Intermittent Hypoxic Breathing with Exercise Mimics Hypoxic Training SpO2 and Improves Waist Circumference and RMR in Obese Women

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ABSTRACT

Objective: This study aimed to investigate the effects of utilizing a hypoxic breathing protocol to achieve hypoxia during functional training, including the impact on body composition, skeletal muscle strength, resting metabolic rate, and blood oxygen [SpO2] values.

Design and Methods: five obese women, were randomized into either the experimental hypoxic breathing exercise group (HYP) (n=3) or the control group without hypoxic breathing during exercise (NOR) (n=2). Both groups were instructed to perform 12 weeks of exercise at a frequency of four times per week. Several muscle groups were exercised, performing a combination of mobility, plyometrics, and compound strength exercises using resistance bands and a Pilates mini-ball. Muscle strength was evaluated using the standard National Academy of Sports Medicine strength assessment protocol for both squats and push-ups.

Results: Our primary finding**s show** blood oxygen (SPO2) levels reflecting statistically significant decreases to values typically seen in a traditional hypoxic training protocol in the HYP group (+/- 85%) vs. the NOR group (+/- 96%). We also found statistical significance in waist circumference decrease and RMR increase in the HYP group. There was a non-significant greater decrease in fat-loss in the HYP group.

Conclusion: resistance training with an intermittent hypoxic breathing protocol using hypoventilation decreases SPO2 levels and waist circumference and increases RMR more than traditional training with normoxic SpO2 levels in obese women.

Keywords: Breathing Exercise, Breath Holding, Obesity Management, Oxygen Saturation, Intermittent Hypoxic Training, Hypoxic Conditioning

Introduction

The obesity epidemic is currently overwhelming our healthcare system and the workforce. The direct and indirect consequences related to obesity, including medical costs, work productivity, and mental health, are exponentially growing every decade. In 2008, costs in the USA alone were estimated at $147 billion [Goettler & Sonntag, 2017]. The economic implications alone demand more effective strategies for addressing the crisis. Currently, the obesity epidemic is costing an average of 2.2% of GDP in all countries and is expected to rise to 3.2% in a period of less than 40 years [Okunagbe et al., 2022]. This problem must be disentangled, and new modalities should be explored to curtail this rising problem that presents danger to the world's economic power, health systems, and the physical and mental health of its citizens.

Nutrition and exercise therapy are two of the suggested strategies to manage and prevent obesity, but often these general strategies do not provide a reliable solution for all in the obese population [Norman et al., 2023] Exercise is an intervention that expends energy, increases metabolic rate, builds muscle, and improves mental health [Park et al., 2023]. However, the injury rate is often much higher in the obesity population when compared to the average weight American adult due to the extra forces placed on the body [Goettler, et al., 2017]. Additionally, muscle injury tends to be higher in those with high BMI [Kim & Yoon, 2021]. Therefore, the obese population has a higher likelihood to be stuck in a vicious cycle of beginning an exercise protocol and cessation of an exercise protocol leading to a sedentary life due to lack of enjoyment and injury.

It is essential to find novel approaches that aim to increase exercise efficacy while decreasing the impact and volume of exercise in order to reduce the risk of injury in the obese. Hypoxic training has been

proposed as a novel strategy for tackling this problem. Intermittent hypoxic training (IHT), is an exercise training protocol in an low oxygen environment, which can be performed at altitude or at sea level by breathing low oxygen air from a hypoxic generator or in a room with oxygen that has been lowered using an oxygen/nitrogen shift [Serebrovskaya et al., 2002]. IHT has been shown to be a therapeutic modality for the obese population in terms of increasing fat oxidation, blood glucose control, muscle mass, metabolic rate, and strength at much lower intensities of exercise with resulting lower exercise impact [Jung et al., 2020]. Jung et al. [2020] showed improvements in many blood markers, including triglycerides and cholesterol, in an obese population utilizing a low impact pilates protocol at 14.5% oxygen. Other studies have shown increased fat-loss and strength gain in groups using hypoxic exercise vs normoxic exercise (sea-level oxygen) including resistance training in a circuit style [Guardado et. Al, 2020]. Especially of note are the studies that have shown that low-impact, low-intensity exercise in a hypoxic environment has the ability to be more effective than normoxic exercise in obese populations [Netzer et al., 2008]. Netzer et al. [2008] was able to show that obese men exercising in moderate hypoxia led to greater weight-loss than those exercising in sham hypoxia. This could have positive long-term implications for the obese, who could benefit from accelerated body composition results without as much impact and shear forces on their body as they maintain an exercise regimen.

