ATA values. However, due to imprecise literature descriptions and a lack of distinct boundary between ATA values used in compared methods, the authors of the research cited in this paper appear to be somewhat inconsistent in using their terms. Moreover, the aim of this article is to describe the health-promoting benefits of using normobarism by people. Unfortunately, due to the lack of publications on the effectiveness of normobarism, test results will be taken from hyperbaric studies on humans and animals. It may be assumed that at least some healthy benefits resulting from the hyperbaric exposure will also be applicable to normobarism.

**Table 1. Comparing parameters of average atmospheric conditions with conditions in hyperbaric and normobaric chamber**

| Atmospheric parameters | Average atmospheric conditions at the sea level | Normobaric chamber | Hyperbaric chamber (depending on the purpose of exposure) |
|---|---|---|---|
| Pressure (hPa) | approx. 1 000 | **1 500** | 1 500 - 3 500 |
| Humidity (%) | 30-60 | **max. 65** | 40-60 |
| - oxygen (O2) content (%) | 20.94 | **35-40** | 22-99 |
| - CO2 content (%) | 0.036 | **0.5-1.5** | approx. 0.03-0.08 |
| - hydrogen (H2) content (%) | 0.0001 | **0.50** | approx. 0 |
| - nitrogen (N) content (%) | 78.08 | **approx. 60** | approx. 0-77 |

### 1.2. Influence of hyperbarism and normobarism on the nervous system

Approximately 1 $cm^3$ of neural tissue contains about 1 km of blood vessels and a sufficient supply of oxygen is absolutely necessary to repair the damaged regions [9]. Although the weight of the human brain is only about 2% of body weight, the brain consumes almost 20% of the oxygen used [10]. The use of hyperbarism modulates the activity of neural tissue, also indirectly, through glial cells [11]. Exposure to hyperbaric conditions of 4.96 ATA for one hour [12] may have neurotoxic effects. Oxidative stress caused by using a pressure higher than 4 ATA induces lipid peroxidation [13,14]. However, pressure lower than 3 ATA doesnot cause such effects [15,16]. The value of 1, 2 ATA increases the pressure by 20%, so theoretically, the blood oxygen level should be increased by 30% compared to the level in normal pressure conditions [17].

Interestingly, the basic biophysical mechanisms, such as those that control the relationship between perfusion and static blood volume, have not yet been clarified [18]. Clinical symptoms, caused by the toxic effects of oxygen on the brain tissue, occur presumably due to the effects of increased production of reactive oxygen forms and they manifest themselves only when there is a large dose of breathing oxygen at a significant hyperbaric pressure [i.e. approx. 2 ATA]. However, studies on humans and animal models indicate that exposure to hyperoxia in normobarism (breathing gas which comprises 100 % of oxygen at 1 ATA) has a lower, but also destructive effect on the function of developing nerve tissue [19, 20, 21] and amodulating effect on excitability of mature neurons [22, 23]. However, in the case of the normobaric chamber constructed by Dr Pokrywka, there is no breathing of pure oxygen. Significantly, **even a small increase in atmospheric pressure**, e.g. by 1.05 ATM 1.05 at a depth of 402 m below sea level, may cause observable physiological changes [24]. The normobaric chamber described by Dr Pokrywka provides constant pressure of 1.5 ATA and the content of carbon dioxide in air inside the normobaric room, ranging from 0.7 to 1.3% [25]. Blood hypercapnia and hyperoxia induce changes in brain hemodynamics by regulating vascular tonus [26]. Inhalation of $CO_2$ and $O_2$ is associated with increased and decreased cerebral perfusion (i.e. respectively with vasodilation and vasoconstriction of blood vessels) [26, 27, 28, 29, 30]. Cerebral vasculature is regulated by neuronal changes (e.g. neurovascular coupling) and biochemical factors, such as nitric oxide, superoxide dismutase and acidosis [31, 32].

