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Section II – Exercise Physiology and Sports Medicine

Ten Sessions of Hyperbaric Oxygen Therapy Fail to Improve Physical Performance or Body Composition in Healthy Young Men

by
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Hyperbaric Oxygen Treatment (HBOT) is a therapeutic method that combines the effects of hyperoxia and increased pressure. This clinical trial aimed to assess how ten HBOT sessions would influence body composition and physical performance of healthy young men, and whether the frequency of treatment would affect these outcomes. Healthy adult males were enrolled and randomized into three groups: a control group (n = 15), frequent HBOT users (six sessions per week; n = 20), and rare HBOT users (three sessions per week; n = 19). Participants in the intervention groups received ten 60-min sessions of 100% oxygen at a pressure of 2.5 atmospheres absolute (ATA). Participants underwent body composition evaluation and performed an incremental treadmill test before and after the intervention. Marginal but statistically significant reductions in body mass and the body mass index (BMI) were observed only in the rare HBOT users. In both intervention groups, but not in the control group, a significant increase was noted in the maximal speed and distance covered during the treadmill test. Additionally, rare HBOT users showed a significant increase in relative maximal oxygen uptake, while absolute VO_{2max} *remained unchanged. The main finding of our study was that ten hyperbaric oxygen treatments did not significantly enhance body composition or physical capacity in healthy young men. Furthermore, our study showed no indications for the daily HBOT administration in healthy individuals; instead, the findings suggested potential benefits from a less frequent, extended treatment protocol.*

Keywords: *HBOT; body mass; fat mass; maximal oxygen uptake*

Introduction

Hyperbaric Oxygen Treatment (HBOT) is a therapeutic method that involves inhaling nearly 100% (>99% oxygen purity) medical-grade oxygen at pressures greater than 1 atmosphere absolute (ATA), equivalent to 101.3 kilopascals (kPa). The Undersea & Hyperbaric Medical Society (UHMS), however, recommends using a higher pressure—at a minimum of 2 ATA (202.65 kPa)—for effective HBOT treatment.

Breathing nearly 100% oxygen creates a positive gradient, promoting greater diffusion from hyperoxygenated lungs to hypoxic tissues. Concurrently, with increased pressure in the hyperbaric chamber, oxygen solubility in plasma increases significantly—the greater amount of gas dissolves in the liquid, and existing gas bubbles are decreased in size (Ortega et al., 2021). Breathing pure oxygen at 1 ATA increases plasma oxygen solubility threefold, and at pressures of 2–3 ATA (used in high-pressure HBOT) solubility can increase by as much as 10–20 times compared to atmospheric pressure (Chander et al., 1999).

Improved oxygenation of muscles, especially distal ones, raises expectations of increased muscular endurance, which could translate into longer and/or more efficient exercise performance. However, in various research settings, it has been demonstrated that a single exposure to 95–100%

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oxygen under hyperbaric conditions (2.0–2.5 ATA; 60–90 min) has no direct ergogenic effect on exercise performance in trained individuals (Hodges, 2003; McGavock et al., 1999; Webster et al., 1998). Only in a specific population, i.e., very young and unfit female students, one session of HBOT (2.8 ATA; 60 min) caused significant changes in physical performance. Maximal oxygen uptake increased, but only within a limited time frame, up to 3 hours after the HBOT session (Cabrić et al., 1991).

Yet, repeated high-pressure hyperbaric treatment induces certain physiological mechanisms that may influence human metabolism and, ultimately, physical performance and body composition. Primarily, 40 daily sessions of HBOT at 2.0 ATA are known to increase the number of mitochondria (mitochondrial mass) and their activity, specifically, maximal oxygen phosphorylation capacity and maximal uncoupled capacity (Hadanny et al., 2022). As a result, hyperbaric oxygen can enhance the efficiency of aerobic metabolism and concurrently improve exercise endurance. In mice, following four weeks of daily administration (2.0 ATA; 60 min), enhanced aerobic metabolism was evidenced by increased fatty acid oxidation, which, as a cumulative effect, resulted in a reduction in fat body mass (Yuan et al., 2020). Studies on single HBOT (2.0–2.5 ATA; 60–90 min) performed in healthy individuals, obese patients, and those with Type 2 diabetes suggest that, by increasing peripheral insulin sensitivity, HBOT modulates glucose metabolism (Fu et al., 2022; Wilkinson et al., 2012), and therefore may serve as a supplementary intervention for weight control. Furthermore, HBOT promotes the production of anti-inflammatory factors and enhances antioxidant defense mechanisms (Fu et al., 2022). Supplemental oxygen (2.5 ATA; one 30-min session or ten 60-min sessions) may facilitate healing processes and the removal of waste products (Sueblinvong et al., 2004), thereby aiding the recovery of sore and/or damaged muscle tissue (Chen et al., 2019). Recent research on the prolonged effects of HBOT (1.3–2.5 ATA; 30–60 min; 1–10 sessions) in the sports science field has focused on improving the rate of tissue recovery from various types of injuries and accelerating post-exercise restitution (Mekjavic et al., 2000; Moghadam et al., 2020; Park et al., 2018).