Although this approach shows promise, many do not have access (due to location and financial constraints) to using this modality. To help a greater number of those in the obesity population, it is imperative that an alternative solution be presented. Using one's own breath to achieve intermittent hypoxia is a novel approach that is beginning to be explored [Malshe, 2011]. More research is needed in using breath induced hypoxia to establish effective protocols, including dosage [frequency, volume, and intensity]. Woorons et al. [2007] and his lab that is devoted to hypoxic training using voluntary hypoventilation, has shown a repeated connection between exercising and hypoventilation in terms of creating a hypoxic environment during exercise. This study explores a proprietary Intermittent Hypoxic

Breathing (IHB) protocol developed in our lab. We aim to confirm a decrease in blood oxygen levels (SpO2) consistent with hypoxia obtained at elevation or with a commercial hypoxic training mask. With this novel approach, we plan to continue studying the impact of proven IHB protocols on various health markers in those with obesity.

Methods

Five obese women (age: 47.44 ± 6.42 years) volunteered to participate in this study and were assigned to either (HYP) hypoxic breathing with exercise or (NOR) normal breathing with exercise. The authors decided to study females only in this study to focus on a population other than male athletes, which has been shown to be a primary population studied in other hypoxic studies.

Ethical approval was obtained from the ethics board committee at American Public University System (https://www.apus.edu/academic-community/research/institutional-review-board/) as well as New York Institute of Technology (https://www.nyit.edu/ospar/institutional_review_board).

Two sets of 10 inch latex loops (GoFit Band), a pilates mini ball (Franklin Ball), and an 18 inch chair were used in the exercises (participants provided their own). Pulse Oximeters (Beurer) were provided for the participants to measure SpO2 values at the conclusion of each exercise for 30 seconds.

Each participant was informed of the procedure of the study and provided informed consent.

Experimental Design

In order to test the effects of 12 weeks of both controlled hypoxic breathing (HYP) and normal, uncontrolled breathing (NOR) on body composition (BC), resting metabolic rate (RMR), total body strength (TBS), and blood oxygen values (SpO2), 5 women (HYP *n=3*, NOR *n=2*) were assigned a 12 week video guided cardio and resistance training protocol, performed 4 times per week using resistance bands in an endurance repetition range (50% 1RM). HYP followed a guided video with controlled slow breathing (hypoventilation) with progressive breath retentions, guided by a metronome to stay at a precise rate of a 2 second inhalation and 8 second exhalation, followed by progressive increases in breath retentions. The control group (NOR) followed the video with no breath cuing and therefore, breathed involuntarily. SpO2 was recorded at the conclusion of each exercise in both the control NOR group and the experimental group HYP. The women assigned to HYP received instruction on the hypoxic breathing method 1 week prior to beginning the experiment for practice. DEXA body composition, resting metabolic rate, waist circumference, and strength were assessed before and after the 12 week protocol.

Intermittent Hypoxic Breathing Technique

Experimental group (HYP) followed a video workout that followed a breathing technique (*Breathography)* inclusive of the following components: 1. ZipUp Activation. This is a 2 second exhale on a hiss-ing sound that activates the pelvic floor, transversus abdominis, and postural muscles as a prep for the exercise. 2. Engaged Inhale. This is 2 sniffs of air through the nostrils over the course of 2 seconds, keeping the abdominals engaged. 3. Engaged Exhale. This is an 8 second exhalation consisting of four key sounds (phonation): Blow, Hiss, Soft Shh, Loud Shh. The final part of the exhale is a forced exhalation, and the participant is encouraged to “force the air out” of the lungs, moving to low lung volume. Over the course of 12 weeks, breath retentions following the Engaged Exhale progressed from 0 (week 1) up to 12 seconds (weeks 9, 10, 11, & 12).

