IHHE, HBOT and sportsmedicine

1. Introduction

Oxygen is an often neglected nutrient because it is absorbed in the human body through the lungs and not, like all other nutrients, through the gastrointestinal tract. Oxygen is key for human cells to perform so-called aerobic respiration, which takes place in the mitochondria. This makes oxygen one of the essential nutrients for our cells.

However, if there is a lack of oxygen in the tissues, a condition called hypoxia can occur.

2. Intermittent Hypoxia Therapy (IHT)

Intermittent hyperoxia-hypoxia training (IHHT) is used for its health-promoting effects both as adjuvant therapy for chronic diseases and as an essential component of preventive medicine. The goal here is to non-specifically increase physical resistance by optimizing mitochondrial respiration.

In particular, intermittent hypoxia training programs have been shown to be especially effective. Normobaric hypoxia systems have been shown to be inexpensive and effective alternatives to costly stays in the mountains. Based on these findings, a new form of hypoxia exposure (Intermittent Hypoxia-Hyperoxia Training, IHHT) with recovery phases was developed. This involves the inhalation of hypo- and hyperoxic gas mixtures in alternating minute intervals. It has been shown that this therapy regime is particularly well tolerated and yet achieves similar clinical successes such as improving physical resilience or rebalancing the autonomic nervous system.
Adaptation is induced by inhaling a hypoxic gas mixture in a discontinuous mode, resulting in a repetitive shift, or "swing," in blood oxygen saturation (SpO2) from 100-94% to 86- 78%. The oxygen content of the inhaled air varies between 20.9% (room air) and 10-14% (via the mask). It is the alternation of these different oxygen contents that has proven particularly effective in stimulating mitochondrial biogenesis and mitophagy.

Continuous renewal of mitochondria can reduce oxidative stress, increase the efficiency of oxidative metabolism, slow the aging process, and prevent and/or delay the development of age-related diseases. IHT induces mitochondrial recovery at the cellular level. Hypoxia controlled in time and intensity leads to a positive change in the respiratory chain (TCA).

What reactions can be observed in the patient's body immediately after IHT? A positive physiological reaction is already evident after 15-30 minutes. Patients describe the onset of a state of general calm, often accompanied by relaxation and drowsiness, slowing of breathing and heart rate. Sleep and mood improve after only one or two sessions.

Indications:
- chronic and stress-related diseases (including exhaustion, sleep disorders)
- metabolic syndrome (diabetes mellitus type 2, arterial hypertension and obesity)
- chronic musculoskeletal pain syndromes (including tension, herniated discs)
- chronic cardiovascular diseases
- chronic lung diseases

- neurodegenerative diseases (e.g. dementia, Alzheimer's disease, Parkinson's disease)
- chronic psychological disorders (e.g. depression) including syndromes with fatigue symptoms (e.g. post-viral fatigue syndrome, burn-out syndrome, fibromyalgia)
- psychovegetative syndromes (including inner restlessness)
- rheumatic diseases
- cancer diseases
- LongCoVid

Contraindications:
- myocardial infarction within the last three months
- unstable angina pectoris
- acute ischemic stroke within six months)
- acute infectious diseases
- chronic renal failure requiring dialysis
- poorly controlled arterial hypertension
- severe peripheral circulatory disorder
- congenital anomalies of the heart and large blood vessels
- thrombosis and embolism complications
- primary and secondary polycythemia
- personal intolerance to hypoxia
- psychological or mental disorders.

3. Hyperbaric Oxygen Therapy (HBOT)

Hyperbaric oxygen therapy is a treatment for hypoxic and inflammatory conditions. HBOT consists of the delivery of pure oxygen under elevated pressure. Depending on the protocol, the estimated duration of the session varies from 1.5 to 2 hours and can be performed one to three times daily, with between 20 and 60 therapeutic doses administered depending on the condition.

The creation of a hyperbaric environment with pure oxygen allows a significant increase in oxygen delivery to the blood (hyperoxemia) and tissues (hyperoxia). Thus, hyperbaric ventilation has multiple effects in the organism and can be used to support clinical treatment of various pathological processes such as wound healing, tissue destruction or circulatory disorders.