In the context of recreation and sports, studies have been conducted on relatively small sample groups, using study protocols that varied greatly in terms of: 1) hyperbaric pressure (1.3–2.8 ATA), 2) duration of a single session (30–90 min, 3) frequency of treatments (twice a week–daily), and 4) total number of treatments (1–40). Combined with a high risk of bias and the placebo effect, there is currently insufficient evidence to confirm or refute whether hyperbaric oxygen treatment can improve athletic performance (Harrison et al., 2001; Huang et al., 2021; Šet and Lenasi, 2023).

Currently, there are no reliable guidelines regarding the optimal number and frequency of HBOT sessions. Depending on the medical condition, therapeutic doses are recommended one to three times daily over several weeks, ranging from 20 to 60 exposures (UHMS). However, with emerging research (Lee et al., 2023) and the expansion of HBOT indications (e.g., beauty or fitness sectors), the appropriate number and frequency of treatments remain undefined.

This study aimed to evaluate the effects of ten Hyperbaric Oxygen Treatments at a pressure of 2.5 ATA on body composition and physical capacity in young, healthy men, and to determine whether the frequency of individual treatments would influence therapeutic outcomes. Based on this aim, we hypothesized that a series of 10 hyperbaric oxygen therapy sessions at 2.5 ATA would enhance physical capacity by increasing maximal oxygen uptake, while simultaneously reducing body fat and overall body mass through increased fat oxidation driven by improved oxygen availability. Furthermore, we expected that these effects would be more pronounced with a higher frequency of treatments.

Methods

Participants

The study included three groups of recreationally trained, healthy young adult males (aged 18–35 years). As shown in the flow diagram (Figure 1), 80 men who were willing to participate were considered eligible. The exclusion criteria were: 1) prior use of HBOT; 2) reported history of any chronic disease; 3) injuries that impaired the ability to run; 4) abnormal resting electrocardiogram results; 5) pressure-sensitive chest, ear, or sinus conditions; and 6) active smoking. Using a simple randomization method based on a single sequence of dice rolls, 66 of the eligible men were randomly assigned to three study groups. Twenty participants were assigned to the control group and were instructed not to change their current lifestyle during the study period. The remaining participants were allocated to receive HBOT and were divided into two subgroups based on the treatment frequency: frequent users (SGF; 6 sessions per week; n = 23) and rare users (SGR; 3 sessions per week; n = 23). After accounting for all drop-outs, data from 54 participants were included in the final statistical analysis.

One-way ANOVA with the Bonferroni post-hoc test showed that frequent users (n = 20; 27.20 ± 4.11 years) were significantly older (p = 0.008) than both rare users (n = 19; 23.84 ± 2.57 years) and controls (n = 15; 23.60 ± 2.95 years). There were no significant differences among the groups in terms of body height (SGR: 180.91 ± 6.69 cm; SGF: 180.42 ± 6.00 cm and CG: 181.15 ± 5.70 cm; p = 0.936) or body mass (SGR: 81.05 ± 11.24 kg; SGF: 77.44 ± 8.90 kg and CG: 82.63 ± 10.34 kg; p = 0.300).

Participants were advised not to alter their average daily food intake or physical activity levels during the study period. To monitor compliance, they completed detailed questionnaires, including 3-day dietary diaries and the International Physical Activity Questionnaire (IPAQ), at two time points: the beginning and the end of the study. There were no significant differences in the level of physical activity or average caloric intake between baseline and post-intervention. Comparative analysis among the groups only revealed significantly higher protein consumption in the SGR compared to the SGF group at both time points.