Cardio and Resistance Training Program

Both NOR and HYP followed precisely the same video exercise routine 4 times per week. The teacher in the video guided the participants through 17 exercises: sagittal agility, lateral agility, mobility lunge lateral and sagittal, jump lunge, plank, jump squat, single leg squat, lunge, push-up, squat, bent over row, bicep curl/tricep press combo, calf raise, horizontal row, glute bridge, pilates 100, and superman. Interset rest was guided at 15-30 seconds.

Body Composition and Resting Metabolic Rate

DEXA scan (Lunar iDXA) was used to assess body fat, muscle mass, and resting metabolic rate both before and after 12 weeks of exercise.

Waist Measurement

Waist circumference was measured using a tap both before and after 12 weeks of exercise.

Statistical Analysis

All statistical analyses were performed using Graphpad Prism 9.0. Paired T-Tests were conducted to determine significance using an alpha level of 0.05. All results are reported as mean ± SEM.

Results

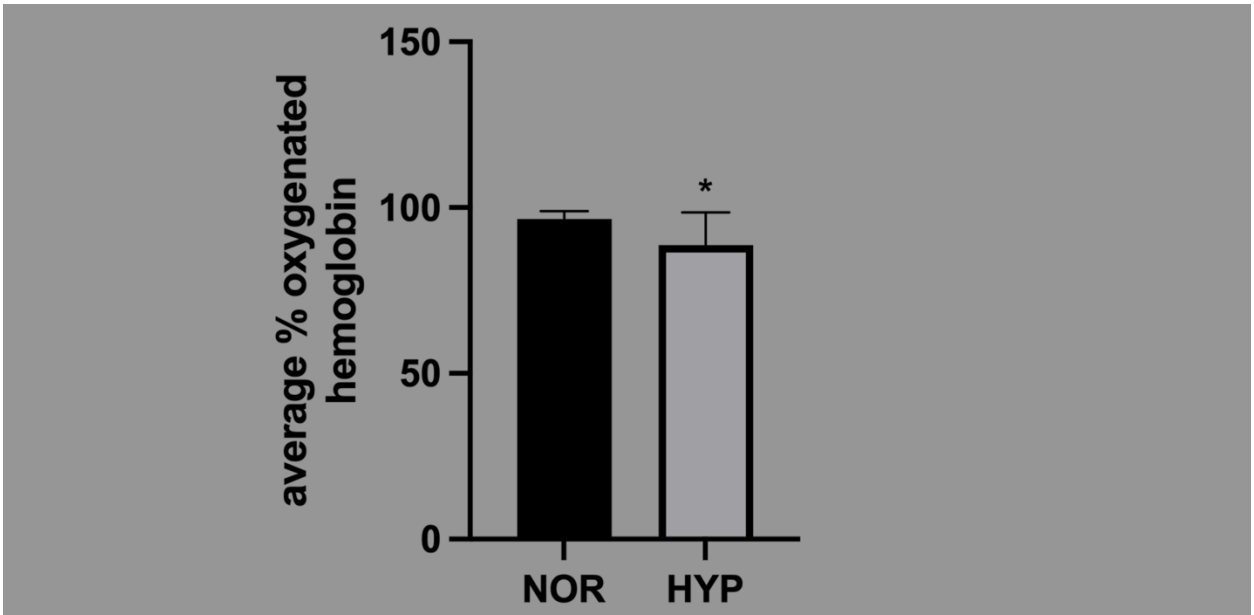

Figure 1. *Intermittent Hypoxic Breathing Protocol Decreases Blood Oxygen Levels and Mimics Traditional Hypoxic Training*

Intermittent Hypoxic Breathing Protocol Decreases Blood Oxygen Levels and Mimics Traditional Hypoxic Training (Figure 1) $p = 0.00008$

