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System-wise effectiveness of hyperbaric oxygen therapy: A review

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Abstract
Hyperbaric Oxygen Therapy (HBOT) offers diverse benefits across multiple physiological systems. By boosting oxygen delivery and regulating cellular responses, HBOT proves effective in healing wounds, controlling infections, and regenerating tissues. Its therapeutic effects extend to cardiovascular, nervous, and respiratory systems, enhancing heart function, protecting neurons, and improving lung function. HBOT also shows potential in treating autoimmune diseases, chronic pain, and spinal cord injuries. Its anti-inflammatory and Immunomodulatory properties contribute to benefits in digestive, urinary, and skin health. Moreover, HBOT's applications in reproductive health, including male and female fertility, are promising. This review underscores HBOT's broad therapeutic potential in promoting overall tissue health and well-being.

Keywords: Hyperbaric Oxygen Therapy (HBOT), system-wise effectiveness, wound healing, therapeutic applications

1. Introduction

Hyperbaric Oxygen Therapy is a specialized medical treatment in which a patient breathes 100% oxygen while inside a sealed chamber that has higher than normal air pressure. This process allows extra oxygen to dissolve into bloodstream, reaching tissues that may not be getting enough oxygen due to injury, infection, or poor circulation. According to the Undersea and Hyperbaric Medical Society (UHMS), Hyperbaric Oxygen Therapy (HBOT) is defined as an intervention where the body is intermittently exposed to 100% oxygen at pressures exceeding 1 atmosphere absolute (ATA) (Levett, Bennett, & Millar, 2015; UHMS, 2019) [1].

2. Review methods

Our review of the effects of hyperbaric therapy draws on data analyzed from PubMed, and Google Scholar.

3. The state of knowledge

3.1 The key effects of hyperbaric oxygen therapy [2, 3]

- **Wound healing dynamics:** Hyperbaric oxygen therapy orchestrates a symphony of cellular responses that accelerate wound closure and tissue regeneration.
- **Infection control mechanism:** By modulating oxygen levels in the bloodstream, HBOT creates an environment that disrupts the pathogenicity of microorganisms and enhances the host's defense mechanisms.
- **Bacterial growth inhibition:** The therapeutic effects of HBOT include the suppression of anaerobic bacterial proliferation, which is crucial for preventing wound infections.
- **Immunomodulatory effects:** HBOT's ability to restore neutrophil function plays a pivotal role in augmenting the body's innate immune response and fighting infections.
- **Reperfusion injury mitigation:** Hyperbaric oxygen therapy exerts a protective effect on tissues by reducing leucocytes adhesion and inflammation during reperfusion injury.
- **Neurological recovery and plasticity:** HBOT's Neuroprotective properties facilitate improved neurological outcomes by promoting neural adaptation and recovery after traumatic brain injury.
- **Cellular protection:** By inhibiting apoptotic pathways, HBOT safeguards against cellular damage and preserves tissue integrity in the brain and other organs.
- **Systemic anti-inflammatory response:** The therapeutic benefits of HBOT include a reduction in systemic inflammatory markers, which contributes to overall health and well-being.
- **Tissue engineering and regeneration:** HBOT's ability to stimulate angiogenesis and collagen production makes it an effective treatment for promoting tissue repair and regeneration.
- **Pain modulation:** Hyperbaric oxygen therapy has been shown to alter pain perception and improve functional capacity in individuals with chronic pain syndromes.