The recruitment period spanned from April 1, 2022, to November 30, 2022. All participants were informed about the study's objectives and procedures and provided written informed consent. The project was approved by the Ethics Committee at the Poznan University of Medical Sciences, Poznań, Poland (approval code: 953/21; approval date: 09 December 2021) and in accordance with the Declaration of Helsinki. The study was also registered in a clinical trials registry under the trial number NCT06284603.

Design and Procedures

A controlled experimental study was performed. Study participants underwent 10 sessions of hyperoxia under hyperbaric conditions, with varying frequencies of individual treatments (three or six times per week). The Perry Baromedical monoplaced hyperbaric oxygen therapy chambers (Riviera Beach, Florida, USA), located at the Baromedical Medical Center Ltd. in Poznań (under an agreement between the university and the center), were used for the intervention. Considering the UHMS guidelines which recommend using a pressure of ≥ 2.0 ATA for clinical effect, and in accordance with best practices at the center, each session consisted of 60 min of exposure to 100% oxygen (3 intervals of 20 min, with two 5-min breaks in between) at a pressure of 2.5 ATA (Laspro et al., 2024; UHMS). Oxygen was administered through a face mask, which was removed twice for 5 min during the session, in accordance with verbal instructions and agreed-upon signs from certified staff.

The study protocol included two visits to the Human Movement Laboratory "LaBthletics" at the Department of Athletics, Strength and Conditioning, Poznan University of Physical Education, Poznań, Poland. Testing procedures were conducted the day before the first treatment (before) and the day after the final HBOT session (after). Participants were instructed to refrain from any high-intensity or prolonged training sessions, as well as avoid alcohol consumption, for at least 24 hours prior to testing. During all measurements, the ambient temperature remained at 20–21°C. Participants were previously familiarized with the procedures and testing protocols.

On the testing day, participants arrived at the laboratory in a fasting state in the early morning hours. Body mass and height were measured using a digital analyzer (SECA 285, Hamburg, Germany). The body mass index (BMI) was later calculated by dividing body mass by height squared. Body composition was assessed using dual X-ray absorptiometry (DXA; Lunar Prodigy Pro device; GE Lunar Healthcare, Madison, WI, USA) and analyzed using enCORE v. 16 SP1 software. To minimize measurement error, participants wore only undergarments and removed all jewelry and metal objects. Measurements were carried out according to standardized DXA scanning protocols (Hind et al., 2011; Nana et al., 2016). Following a light breakfast (excluding coffee and tea), participants underwent a Cardiopulmonary Exercise Test (CPET). Capillary blood samples (20 μL) were collected from the fingertip immediately before and three minutes after the test to assess lactate concentration using a spectrophotometric enzymatic method (Biosen C-line, EKF Diagnostics, Barleben, Germany).

Maximal oxygen uptake (VO_{2max}) was measured using a ramp incremental running test on a treadmill (h/p/cosmos Sports & Medical, Germany). The protocol began with 3 min of standing followed by 3 min of walking at 4 km/h. Thereafter, the speed increased gradually by 0.67 km/min (increment of 2 km/3min) until volitional exhaustion. Oxygen uptake was measured with the use of a portable breath-by-breath ergospirometer (MetaMax 3B-R2, MetaSoft Studio software 5.1.0, Cortex Biophysics GmbH, Leipzig, Germany). The heart rate (HR) was recorded continuously using the Polar H9 heart rate sensor (Polar Electro, Oy, Kempele, Finland). VO_{2max} was considered achieved if at least three of the following criteria were met: (i) a plateau in VO_2 despite increasing running speed, (ii) blood lactate concentration ≥ 9 mmol/l, (iii) respiratory exchange ratio ≥ 1.10, and (iv) heart rate ≥ 95% of the age-predicted HR_{max} (Edvardsen et al., 2014).

The first ventilatory threshold (VT1)—the exercise intensity above which aerobic metabolism is supplemented by anaerobic pathways—was estimated using a modified V-slope method, supported by the ventilatory equivalent method (VE/VO_2 method) and the end-tidal O_2 pressure method ($PetO_2$). The respiratory compensation point (RCP; VT2)—the intensity of exercise above which blood lactate concentration increases exponentially—was estimated based on the nonlinear increase in VCO_2, hyperventilation, and a drop in end-tidal CO_2 pressure ($PetCO_2$) (Anselmi et al., 2021; Skinner and McLellan, 1980; Wasserman et al., 1973). Individual VT1, RCP, and VO_{2max} values were determined by consensus between two independent observers.

