Bimini

Effect of Ultra-fine Oxygenated Nanobubbles on Regional Saturation of Oxygen (rS02) & Muscle Oxygen Saturation (sMO2)

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Background

Athletes around the world struggle with musculoskeletal injuries, pain and fatigue which can delay their next training session or even worsen their performance. The smallest decrease in recovery time is extremely valuable. We hypothesize the use of the Bimini NanoJet® Ultra-Fine Bubble (UFB) hydrotherapy, a nanobubble oxygenation technology, will increase oxygenation to recovering tissues, therefore decrease pain, inflammation and overall recovery time from exercise. We aim to combine this therapy with near-infrared spectroscopy (NIRS), using products from Moxy and Nonin, to measure regional oxygen saturation of the recovering tissues. This will provide motivated athletes with real time awareness of their muscle recovery.

Supported using devices from:

NONIN

MOXY MUSCLE OXYGEN MONITOR

The Bimini NanoJet® UFB hydrotherapy system continuously infuses water with ultra-fine air bubbles that are less than 0.1 microns in size. On average, human skin pores are 50 microns in size which nanobubbles should penetrate with ease. This has the potential to supply additional oxygen to recovering tissues. One proposed mechanism is that effective oxygen delivery may increase reactive oxygen species at therapeutic levels to initiate an early cascade of valuable growth factors and neovascularization. Additionally, it is proposed that an increase in oxygen allows for vasoconstriction, decreased vessel permeability and decreased edema, therefore diminishing diffusion distance for optimum oxygen delivery (5).

One area that has been researched extensively is hyperbaric oxygen therapy (HBOT). An understanding of HBOT is crucial in predicting the vast potential for UFB, as both therapies provide hyperoxygenated environments for recovering tissues. Anecdotally, many athletes have recognized significant benefit from HBOT. One example is Hines Ward, a legendary wide receiver for the Pittsburgh Steelers, who reported HBOT helped lengthen his career. Also, during the 1998 Nagano Winter Olympics, many athletes reported improvement of fatigue with the use of HBOT (2). From a research standpoint, a study published in 2019 by Chen et al. showed a decreased serum concentration of intracellular enzymes as a surrogate for muscle damage and decreased patient reported pain scores in collegiate and professional baseball players with muscle injuries when treated with multiple sessions of HBOT compared to the control group (1). These examples are just a glimpse of the benefits that increased oxygen environments may have in recovery.

Materials:

- Bimini NanoJet® UFB Hydrotherapy System
- Dynamic Temperature and Oxygenation Probe
- Moxy Sensor of the Moxy Monitoring System
- Nonin SenSmart Universal Oximetry Systems

NIRS is a non-invasive technology that utilizes multiple lasers and detectors to determine mixed venous blood oxygen saturation of tissues 1-3 cm below the sensors by measuring the absorption spectra of the tissue chromophores oxyhemoglobin and deoxyhemoglobin. The mixed venous oxygen saturation is affected by many aspects of physiology, but overall represents the relationship of oxygen delivery and utilization in tissues (3, 4). To showcase the utility of this non-invasive technology, one study performed by Marimón et al. compared NIRS placed over the cerebrum to oxygen saturation from mixed venous samples taken from central venous catheters in pediatric patients undergoing heart surgery and found a moderate and significant correlation (4).

Therefore, NIRS can be trusted as a non-invasive measuring tool to acquire mixed venous oxygen concentration in our study. One NIRS sensor in our study is the Moxy device that we will utilize to record muscle oxygen saturation (SMO2) of the rectus femoris muscle. The other is the Nonin device that we will utilize to record regional oxygen saturation (rSO2) over the femoral vessels.

The goal of this research is ultimately to align with every athlete's desire to return to training and performing as soon as possible. In this paper, we present 8 cases demonstrating the validation and potential of the Bimini NanoJet®. Each case presents data of SMO2 readings during treatment with the last case presenting data of SMO2 and rSO2. The potential for benefit with this technology is massive and this area of research is calling for further exploration.

Case 1: CD

Description:

CD is an active high school track athlete with no chronic medical conditions who has a heavy training regimen in preparation for racing. During his season he trains several days per week with rigorous workouts that focus on sprints. He frequently experiences post training a soreness the day following rigorous training. The severity of his symptoms is comparable to many of his peers with similar training schedules.