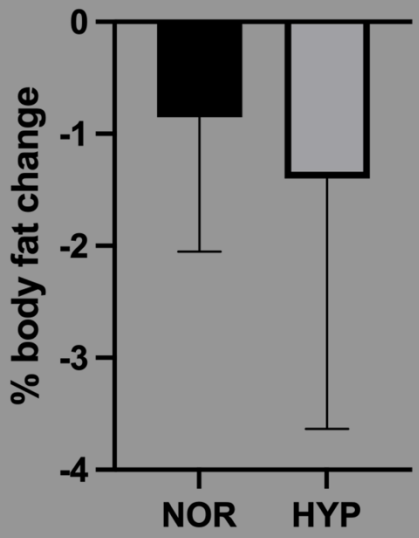

Figure 2. *Hypoxic Training (Using Intermittent Hypoxic Breathing) Increases the rate of Body Fat lost in Obese Women During a 12-week Low-intensity Exercise Program*

Hypoxic Training (Using Intermittent Hypoxic Breathing) Increases the rate of Body Fat lost in Obese Women During a 12-week Low Intensity Exercise Program (Figure 2) $p = 0.39$ HYP ; $p = 0.5$ NOR

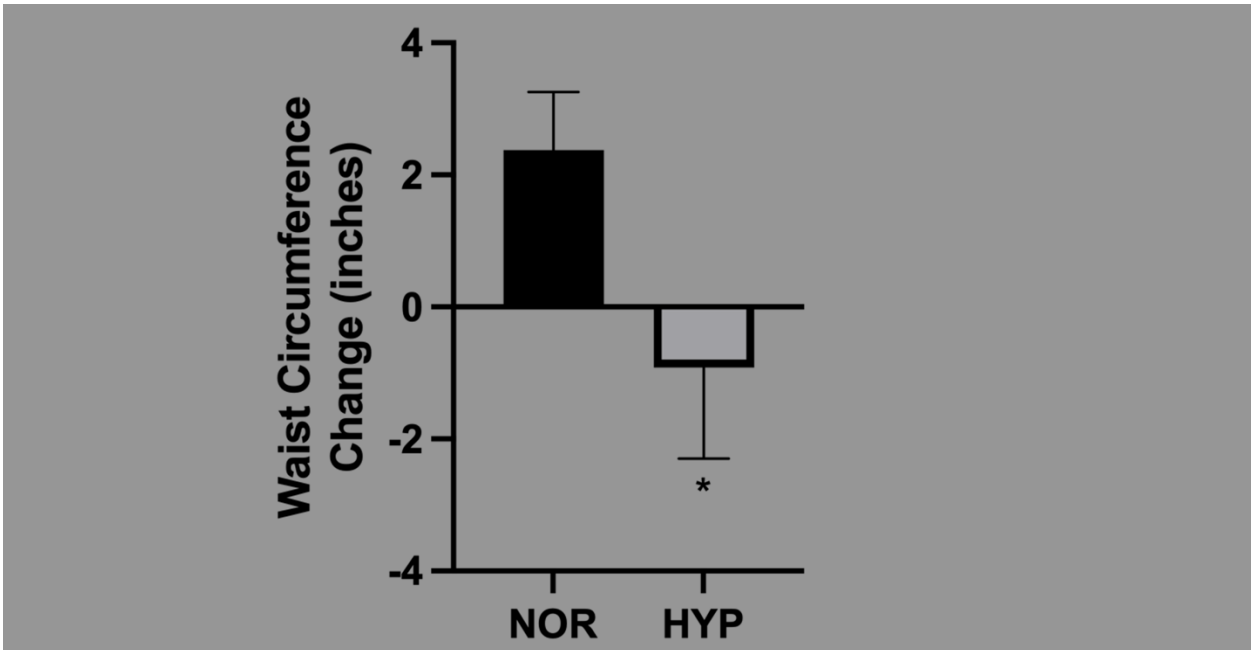

Figure 3. *Hypoxic Training (Using Intermittent Hypoxic Breathing) Decreases Waist Circumference to a greater degree than Normoxic Training in Obese Women During a 12-week Low-intensity Exercise Program*

Hypoxic Training (Using Intermittent Hypoxic Breathing) Decreases Waist Circumference to a greater degree than Normoxic Training in Obese Women During a 12-week Low Intensity Exercise Program (Figure 3) $p = 0.03$ HYP ; $p = 0.5$ NOR