Statistical Analysis

The sample size was estimated a priori based on the assumption of at least medium effect size (Cohen's d = 0.5). Using an α-level of 0.05 and a statistical power (1- β) of 0.80, it was calculated that a minimum of 14 participants per group would be required to detect significant differences in the main variables over time and to compare them among groups (G*Power software; Heinrich-Heine-Universität, Düsseldorf, Germany). To compare the means of key variables simultaneously among participants (among study groups) and within subjects (across time points), a two-way mixed ANOVA was used. Prior to conducting this test, all necessary assumptions regarding the data were checked, including the absence of outliers, normality of variable distribution, homogeneity of variances, and sphericity. Since no statistically significant interaction or group effects were found, no post-hoc tests were later conducted. For the few variables in which a significant effect of time was observed in the two-way mixed ANOVA, paired-sample *t*-tests were performed within groups. Additionally, one-way ANOVA with the Bonferroni post-hoc test was performed to detect significant differences among groups at each time point. The level of significance was set at 0.05. The statistical analyses were conducted using Statistica 13.3 software (Tibco, Palo Alto, CA, USA).

Results

The study results are presented in Tables 1 and 2 as means ± standard deviation (SD). No significant two-way interactions were found in any of the variables studied. However, some significant within-group changes over time were observed among HBOT users. In the body composition indices, significant decreases in body mass and the BMI were found in rare HBOT users (p = 0.010 and p = 0.007, respectively). These changes resulted from concurrent but non-significant decreases in both fat and lean body mass. In both HBOT groups, but not in the control one (Table 2), a significant increase was observed in running speed (V; SGR: p = 0.029 and SGF: p = 0.007) and distance covered (S; SGR: p = 0.019 and SGF: p = 0.016) at the end of the exercise test. In rare HBOT users, relative maximal oxygen uptake, but not its absolute level, increased significantly after the intervention (p = 0.043). In the other groups and at other time points, the differences in both relative and absolute oxygen uptake were non-significant before and after the intervention. The heart rate (HR) measured at the end of the exercise test remained unchanged across all three groups following the intervention (SGR: 189 vs. 189 beats/min; SGF:188 vs.185 beats/min; CG: 189 vs. 189 beats/min). In both study groups, post-exercise blood lactate concentration was significantly higher at the second term of the study (SGR: 11.38 vs. 12.42 mmol/L, p = 0.024; SGF: 11.18 vs. 12.09 mmol/L, p = 0.011). There were some significant baseline differences in physical capacity indices between the SGF group and the CG (Table 2). Before the intervention, frequent HBOT users demonstrated significantly higher values in running speed (p = 0.015) and covered distance (p = 0.012) at the first ventilatory threshold, as well as in relative oxygen uptake at all stages of the exercise test (VT1: p = 0.003; RCP: p = 0.020, and max: p = 0.020). These differences were no longer present after the intervention.

Table 1. Body composition characteristics of participants measured before and after the HBOT intervention.

	SGR (n = 19)		SGF (n = 20)		CG (n = 15)		ANOVA		
	before	after	before	after	before	after	p	η^2	Power
Body mass (kg)	81.05 ± 11.24	80.52 ± 11.04*	77.44 ± 8.90	77.17 ± 8.55	82.63 ± 10.34	82.40 ± 10.34	0.722§	0.013	0.099
Fat mass (%)	18.75 ± 5.05	18.64 ± 5.62	19.34 ± 4.87	18.82 ± 4.89	20.88 ± 7.30	21.13 ± 7.25	0.056	0.107	0.565
Fat Mass (kg)	14.93 ± 5.49	14.75 ± 5.84	14.51 ± 4.46	14.13 ± 4.51	17.07 ± 7.70	17.27 ± 7.75	0.058	0.106	0.560
Lean Body Mass (kg)	63.27 ± 7.48	62.96 ± 7.69	60.03 ± 7.10	60.38 ± 6.86	62.54 ± 6.11	62.26 ± 5.95	0.161	0.069	0.376
Body Mass Index	24.71 ± 2.75	24.54 ± 2.64*	23.81 ± 2.65	23.72 ± 2.66	25.18 ± 2.97	25.09 ± 2.99	0.753§	0.011	0.093
Relative Skeletal Muscle Index	9.39 ± 0.94	9.35 ± 0.96	8.84 ± 1.05	8.88 ± 1.05	9.14 ± 0.85	9.19 ± 0.87	0.380	0.037	0.212

§ significant time effect in two-way mixed ANOVA
** significant within-group difference between study terms (time effect) (dependent t-test for paired samples)*
Abbreviations: SGR: rare HBOT users; SGF: frequent HBOT users; CG: control group

Table 2. Cardiopulmonary exercise test results before and after the HBOT intervention.