On exam, CD is an athletic appearing, well nourished, pleasant and cooperative teenage male. He has normal vitals at rest in addition to benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

CD was consented and eager to participate in this study. CD was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician. He was continuously monitored during the study by both a board-certified sports medicine physician and professional sports physiologist.

During the study, CD wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. He also wore a heart rate (HR) monitor on the right humerus over the brachial artery. These sensors provided real time capture and continuous monitoring of SMO2 and HR.

From time 0-5 minutes, CD was at rest in a comfortable seated position. He was then transitioned to a treadmill and began jogging at 5-6 mph and a goal of 75% maximum HR from time 6-15 minutes. CD was then transferred to a bathtub equipped with a Bimini NanoJet® infuser. CD was positioned in a resting position with his bilateral lower extremities and lower trunk submerged, other than the very top of the Moxi sensor which was kept above the surface for data capturing purposes.

The water was maintained at 95 degrees Fahrenheit. CD remained in non-infused water for 20 minutes with an oxygen content of 4 parts per million (ppm), from time 18-38 minutes. The Bimini UFB infusion was started and delivered increased amounts of oxygen to the bath water. CD remained in this treatment environment for 25 minutes, from time 38-63 minutes. The water oxygen concentration increased from 4 ppm prior to initiation of Bimini, up to a peak of 18.9 ppm. After the 25-minute treatment, CD was transferred out of the bath where he stood to dry off and recover. The study period was completed at this time.

Results:

During the initial dry, seated resting period from 0-5 minutes, CD's baseline SMO2 values ranged from 50-60%. This dropped significantly to a low value of 10% SMO2 during the exercise treatment period, time 6-15 minutes. After transitioning to the 95-degree Fahrenheit bath without Bimini therapy and an oxygen concentration of 4ppm for 20 minutes, from time 18-38 minutes, the SMO2 increased to average near 60%. Upon initiation of Bimini NanoJet® infusion of the treating bath water, which lasted for a 25-minute treatment from time 38-63 minutes, both the water oxygen concentration and SMO2 increased.

The water oxygenation without Bimini was steady around 4 ppm, but progressively increased with the initiation of Bimini to a peak value of 18.9 ppm at time 54 minutes. During the first 15 minutes of the Bimini NanoJet™ infusion, SMO2 had peaks and valleys. This included values near CD's baseline of 50-60% SMO2, with two significant peaks of 81% SMO2 and 71% SMO2 at times 42 minutes and 46 minutes respectively. For the last 10 minutes of the Bimini treatment, from time 53-63 minutes, the SMO2 values climbed steady, returning to 81% SMO2 once again by the end of the treatment. After the 25-minute Bimini NanoJet® treatment, CD exited the bath where he rested in a standing position while drying off and completing the study. The SMO2 value returned to the 50's % and even lower false values were recorded as the Moxy sensor was manipulated during drying and removed from the patient.

CD provided subjective data following this treatment. He performs a weekly intense sprint exercise routine. The previous week he had completed his sprint routine with difficulty, however, the day following the Bimini NanoJet® treatment CD was able to increase his sprints by 50% without major difficulty.

