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Review Article

Hyperbaric Oxygen therapy and anti-aging Practice and Protocols

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Abstract

In the quest for effective anti-aging solutions, this paper explores the potential of Hyperbaric Oxygen Therapy (HBOT) as a promising, noninvasive approach. HBOT involves exposure to high-pressure oxygen environments and has demonstrated notable effects, including the reduction of senescent cells, promotion of angiogenesis, and improvement in tissue health. Emerging protocols featuring intermittent exposure to hyperbaric conditions have shown promise in increasing length of the telomere, enhancing cognitive function, and rejuvenating various physiological aspects. Despite promising preclinical results, the lack of substantial clinical trial data remains a gap, and concerns about potential adverse effects persist. Standardized protocols, guidelines, and biomarkers are crucial for optimizing the potential benefits of HBOT in anti-aging strategies. Further research is imperative to ascertain ideal treatment parameters and safety profiles, particularly for individuals seeking healthy aging outcomes.

Keywords: Hyperbaric oxygen therapy; Anti-aging; Senescent cells; Telomere; Standardized protocols; Healthy aging.

Introduction

Aging is a multifaceted biological phenomenon associated with various mechanisms, including cellular senescence, telomere shortening, oxidative stress, inflammation, and epigenetic modifications [1,2]. It not only significantly impacts one's quality of life but also constitutes a significant contributing factor to various age-related illnesses [3]. Hence, there is a pressing necessity to discover appropriate interventions that decelerate the aging process and mitigate or delay the onset of incapacitating age-associated ailments [4]. Numerous strategies for combating aging are currently under development. These encompass methods such as enhancing autophagy [5], eliminating senescent cells [6], infusing young blood plasma [7], practicing intermittent fasting [8], engaging in regular physical exercise [9], increasing antioxidant consumption [10], and exploring stem cell

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therapy [11]. These approaches hold promise for maintaining overall health and for delaying the onset of age-related diseases [12]. However, established therapies, like young plasma transfusion and stem cell grafting, entail a degree of invasiveness. While they exhibit sufficient safety profiles, relying solely on lifestyle modifications such as physical exercise and intermittent fasting may not guarantee conclusive effectiveness. On the other hand, serotherapeutic, as a noninvasive strategy, remain relatively unexplored in humans and are in the early stages of development for routine clinical application. This is primarily attributed to the intricate, time-consuming, and costly nature of the pharmacological development process. Consequently, as researchers strive to enhance current approaches, they are also exploring new avenues for achieving healthy aging that are noninvasive, sufficiently potent, and user-friendly. One such promising contender in this pursuit is Hyperbaric Oxygen Therapy (HBOT) [3,13].

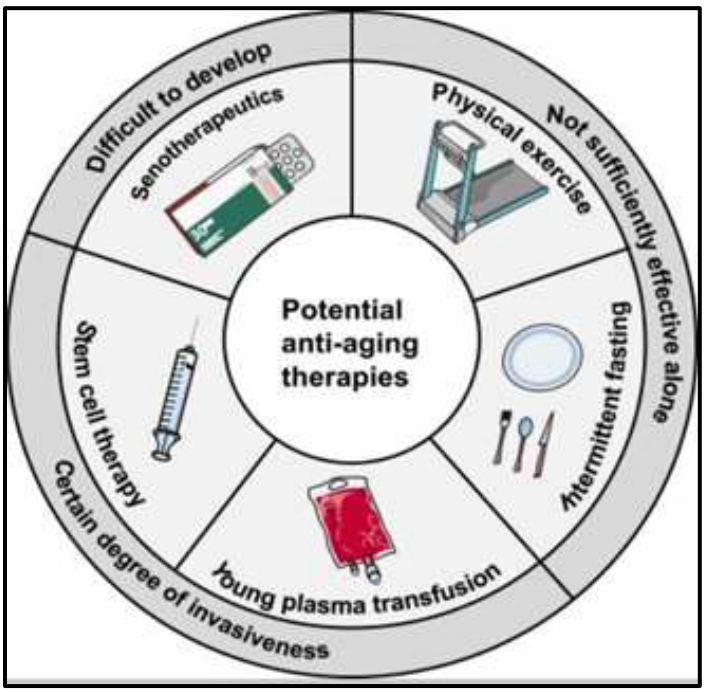

Figure 1: Possible approaches to combat aging and their limitations [3].