	SGR (n = 19)		SGF (n = 20)		CG (n = 15)		ANOVA		
	before	after	before	after	before	after	*p*	η²	Power
EE (kcal·h⁻¹)									
EE_{VT1}	830.21 ± 166.57	858.79 ± 197.55	887.70 ± 207.33	869.75 ± 140.23	736.00 ± 178.00	808.07 ± 211.88	0.265	0.051	0.280
EE_{RCP}	1113.53 ± 143.65	1151.89 ± 145.66	1168.80 ± 164.29	1144.95 ± 153.98	1119.67 ± 151.91	1169.53 ± 171.27	0.099	0.087	0.465
EE_{max}	1204.26 ± 133.36	1239.05 ± 142.84	1222.75 ± 156.01	1229.90 ± 139.61	1182.40 ± 131.14	1232.87 ± 164.33	0.417§	0.034	0.195
EE_{end}	1219.47 ± 132.36	1263.05 ± 151.70	1241.20 ± 157.97	1249.50 ± 137.06	1203.60 ± 149.17	1265.60 ± 191.60	0.276§	0.049	0.273
S (m)									
S_{VT1}	1165.47 ± 381.07	1266.16 ± 455.90	1395.55 ± 529.37#	1308.20 ± 321.76	966.20 ± 388.68#	1077.67 ± 482.09	0.204	0.060	0.330
S_{RCP}	2268.53 ± 541.77	2390.95 ± 567.73	2606.60 ± 556.49	2501.95 ± 548.39	2289.67 ± 600.13	2332.00 ± 668.36	0.130	0.077	0.416
S_{max}	2908.26 ± 648.56	2929.84 ± 543.85	3050.85 ± 606.54	3126.30 ± 639.51	2719.13 ± 621.55	2783.13 ± 647.84	0.790	0.009	0.085
S_{end}	3275.58 ± 593.17	3362.84 ± 563.90*	3493.80 ± 611.47	3611.40 ± 631.85*	3074.07 ± 653.31	3127.00 ± 684.88	0.583§	0.021	0.135
V (km·h⁻¹)									
V_{VT1}	9.65 ± 1.68	10.02 ± 1.92	10.42 ± 2.15#	10.23 ± 1.38	8.69 ± 1.73#	9.13 ± 2.00	0.378	0.037	0.213
V_{RCP}	13.59 ± 1.73	13.97 ± 1.66	14.46 ± 1.58	14.19 ± 1.64	13.55 ± 1.85	13.66 ± 2.02	0.142	0.074	0.399
V_{max}	15.57 ± 1.75	15.72 ± 1.47	15.84 ± 1.64	16.04 ± 1.75	14.96 ± 1.74	15.14 ± 1.78	0.978	0.001	0.053
V_{end}	15.89 ± 1.53	16.11 ± 1.46*	16.27 ± 1.58	16.57 ± 1.64*	15.21 ± 1.79	15.35 ± 1.78	0.590§	0.020	0.133
VO_2 (L·min⁻¹)									
VO_{2VT1}	2.83 ± 0.57	2.94 ± 0.67	3.18 ± 1.07	2.97 ± 0.47	2.55 ± 0.60	2.78 ± 0.72	0.150	0.072	0.390
VO_{2RCP}	3.70 ± 0.48	3.83 ± 0.48	3.90 ± 0.55	3.81 ± 0.51	3.72 ± 0.50	3.89 ± 0.57	0.101	0.086	0.463
VO_{2max}	4.00 ± 0.44	4.12 ± 0.48	4.07 ± 0.53	4.09 ± 0.46	3.93 ± 0.44	4.10 ± 0.55	0.395§	0.036	0.205
VO_2/kg (mL·min⁻¹·kg⁻¹)									
VO_{2VT1}/kg	35.16 ± 6.53	36.84 ± 8.31	39.55 ± 8.70#	38.65 ± 5.39	30.80 ± 6.84#	33.67 ± 8.42	0.223	0.057	0.313
VO_{2RCP}/kg	45.95 ± 5.08	48.00 ± 5.74	50.35 ± 6.24#	49.35 ± 6.00	45.27 ± 5.81#	47.07 ± 6.03	0.075	0.097	0.517
VO_{2max}/kg	49.79 ± 5.05	51.68 ± 5.72*	52.90 ± 6.43#	53.50 ± 6.83	47.87 ± 5.44#	49.47 ± 5.57	0.582§	0.021	0.136