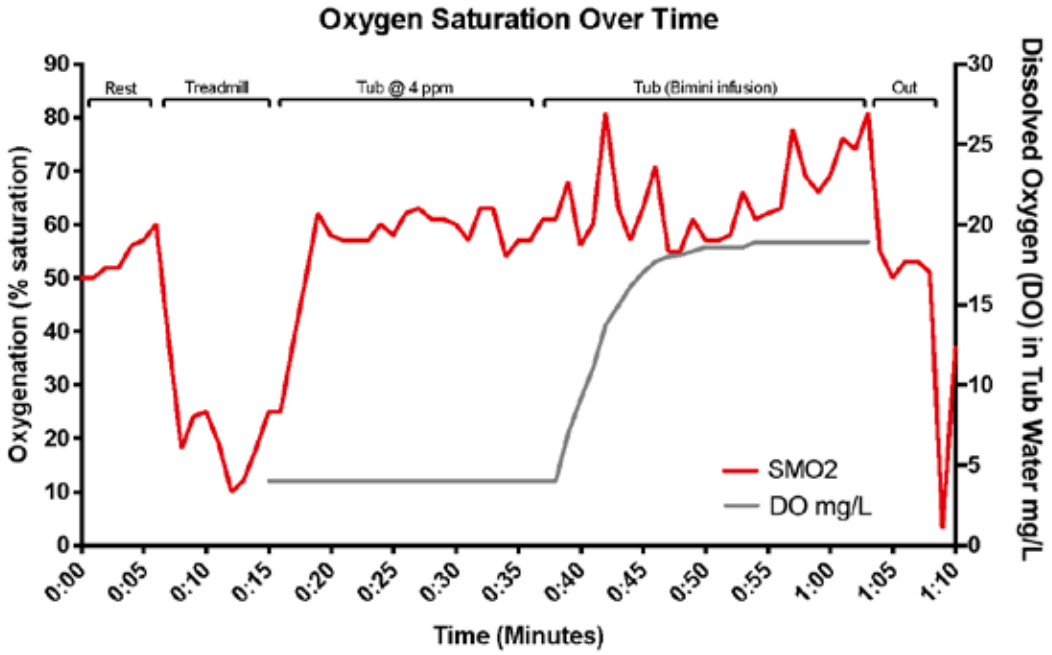

Figure 1. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor. Real time dissolved oxygenation values of the bath water used for treatment during the time of Bimini's NanoJet® UFB infusion. (Values at time 51-53 minutes were not recorded due to technical difficulties, therefore the value from time 50 was kept in place for these time intervals to maintain the linear congruency of the graph.)

Case 2: EM

Description:

EM is an active teen-age female with no chronic medical conditions who plays soccer. She has no complaints regarding her current training.

On exam, EM is an athletic appearing, well nourished, pleasant and cooperative female who appears stated age. She has normal vitals at rest in addition to benign cardiac and pulmonary exams. She exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

EM was consented and eager to participate in this study. EM was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician and professional sports physiologist. She was continuously monitored during the study.

During the study, EM wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris providing real time capture and continuous monitoring of SMO2.

Prior to EM entering the bathtub equipped with a Bimini NanoJet® infuser, Bimini ran for 10 minutes reaching an oxygen content of 17 parts per million (ppm). EM's initial SMO2 was 50% prior to infusion. EM was positioned in a resting position with his bilateral lower extremities and lower trunk were submerged, other than the very top of the Moxy sensors which were kept above the surface for data capturing purposes. Treatment time was 40 minutes. Tub temperature maintained between 98. to 97 degrees Fahrenheit throughout 40-minute treatment protocol. Throughout the treatment, O2 content of the tub remained between 17-18 ppm. After the 40-minute treatment, EM was transferred out of the bath where she stood to dry off and recover. The study period was completed at this time.

Results:

Prior to EM entering the tub her SMO2 was recorded as 50% via the Moxy NIRS sensor. After 5 minutes in the active Bimini NanoJet® infusion tub, her SMO2 reached 94%. Two hours after treatment, EM played a 90-minute soccer game. Patient reported no preserved difference in performance by using the NanoJet® 2 hours before the game.

Case 3: DC

Description:

DC is an active middle-aged male with no chronic medical conditions who performs heavy aerobic and weightlifting exercises 5 days per week. His recovery times are typically faster compared to his peers.

On exam, DC is an athletic appearing, well nourished, pleasant and cooperative male who appears stated age. He has normal vitals at rest in addition to benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

DC was consented and eager to participate. DC was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician and professional sports physiologist. He was continuously monitored during the study.

During the study, DC wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. A heart rate (HR) monitor was worn on the right humerus over the brachial artery. These sensors provided real time capture and continuous monitoring of SMO2 and HR.

DC stood for 10 minutes in dry land next to the treating tub equipped with the Bimini NanoJet®. He then transferred into a tub with the Bimini NanoJet® actively infusing the water with an initial temperature of 102 degrees Fahrenheit. DC remained submerged for 32 minutes. During this time the water temperature lowered to 92 degrees Fahrenheit.

Results:

From time 0-10 minutes while DC stood outside of the tub his SMO2 stayed between 40-60%. When he transferred into the tub equipped with the active Bimini infusion, his SMO2 briefly increased to a high of 75% and gradually returned to baseline. After 20 minutes of treatment the SMO2 rose once again, from 55% up to near 90% from time 30-40 minutes. The SMO2 plateaued near 90% as the treatment concluded.