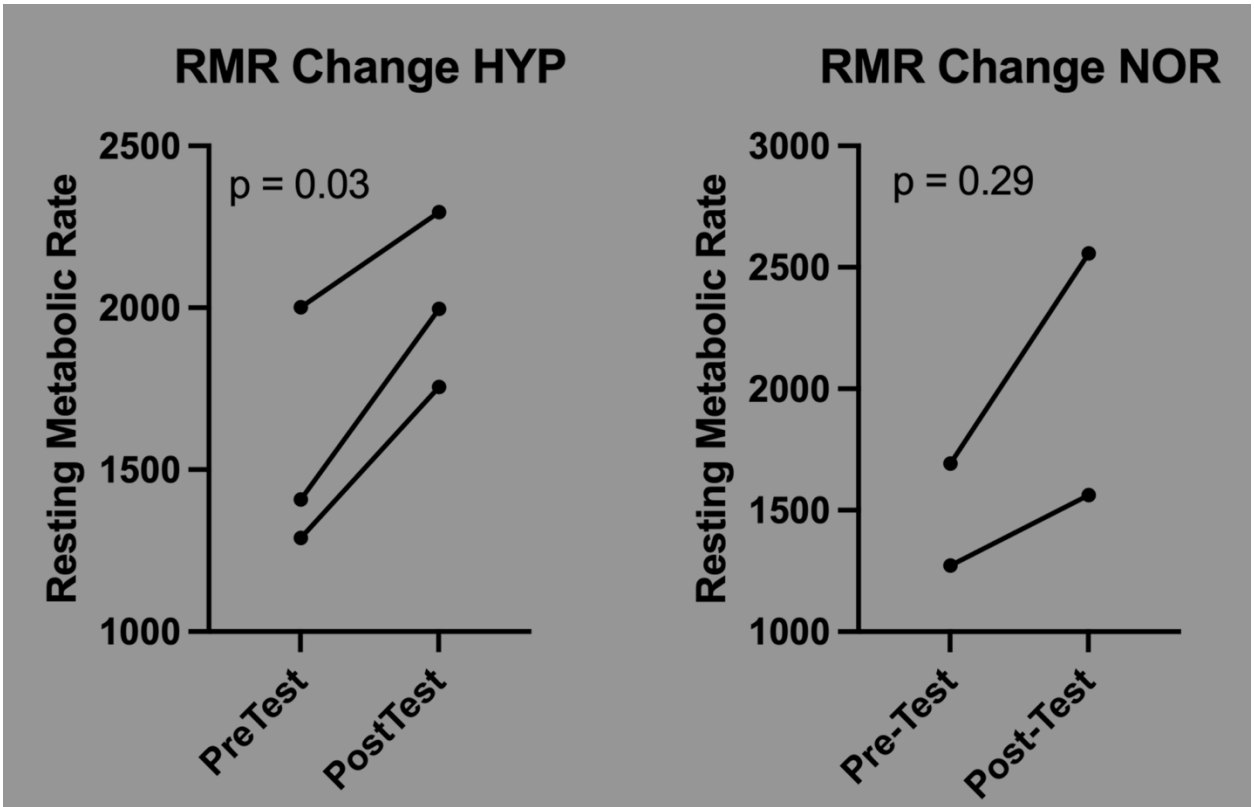

Figure 4. *Resting Metabolic Rate Significantly Increased in Obese Women following a 12-week Hypoxic Training Protocol*

Resting Metabolic Rate Significantly Increased in Obese Women following a 12-week Hypoxic Training Protocol (Figure 4) p = 0.03 HYP ; p = 0.29 NOR

Discussion

The major finding of the present study is that the novel therapy of IHB reduces SPO2 levels to that consistent with hypoxic training environments. Additionally, IHB combined with low-intensity exercise for 12 weeks (HYP) showed significant increases in RMR and decreases in waist circumference when when compared to those in the control, NOR group. The HYP group showed greater decreases in bodyfat loss, albeit the results non-significant.