*§ significant time effect in two-way mixed ANOVA; * significant within-group difference between study terms (time effect) (dependent t-test for paired samples);*
 # significant between-group (SGF vs. CG) difference within study term ('group' effect) (One-way ANOVA, with Bonferroni post-hoc test).
Abbreviations: EE: energy expenditure; S: covered distance; V: running speed; VO_2: oxygen uptake; SGR: rare HBOT users; SGF: frequent HBOT users; CG: control group.
Time points: VT1: at first ventilatory threshold; RCP: at respiratory exchange point; max: at maximal oxygen uptake; end: at the highest absolute value achieved during CPET

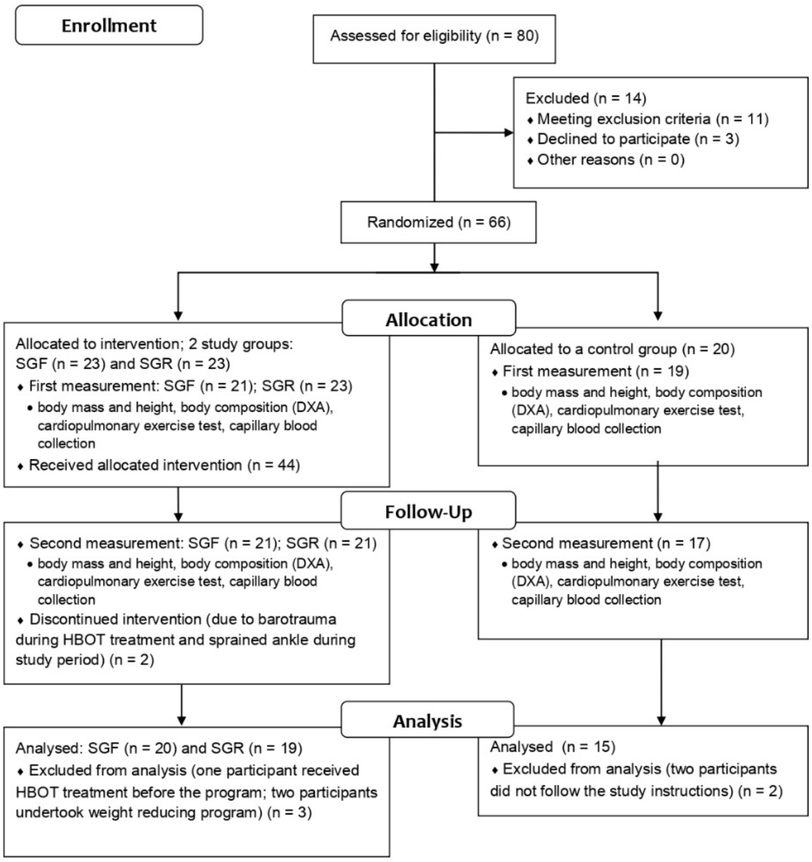

Figure 1. Flow diagram.

Discussion

This study was based on the assumption that high-pressure hyperbaric oxygen treatment can enhance the efficiency of aerobic metabolism, thereby increasing fat oxidation and influencing oxygen uptake during physical exercise. At the same time, we aimed to determine whether the frequency of individual treatments would affect the outcome of HBOT therapy. The main finding of our study was that ten hyperbaric oxygen treatments at 2.5 ATA, administered either three or six times per week, could not be considered a potent booster of body composition or aerobic capacity in young healthy men. However, the evidence suggested a slight positive impact of a series of HBOT sessions on body mass and aerobic performance indices. Since there were no significant differences in post-treatment physiological responses between the different HBOT frequency groups, we concluded that treatment frequency did not substantially influence the overall HBOT effect.