Hyperbaric oxygen therapy and its role in anti-aging

Hyperbaric oxygen therapy (HBOT) involves exposing the body to an environment with pressures greater than one absolute atmosphere (ATA) while breathing 100% oxygen [14,15]. It has evolved into a firmly established therapeutic approach for numerous medical conditions. The noninvasive character, excellent safety record, and widespread clinical use of HBOT position it as a strong candidate for various novel applications, including addressing the challenges of aging and age-related diseases [13,16].

HBOT demonstrated notable effects in modifying the aging process by reducing the presence of senescent cells, promoting the

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formation of new blood vessels (angiogenesis), and enhancing the length and stability of elastic fibers while increasing collagen density [17]. Moreover, this therapy is employed to expedite tissue healing and enhance its physiological characteristics by delivering an augmented oxygen supply to the injured tissue [18,19].

While oxygen is crucial for tissue balance and the overall survival of organisms, paradoxically, it is also regarded as a fundamental catalyst for the aging process. Oxygen functions as a generator of reactive oxygen species (ROS), which can have advantageous roles in specific contexts.

However, the excessive production of ROS has the capacity to initiate the progressive deterioration of macromolecules, encompassing lipid peroxidation, impaired protein function, and DNA impairments. All of these factors collectively contribute to the aging process [20,21].

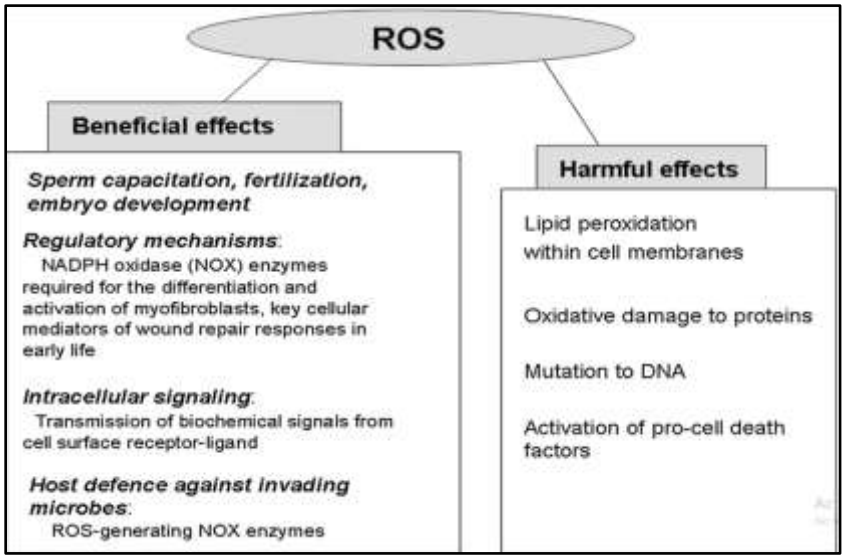

Figure 2: Benefits and drawbacks of Reactive Oxygen Species (ROS) [20].

Although its efficacy in addressing the aging process is still a subject of discussion, research conducted by Tel Aviv University (TAU) and the Shamir Medical Center in Israel has revealed that a distinct treatment regimen involving high-pressure oxygen in a pressure chamber has the potential to reverse two significant aging-related phenomena: the reduction in telomere length and the buildup of aged and dysfunctional cells within the body [22,23]. HBOT delivers its positive outcomes, including the promotion of angiogenesis, reduction of inflammation, reinforcement of antioxidant defenses, and activation of stem cells, have the potential to play a role in countering the aging process by improving tissue health, lowering oxidative stress, and enhancing cellular repair and rejuvenation [24].