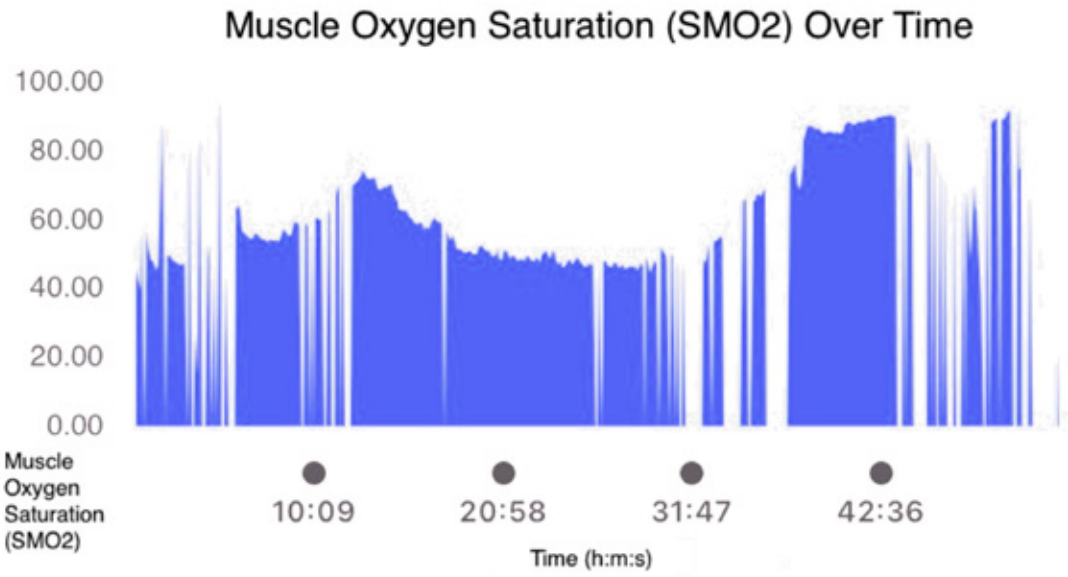

Figure 2. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor.

Case 4: PR

Description:

PR is a middle-aged male with no chronic medical conditions. He exercises 5 days per week using a watt bike and various weight training routines.

On exam, PR is an athletic appearing, well nourished, pleasant and cooperative male who appears his age. He has normal vitals at rest in addition to benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

PR was consented and eager to participate. PR was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician. He was continuously monitored during the study.

During the study, PR wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. A heart rate (HR) monitor was worn on the right humerus over the brachial artery. These sensors provided real time capture and continuous monitoring of SMO2 and HR.

PR stood for 5 minutes in dry land next to the treating tub equipped with the Bimini NanoJet® device. He then transferred into a tub with the NanoJet® actively infusing the water where he stayed for 35 minutes, from time 5-40 minutes.

Results:

From time 0-5 minutes while PR stood outside of the tub his SMO2 stayed between mid 40s-mid 50 % range. When he transferred into the tub equipped with the active Bimini NanoJet® infusion, his SMO2 gradually rose and maintained near 70% for the first 20 minutes of treatment, time 5-25 minutes. After 20 minutes of treatment the SMO2 rose once again, into the mid 80% range where the SMO2 plateaued for 5 minutes. Finally, for the last 5 minutes of treatment the SMO2 fell into the 60% range.