Studies conducted in animal models support the hypothesis that repeated HBOT sessions can improve body composition by enhancing aerobic metabolism and facilitating fatty acid oxidation. For example, after four weeks of daily HBOT sessions (2.0 ATA; 60 min), decreased body mass, reduced fat deposition, and normalized phosphorylation of hormone-sensitive lipase were noted in the adipose tissues of diet-induced overweight mice (Yuan et al., 2020). These effects were likely associated with improved circulation, elevated skeletal muscle L-carnitine levels, and increased expression of peroxisome proliferator-activated receptor alpha. Additionally, it has been shown that long-duration HBOT sessions (3 or 6 hours) at low hyperbaric pressure (1.0 ATA), administered over seven consecutive days, significantly reduced body mass in healthy Sprague Dawley rats (Liang et al., 2022). Moreover, the study demonstrated that in hyperlipidemic, but not in healthy animals, HBOT accelerated fat oxidation, lowered blood lipid concentrations, and helped protect heart and kidney function by reducing vascular damage (Liang et al., 2022). In our young healthy individuals, we observed only modest changes in overall body mass and fat mass after a series of HBOT sessions. However, the 530-gram reduction in body mass among rare users reached statistical significance. This decrease, however, resulted from concurrent, yet statistically non-significant, reductions in both lean and fat body mass. In another study, longer duration of hyperbaric oxygen treatment (40 daily sessions), but at lower pressure (2.0 ATA), led to a slight decrease in fat mass, without a change in total body mass in the HBOT group (Hadanny et al., 2022). Although HBOT may exert some positive effects on body composition in healthy individuals, it should not be considered a potent fat-burning strategy. To date, there is a lack of evidence either supporting or refuting the idea that hyperbaric oxygenation can enhance athletic performance (Huang et al., 2021; Šet and Lenasi, 2023). A single exposure to 95–100% oxygen under hyperbaric conditions (2.0–2.5 ATA; 60–90 min) has no direct ergogenic effect on exercise performance. This has been demonstrated in several studies, for example, in young endurance cyclists during a maximal cycle ergometer test (Webster et al., 1998); in moderately trained runners during an incremental running test to volitional exhaustion (Hodges, 2003); in physically active young men in subsequent high-intensity running or lifting performance (Rozenek et al., 2007); and in trained runners of both sexes (McGavock et al., 1999). Only one relatively old study, conducted on female physical education students, showed that a single HBOT session (2.8 ATA; 60 min) significantly increased maximal oxygen uptake during a treadmill exercise test performed 30 min and 3 h, though not 6 hours, after the HBOT session (Cabrić et al., 1991). Unlike the other research, this study involved very young and unfit individuals and was conducted under higher pressure, making direct comparisons questionable, if not impossible. In a pilot study, six young soccer players underwent a three-week protocol of hyperoxic cycling training (15 sessions, 75% of maximal power output) in the hyperbaric chamber (2.0 ATA). The intervention resulted in non-significant changes in VO_{2max} and maximal power output (Burgos et al., 2016). Similar results were found in other studies where physical training—typically high-intensity interval training (HIIT)—was combined with hyperbaric oxygen treatment. While increases in physical endurance were observed, these improvements appeared to result from HIIT training alone, as no significant differences were noted between the sham and study groups (Alvarez Villela et al., 2022; DeCato et al., 2019). Interestingly, a comparative analysis of the effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) revealed that MICT had a more pronounced effect on VO_{2max} (Feng et al., 2025).

The influence of a series of HBOT treatments has, to date, been studied on only few occasions, typically focusing on post-exercise recovery rather than directly on physical performance. In our study, we observed a very slight positive effect of high-pressure HBOT treatments on maximal oxygen uptake levels; however, statistical significance was achieved only in the group of rare users. Nevertheless, this improvement can be explained by the concurrent significant reduction in body mass during the hyperbaric treatment, which would understandably increase relative VO_{2max} when expressed in ml of O_2 per kg. Some beneficial effects of ten HBOT sessions may be seen in both study groups, as the physical effort during the post-treatment exercise test was greater: the effort lasted longer, and both maximal speed and distance covered were significantly higher. This change—absent in the control group— occurred without corresponding changes in HR_{max} and VO_{2max}, which may suggest an improved physiological capacity to continue anaerobic running at speeds near VO_{2max}. Furthermore, the absence of such changes in the control group, along with the lack of additional training during the HBOT treatment period, allows us to reasonably exclude improved running economy as the underlying cause.