Similarly, additional research has corroborated these outcomes in aging skin, by expediting the proliferation of epidermal basal cells [25], in endothelial cells by stimulating the expression of antioxidants [1] and in the brain, where HBOT seems to enhance cerebral blood flow [26].

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These collective findings suggest that HBOT possesses anti-aging properties [27].

Emerging HBOT protocols for anti-aging

In recent times, Hyperbaric Oxygen Therapy (HBOT) has found application in novel medical contexts, employing protocols featuring reduced oxygen pressure levels (2 ATA or lower) and an increased frequency of daily sessions (40-60 sessions) [28].

A particular emerging regimen, characterized by repeated intermittent exposure to hyperbaric conditions, has demonstrated the potential to induce a range of effects in aging individuals [3,29]. These effects encompass alterations in the transcriptome [30], extension of telomeres [22], enhanced cognitive function [26], rejuvenation of the skin [31], and improvement in pulmonary function parameters [28].

Additionally, it can enhance mitochondrial function and cellular metabolism, minimize inflammatory responses, decrease apoptosis (cell death), mitigate oxidative stress, and promote the initiation or facilitation of angiogenesis [32].

The protocol comprises 60 consecutive daily sessions of HBOT, involving 100% oxygen at 2 ATA for 90 minutes, interspersed with intermittent air breaks. This process triggers physiological effects typically associated with a hypoxic state, with the exception of an increase in mitochondrial metabolism due to the activation of SIRT1 [31,33]. These findings will establish a robust groundwork for further investigation. Another approach, a modified version of HBOT known as mild hyperbaric oxygen therapy, delivers appropriately high atmospheric pressure alongside 35-40% oxygen [34,35]. This therapy has determined that exposure to hyperbaric conditions with moderate atmospheric pressure and oxygen levels have a positive impact on the oxidative metabolism within cells and tissues [34-36]. Despite the initial anticipation that HBOT may induce substantial oxidative stress, research indicates that a single exposure to hyperoxic conditions leads to a temporary increase in reactive oxygen species (ROS) generation [37,38]. However, when HBOT sessions are repeated, they stimulate a response involving antioxidants resulting in a protective effect and the restoration of ROS levels to normalcy [39,40].

While preclinical studies have showcased significant potential, the absence of substantial clinical trial data for this modified therapy remains a notable gap. Further research is needed to determine efficacy, sustainability, and optimal treatment conditions, including oxygen pressure, exposure time, frequency, and age range [13-41]. Additionally, concerns persist about potential adverse effects such as claustrophobia, barotrauma, and visual issues due to the unique atmospheric environment during HBOT [42].

Furthermore, when considering healthy aging individuals rather than patients with specific conditions like pneumothorax, it is likely that the tolerance for side effects is even more limited [3].

Hence, in order to optimize the potential advantages of Hyperbaric Oxygen Therapy (HBOT) in anti-aging approaches, the establishment of standardized protocols and guidelines becomes imperative [43].

Moreover, research efforts should be directed toward the identification of biomarkers capable of objectively quantifying the impact of HBOT on aspects associated with aging.

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Conclusion

In conclusion, aging is a complex process influenced by various mechanisms, and addressing it is crucial due to its impact on quality of life and age-related diseases. It is a scientific measurable process which we would propose that some aspects can be influenced with available technology. Numerous strategies, from eliminating senescent cells to exploring HBOT, show promise in this endeavor. HBOT, in particular, exhibits potential in reversing aging-related phenomena, and its mechanisms suggest anti-aging properties. However, further research, particularly in modified HBOT regimens, is essential to establish efficacy and safety. Standardized protocols and biomarkers are needed to optimize its potential in anti-aging approaches.

Conflict of Interest

None

Author's Contribution

Dr. Gordon Slater: Lead designer of Integrant a Biotechnology Company and is also the Director of Regen U clinics.

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