3.2 Therapeutic efficacy of HBOT in various physiological systems

Cardiovascular system	• It increases the Left Ventricular Ejection Fraction in acute MI. • Myocardial repair and enhance cardiac function in heart failure. • Decreases the frequency and duration of paroxysmal tachycardia and premature ventricular contraction in case of arrhythmias. • Increases oxygen delivery to ischemic and reperfused tissues, enhancing tissue oxygenation. • Promotes Angiogenesis [4]
Nervous system	• Enhance neuro metabolism. • Prevent delayed neurological effects of carbon monoxide poisoning. • Protective effects through attenuation of the selective motor neuron death in case of SCI. • Mitigates spinal cord injury by decreasing edema, improving neuronal function, and stabilizing the blood-spinal cord barrier via regulation of MMP-2, IL-6, MMP-9, and VEGF. • Modulate Blood Brain Barrier permeability. • Elevates IL-10 overproduction, neurogenesis, and angiogenesis in case of TBI. • Enhance neuroprotection and improve prognosis through inhibiting cerebral edema in brain injury. • It protects the nerve fibres from ischemia. • Decreases neuropathic pain. • It shows potential in slowing neurodegenerative disease progression [5]
Respiratory System	• Supports cellular respiration and helps overcome severe anemia by delivering sufficient plasma oxygen. • Elevates vasoconstriction. • Improve lung function and Efficiency. • Anti- inflammatory effects which reduce airway inflammation in asthma [6]
Endocrine system	• Significantly reduces blood glucose level and lipid profile [7] • Faster the diabetic foot wound healing. • Regulates the nitric oxide synthesis in diabetes mellitus [8] • Useful in increasing the level of T3 and T4 in early hypothyroidism [9]
Digestive system	• Stimulate stem cell production, enhancing cellular regeneration and repair, which can be particularly beneficial for conditions like stomach ulcers and gastrointestinal issues. • Reduce systemic inflammation, promoting overall health and well-being. • Improve circulatory function, boosting blood flow and lymphatic drainage. • Promotes optimal cellular function by enhancing nutrient uptake and facilitating cellular cleansing. • Optimize endocrine function, accelerating metabolic rate and potentially aiding in weight management. • Support treatment of various conditions, including gastrointestinal disorders such as inflammatory bowel disease, pancreatitis, and peptic ulcers [10]
Urinary system	• Increase the bladder capacity, leading to a decrease in symptoms of frequent urination (pollakiuria), particularly nocturia (nighttime urination). • Augments the effectiveness of chemotherapy and radiation therapy for prostate cancer treatment. • Reduce the frequency of surgical procedures after multiple sessions in case of pyelonephritis. • It effectively alleviates hematuria and dysuria while enhancing bladder mucosa health. • Efficiently treats urinary retention and gas cystitis. • Protective effects on kidney tissues which have suffered on acute ischemia [11]. Protective effects on kidney tissues which have suffered from an acute ischemia protective effects on kidney tissues which have suffered from an acute ischemia protective effects on kidney tissues which have suffered from an acute ischemia
Skeletal system	• Osteomyelitis. • Chronic soft tissue infections. • Stimulates osteoblastic properties. • Heals degenerative disease of bone (osteoarthritis) [12]. • Treats acute and chronic spinal pain. • boosts fibroblast, collagen, and elastin production, enhancing tissue health [13].
Immune system	• Reduce pro inflammatory acute phase proteins • Increases the growth factors [14]. • Boosts tissue oxygen, restoring leukocytes' bacterial-killing ability in hypoxic wounds. • Functions as a potent agent that either inhibits the growth of bacteria (bacteriostatic) or directly kills bacterial cells (bactericidal) by increasing the formation of free oxygen radicals [15].
Integumentary system	• Treats burns & heals allogenic skin grafts faster. • Heals skin ulcers and inflammation of subcutaneous tissues. • Supports treatment of autoimmune diseases like atopic dermatitis and psoriasis by reducing oxidative stress and modulating T_{reg} cells [16].
Reproductive system	• Increase sperm morphology and density. • serves as a valuable adjunctive treatment for male infertility [17]. • Improve the quality of oocytes and fertility of aged females [18].

Conclusion

Hyperbaric Oxygen Therapy (HBOT) is a game-changer. By boosting oxygen flow, reducing swelling, and helping cells regenerate, it's shown real promise in treating a range of health issues. From helping wounds heal faster to supporting heart health and brain function, HBOT's benefits are wide-ranging. It can even help with conditions like chronic pain, autoimmune diseases, and spinal cord injuries. As research continues to uncover its potential, HBOT is looking like a valuable tool in the medical world.

Declarations

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