Increased delivery of oxygen to the tissue is caused primarily by the increased partial pressure [25]. Elevated levels of carbon dioxide and oxygen increase the firing rate of nerve

cells, which are chemo-receptors sensitive to carbon dioxide in the nucleus of the solitary tract. This increase is greater than in case of exposure to changed level of carbon dioxide or changed level of oxygen separately [33]. The results of these studies are surprising as chemo-receptors sensitive to carbon dioxide owe their name to their sensitivity to CO2 level. The synergistic effect of elevated carbon dioxide and oxygen on the operation of these chemo- receptors clearly shows that there are serious gaps in the present state of knowledge, therefore, we need further research into the impact of different combinations of atmospheric parameters (e.g. elevated levels of $O_2$, $CO_2$ and molecular hydrogen with simultaneousincreased ATA values or other possible combinations) on human body, health and treatment of various diseases.

Until now, the use of hyperbaric oxygen treatment has been tested for nervous systemdiseases such as autism, stroke, cerebral palsy, multiple sclerosis and damage to the hippocampus (a brain structure crucial for the memory) [34]. On the other hand, due to differences in the research methods, it is impossible to draw firm clear conclusions on the clinical effectiveness of the normobaric treatment. The current evidence of hyperbaric treatment effectiveness in case of brain stroke is insufficient [35].

Keim et al. describe a case of a scientist (27 years old) found in a coma due to CO poisoning (carboxyhemoglobin = 31.7%). He underwent five hyperbaric treatments. After discharging from the hospital, he developed chorea, Parkinsonism, dystonia, memory loss, slowed processing speed and verbal fluency, leaving him disabled. A program consisting of regular hyperbaric exposure was initiated for him. Neuropsychological tests were performed at the beginning of the treatment and after every 20 exposures, five of which were performed in the period of 14-22 months after asphyxiation. After the first 20 treatments, a decrease of parkinsonism and dystonia was recorded. After 40 sessions, further improvement was observed in information processing speed, verbal fluency and precision of movements. Finally after 100 sessions, the patient recovered his independence, including the ability to drive and perform paid employment. This case challenges the idea that hyperbaric treatment has no role in the chronic phase of brain injury by CO. However, as the authors point out, randomized clinical trials have to be taken into account when evaluating therapeutic efficiency of regular use of hyperbaric exposures in patients with neurological symptoms after asphyxiation [36].

Harch and Fogarty describe a case a woman (58 years old) diagnosed with rapidly advancing Alzheimer's disease. Images from positron emission tomography showed global and common

metabolic deficits in rear contact areas of the parietal and temporal cortex, as well as anterior cingulate cortex, which is characteristic of Alzheimer's disease. The patient underwent 40 normobaric exposures (1.15 ATA), each lasting 50 minutes, once a day, 5 days a week. The entire program was completed within 66 days. After 21 exposures, increased energy / activity level was observed, as well as improved mood and better results of one of the cognitive functioning tests by performing daily activities and solving crosswords. After 40 exposures, the improvement was recorded in different areas, including the functioning of memory and concentration, sleeping pattern, ability to hold a conversation, improved appetite, ability to use a computer and more 'good days' than 'bad days' during the week (5/7), as well as reduced anxiety, confusion and frustration. Re-examination by positron emission tomography performed one month after completing the therapy showed a general improvement in brain metabolism by 6.5-38% [37]. On the other hand, the program consisting of a repeated treatment in a hyperbaric chamber may lead to chronic pathological lung condition [38].

Reactive oxygen forms released during exposure in a hyperbaric chamber are damaging to DNA and other biological molecules [39]. This may confirm the old paradigm of Paracelsus that the toxicity depends only on the dose, which could also refer to the highly appreciated oxygen [40].

## 2. Hyperbaric and normobaric chambers - similarities and differences

Hyperbaric chambers, used for high oxygen concentration exposures (at approx. 3 ATA) are normally used in clinical hospitals in emergencies, such as carbon monoxide poisoning. Due to the intense oxidation of tissues and the consequent possible negative consequences, the hyperbaric exposure time is limited usually up to 1.5 hours. The authors suggested that because of the known adverse effects of hyperoxia, the more conservative approach tooxidation of critically ill patients deserves further clinical studies in order to select the optimal parameters of oxygen therapy in patients with ischemic stroke [41].

It has been shown that exposure to pressure greater than 2 ATA has antibacterial effect on certain anaerobic and aerobic bacteria. [42, 43]. In view of these differences, further studies should aim at determining the most optimal composition of the atmosphere and the pressure

in the chamber and the treatment program in order to detail the frequency and the length of each exposure.