Increased RMR and decreases in fat-loss have been shown to be a common result from exposing the body to a hypoxic environment while exercising [Camacho-Cardenosa et al., 2019]. Obesity is a worldwide epidemic that lays the groundwork for a slew of cardio metabolic diseases [Jaacks et al., 2019]. Not only does obesity put a burden on the healthcare system, but it also discourages living an active lifestyle due to the discomfort the excess adipose tissue can cause on the skeletal system [Nagi et al., 2024]. Therefore, implementing tools that could not only accelerate fat-loss, but also provide an easier entry to exercise that doesn't require as much mechanical load on the body, could have positive implications on the obese population's ability to maintain a workout regimen. Protocols that aim to reduce the amount of adipose tissue around the waist are important due to waist circumference being representative of metabolic disease [Shen et al., 2006]. To our knowledge, this is the first time it has been shown that waist circumference can significantly improve when exercising hypoxically using breath-work vs normoxically *(figure 3)* although this result has been shown with more traditional IHT protocols [Camacho-Cardenosa et al., 2019].

Although we are not the first research group to show statistical significance in using hypoventilation to achieve meaningful levels of hypoxia *(figure 1),* we believe to be the first to measure waist circumference, fat-loss, and RMR in connection with these levels [Woorons et al., 2007]. Our novel hypoxic breathing method is the first breathwork exercise study to our knowledge to show a significant

increase in RMR *(figure 4*), although there have been some research in the area of isolated diaphragmatic breathing increasing oxygen uptake and RMR without the addition of exercise [Yong et al., 2018]. Increasing RMR in the obese population could have powerful implications in higher success rates in long-term fat-loss with the effects of RMR on body-fat levels [Yu et al., 2021].

Hypoxic training has the potential to accelerate fat-loss through heightening positive exercise stress, while reducing mechanical load on the body, and the mechanisms vary from increased RMR to improved glucose levels [Camacho-Cardenosa et al., 2019]. Our group showed that a group of women using low intensity training with intermittent hypoxic breathing achieved a non-significant greater degree of fat-loss *(figure 2)* than the control group, but a significant increase in RMR (*figure 3)* and decrease in waist circumference *(figure 3)*, laying the ground work for a deeper look into the connection between improvements in body composition with hypoxic exercise using breath-work.

Obesity puts extra strain on the body and can be discouraging for an obese person beginning an exercise regime because of increased risk of injury due to increased forces on joints [Goettler, et al., 2017]. Decreasing blood oxygen during exercise (hypoxic training) is a strategy that does not add impact to the body, but has the potential to be a positive stressor, increasing RMR, reducing waist size, and decreasing body-fat to improve the health of the obese population.

Limitations of this study include the population number. Although we had a large group to begin, there was a high rate of participants who did not return for the post-test measurements, even though many of the drop-out participants continued to submit blood oxygen data for all 12 weeks. Another limitation withing this study is the remote nature of the exercise program with participants self-reporting values, in

which there could lie errors or false reporting. More research is needed using this novel protocol with a larger population.

Conclusion

A hypoxic breathing protocol, as an alternative to higher impact exercise and/or exercise at altitude, might provide a valid alternative for adding intensity to exercise and improving the health of the obese population through body composition improvements more effectively than traditional training. Because the consistently lower levels of SpO2 that mimic traditional hypoxic training, correlate with the statistical significance in improvements in RMR and waist circumference, this novel method is worth exploring to a greater degree for the benefit of the obese population. More research is needed in the area of using breath-work with exercise as a strategy for implementing hypoxia training protocols. However, this frontier could have positive implications in remediating the obesity epidemic by utilizing an alternative tool to apply greater stress on the body that reduces mechanical load. This pilot study provides a novel approach that may be used as a therapeutic modality for the obesity epidemic.

Practical Implications

- Intermittent Hypoxic Breathing in conjunction with exercise might be a valid method for increasing fat loss in the obese population
- Obese individuals in need of a lower intensity, lower impact exercise regimen to reduce the mechanical load on the body could use intermittent hypoxic breathing as an exercise strategy to increase exercise stress, while reducing load on the body
- Intermittent Hypoxic Breathing in conjunction with exercise might be a valid method for increasing strength, while reducing the risk of injury in the obese population
- Intermittent Hypoxic Breathing might be a valid alternative to traditional intermittnet hypoxic training at sea level and/or at altitude

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