To some extent, the differences in the magnitude of response among study groups may also be due to variations in the duration of physiological adaptation to external stimuli. However, the timespan of our study was not so different: 11 days in frequent versus 20 days in rare HBOT users. Longer duration of physiological stimulation may be required to induce measurable adaptations, as demonstrated in a study involving 37 healthy middle-aged master athletes, in which significant improvements in VO_{2max} were observed following 40 daily sessions of HBOT (2.0 ATA; 60 min) (Hadanny et al., 2022). Nonetheless, the differences in the response to HBOT between their study and ours may be attributed not only to the number of sessions or varying hyperbaric pressures, but also to differences in participants' characteristics. Our cohort consisted of younger, recreationally active men, whereas the other study involved middle-aged individuals with a mean of nearly 11 years of sports experience, mainly runners and triathletes.

The Undersea and Hyperbaric Medical Society recommends that, depending on the medical condition, treatments should be administered once to three times daily for several weeks (ranging from 20 to as many as 60 exposures). The primary pathological condition addressed by HBOT is severe hypoxia, which, if untreated, can lead to cellular metabolic dysfunction, organ failure, and eventually death, hence the need for intensive oxygenation. In beauty or fitness sectors—where recipients are generally healthy—oxygenation serves as an adjunctive therapy. As such, it may require different recommendations regarding the frequency and total number of treatments. To date, most of the trails (successful or not) aimed at enhancing physical performance, treating sports injuries, or improving post-exercise recovery have used daily-administered HBOT protocols. The primary difference among the studies was the duration of treatment, which ranged from as few as 4 consecutive days at 2.5 ATA (Harrison et al., 2001) and 7 days at the same pressure (Mekjavic et al., 2000) to as many as 40 days at 2.0 ATA (Hadanny et al., 2022). There was only one study in which 10 sessions of HBOT (2.5 ATA, 60 min) were administered twice a week over a five-week period. This intervention successfully facilitated early recovery from exercise-related muscular injuries in 46 adult baseball players (Chen et al., 2019). We demonstrated that a series of ten HBOT sessions at 2.5 atmospheres delivered less frequently (three times per week) may be more effective in improving body composition and physical performance in young, healthy men than more frequent administration. This represents a novel finding in the application of HBOT within the sports and fitness sector.

Given the potential risks associated with HBOT (Heyboer et al., 2017), this finding gains additional relevance. For instance, in an animal model, HBOT was shown to have differential effects on healthy non-obese mice compared to diet-induced fat animals (Yuan et al., 2020). That study indicated that hyperoxia could exert deleterious effects on the organ systems of lean, metabolically normal mice. Another important argument for less frequent HBOT administration in generally healthy individuals is its potential negative impact on serum erythropoietin (EPO) concentration. While normobaric oxygen exposure has been associated with a significant rise in serum EPO concentrations 8–36 hours post-exposure (the so-called "normobaric oxygen paradox"), hyperbaric oxygen exposure (2.5 ATA; 90 min) has been shown to decrease serum EPO levels for up to 24 hours (Balestra et al., 2006). This raises a legitimate concern that prolonged HBOT use in healthy individuals could impair the erythropoiesis cycle, ultimately reducing the blood's oxygen-carrying capacity. Such an outcome could negatively affect aerobic performance and athletic outcomes across many sports disciplines.

There are few limitations to this study. As we included only young, healthy men, our findings are limited to a single sex and a relatively narrow age range. It would be valuable to investigate whether women and older adults respond similarly to HBOT treatments. Above that, it is possible that the intervention period was too short to elicit more significant physiological effects. A longer post-treatment observation period or an increased number of HBOT sessions may yield different results. Despite the randomization used in our study, the intervention groups were not completely balanced in terms of body composition and physical capacity. While these differences were not statistically significant, they were noticeable and may have influenced the study outcomes.

Conclusions

In conclusion, our results indicate that administering 10 sessions of hyperbaric oxygen therapy at 2.5 ATA, whether three or six times per week, does not lead to significant changes in body composition in the treated men. While a modest improvement in physical capacity was observed, it did not translate into enhanced performance levels. Therefore, the applied HBOT protocol cannot be considered one with ergogenic potential.

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