Table 2. Comparing features of normobaric and hyperbaric chambers

| | **Normobaric chamber** | **Hyperbaric chamber** |
|---|---|---|
| **Purpose** | Oxygen therapy - providing an increased amount of oxygen under pressure. Oxygen gets into the blood, lymph and cerebrospinal fluid which nourishes the brain and spinal cord. | Oxygen therapy - providing an increased amount of oxygen under pressure. Oxygen gets into the blood, lymph and cerebrospinal fluid which nourishes the brain and spinal cord. |
| **The composition of the ambient atmosphere** | Pressure: 1500 hPa, oxygen, carbon dioxide, hydrogen 37% of oxygen | Pressure 1500 - 3500 hPa 99% of oxygen |
| **The material of the chamber** | Black steel | Steel, plastic, or metal |
| **Assembly** | Outdoor - near the existing infrastructure with access to utilities such as electricity, water, sewerage, | Inside a building - it does not require the supply and drainage of water |
| **Access** | Unlimited - no changes in air parameters, free entrance and exit through the airlock | Limited - pressure must be adjusted each time the chamber is opened and closed |
| **Number of persons** | max 40 | 1 to several people at the same time |
| **Time spent in the chamber** | No limits | 1.5 h max |
| **The effects of prolonged use of the chamber** | **Unknown** | Headache, vomiting, fatigue. Oxygen toxicity, chemical lung disease with a single stay longer than 1.5h |
| **Rules of using the chamber** | Smoking is prohibited | Very strict adherence to safety standards due to the possibility of explosion (cotton clothes and linen underwear, no make-up, no jewellery, no shoes, no metal objects, no mobile phones, computers, etc.), |
| | Possibility of watching TV, listening to music, using mobile phones, computers, free movements, eating, drinking etc. | It is absolutely prohibited to smoke, eat and drink in the chamber. |
| | | Hyperbaric oxygen therapy requires special supervision during the treatment and often a medical referral. |

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|---|---|---|
| **Indications** | - Treatment of hard-to-heal wounds,<br>- Acceleration of recovery after surgery<br>- Chronic diseases of the skin psoriasis, urticaria, rash, erythema, atopic dermatitis, acne)<br>- Diseases associated with tissue hypoxia<br>- Treatment of oedema<br>- Cardiovascular diseases (atherosclerosis, hypertension)<br>- Nervous system diseases<br>- Autoimmune diseases and other chronic inflammatory diseases.<br>- Chronic fatigue<br>- Slowing down the ageing process | |
| | | - Decompression sickness |
| | | - Carbon monoxide poisoning |
| | | - Necrotizing infections and acute ischemia of soft tissue |
| | | - Musculoskeletal and multi-organ injuries |
| | | - Thermal burns |
| | | - Idiopathic sudden hearing loss<br>- Diabetic foot syndrome (lll-IV degree of Wagner scale) |
| | | - Infection, ulcers, inflammation |
| **Contraindications** | **Unknown** | - Haemorrhage |
| | | - Certain lung diseases |
| | | - Pacemaker |
| | | - Pregnancy |
| | | - Optic neuritis |
| | | - Fever |
| | | - Pneumothorax and lung surgery within the chest |
| | | - Convulsions |
| | | - Acute ear disorders |
| | | - Sinusitis |

Normobaria is little known area of science. In Poland Dr. Jan Pokrywka is one of its pioneers.

He built a normobaric house, where he lives examine his patients.

Normobaric chambers produced by OXYroom are present on the Polish market and used for regeneration and biological renewal. They were also used to conduct a research evaluatingthe influence of a controlled normobaric environment on vascular endothelial functional parameters, cardiovascular functional parameters and on the autonomic nervous system, as well as on cognitive functions. The research was carried out by a team of scientists managed by Prof. Pawel Zalewski of Collegium Medicum of Nicolaus Copernicus University in Torun. If the efficiency and safety of normobaric exposure are confirmed by scientific studies, then the wide availability of normobaric chambers may provide a new quality in the approach to the preventive healthcare.

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