Indirectly, HBOT leads to better healing, reduced inflammatory response and improved blood flow. Hyperoxic tissue heals faster and more completely due to the readily available oxygen required for collagen formation. With the increased ability to form new vessels, nutrients are transported to the injured area more quickly through newly formed capillary beds, allowing for better healing. The benefits of HBOT include reducing inflammation (incl. antimicrobial activity), attenuating reperfusion injury, promoting wound healing, and improving blood flow.

Interestingly, many of the mediators and cellular mechanisms triggered by hypoxia are also seen in intermittent hyperoxia. This is referred to as the hyperoxic-hypoxic paradox. As with intermittent hypoxia, short-term hyperoxia can lead to favorable cellular outcomes.

Currently, there are 14 approved indications for HBOT. Most of these uses can be grouped according to three main effects: (a) acceleration of wound healing and promotion of blood flow (angionesis), (b) exertion of antimicrobial effects, and (c) as a medical emergency.

Classic clinical indications:
- Air or gas embolism
- Acute thermal burn injury
- Carbon monoxide poisoning
- Wound healing disorders
- traumatic ischemia
-Decompression sickness
- Tinnitus and idiopathic hearing loss
- Severe Anemia

Off-label Use:
- Long-CoVid
- Improved Brain Performance
- Autoimmune Diseases
- Neurodegenerative Diseases
- Erectile Dysfunction

Special Attention:
In clinical practice, HBOT has been shown to accelerate wound healing. HBOT can therefore be an excellent adjuvant in the post-surgical care. The use of HBOT as an antimicrobial adjuvant is particularly useful in healing wounds, as microbial infections are the leading cause of non-healing wounds.

Other therapeutic areas:
HBOT can also be used in the regulation of inflammatory responses and the resulting complications. In this sense, the role of HBOT in the treatment of autoimmune diseases (AD) has been proposed. HBOT has also demonstrated efficacy in rheumatoid arthritis. These results can also be applied to other inflammatory diseases.
Fibromyalgia is a disease characterized by widespread muscle and joint pain, often accompanied by systemic symptoms such as cognitive dysfunction, mood disorders, fatigue and insomnia. HBOT directly affects brain activity, chronic pain and immune system dysregulation, improving the quality of life of affected patients.
HBOT can also be used in the therapy of long-covid: it has bioenergetic, anti-inflammatory, anti-coagulant and tissue-healing effects. In addition, HBOT seems to have a positive effect on patients with erectile dysfunction, after strokes and brain injuries.
The application of HBOT could potentially be extended to new areas such as aging. Research has reported the effect of hyperbaric oxygen in preventing telomere shortening and by eliminating pathologically altered cells.

Offlabel Use:
Although the use of HBOT for brain-related impairments has not yet been approved by the FDA, there are numerous studies showing improved cognitive performance after treatment. HBOT increases cerebral blood flow, which is associated with restoration of physical abilities and cognitive function. HBOT may also have a positive effect on healthy people or slow cognitive decline in older people suffering from cognitive impairment. HBOT resulted in improved sleep, learning curve, and higher cognitive performance such as memory.

Contraindications:
The two most common complications of HBOT are claustrophobia and barotrauma. Rarely, transient hyperbaric myopia occurs.

Absolute contraindications:
- Pneumothorax
- Globular cell anemia
- Decompensated heart failure

Relative contraindications:
- Digital implants and pacemakers
- Pregnancy
- Severe COPD, bronchial asthma, acute upper respiratory tract infections
- Poorly controlled diabetes
- Poorly controlled arterial hypertension
- Acute febrile infection
- Use of penicillin or disulfiram
- Positive history of epileptic seizure, hypoglycemic event, untreated hyperthyroidism

3. Conclusion

HBOT is definitely the more powerful therapeutic agent in oxygen treatment. Its main goal are physiological adaptions such as wound or fracture healing. However, HBOT needs more and longer sessions to reach its real beneficial effect. Additionally, HBOT has more contraindications, needing more administration during the session by specialized staff. IHT, on the other hand, is a soft alternative, affection the patient's ANS immediately, with physiological adaptions after several sessions as well. IHT has nearly no harmful side-effects. Therefore, it is necessary to know about the patient's needs in order to choose the right therapeutic regime.

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