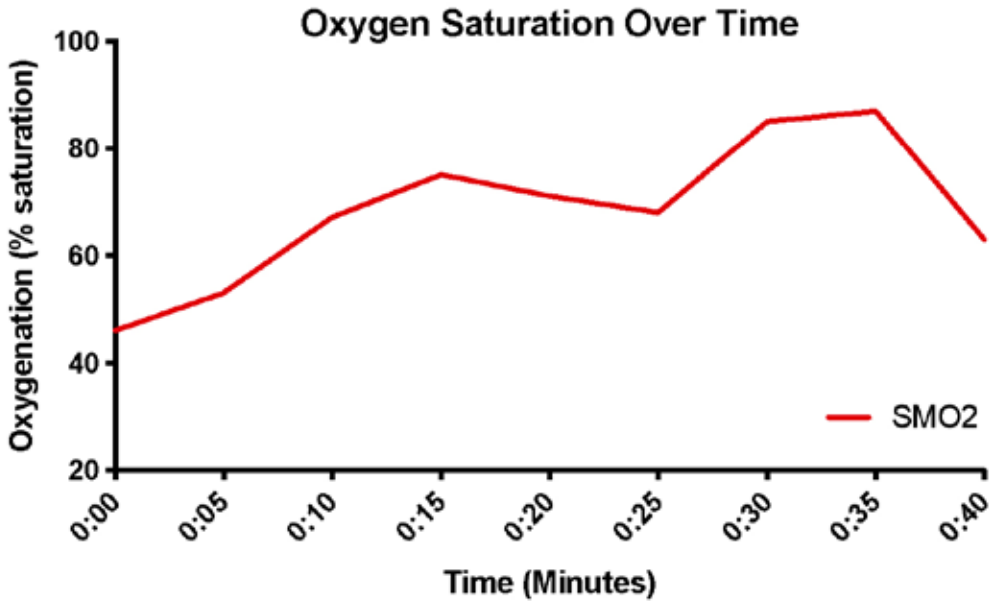

Figure 3. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor.

Case 5: SS

Description:

SS is a 16-year-old swimmer with no chronic medical conditions. She engages in vigorous exercise regularly incorporating aerobic and anaerobic training. SS regularly competes and has no physical complaints regarding her training regimen.

On exam, SS is an athletic appearing, well nourished, pleasant and cooperative female who appears stated age. She has normal vitals at rest in addition to benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

SS was consented and eager to participate in this study. SS was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician and professional sports physiologist. She was continuously monitored during the study.

SS wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. A heart rate (HR) monitor was worn on the right humerus over the brachial artery. These sensors provided real time capture and continuous monitoring of SO2 and HR. Over the course of the weekend: Friday, Saturday, and Sunday, SS underwent a 40-minute treatment on Friday and a 40-minute treatment on Saturday afternoon. SS competed on Saturday and Sunday Morning. For both sessions: SS was positioned in a resting position with his bilateral lower extremities and lower trunk were submerged, other than the very top of the Moxy sensor which were kept above the surface for data capturing purposes.

Treatment session (Friday): Prior to SS entering the bathtub equipped with the Bimini NanoJet® infuser, the NanoJet® ran for 10 minutes reaching an oxygen content of 13 parts per million (ppm). SS's initial SMO2 was 53% prior to infusion. Treatment time was 40 minutes. Tub temperature remained between 95.3 and 96.2 degrees Fahrenheit throughout the protocol. The O2 content of the tub was 18.15 ppm at the 20-minute mark and fluctuated between 18.06 and 18.57 ppm. After the treatment, the patient was transferred out of the bath where they stood to dry off and recover. The study period was completed at this time.

Treatment session (Saturday): Prior to SS entering the bathtub equipped with a Bimini NanoJet® infuser, the NanoJet® ran for 10 minutes however, priming issues occurred. SS's initial SMO2 was 38% prior to infusion. Treatment time was 40 minutes. Tub temperature remained between 98.8 and 96.6degrees Fahrenheit throughout the protocol. At the 5-minute mark, the O2 content of the tub was 16.2 ppm and gradually reached 18.53 ppm by the 40-minute mark. After the treatment, the patient was transferred out of the bath where they stood to dry off and recover. The study period was completed at this time.

Results:

Treatment session (Friday): Prior to SS entering the tub her SMO2 was recorded at 53% via the Moxy NIRS sensor. After 6 minutes in the active Bimini infusion tub, her SMO2 was around 90%. For the duration of the session, SS's SMO2 was between 93-97%. Two hours after treatment, SS did a light swim and competed the following morning. On Saturday morning, SS recorded a Personal Record (PR) in the 50m Swim race, which was the fastest time in 4 years.

Treatment session (Saturday): After her meet, she completed an additional session. At the start, her SMO2 was recorded at 38% via the Moxy NIRS sensor. After 5 minutes in the active Bimini infusion tub, her SMO2 was 46%. At 10 minutes, her SM02 was 72%. By 15 minutes, her SMO2 was 84% and it continued to climb to 91% at 40 minutes. SS competed the following morning with a normal performance, but no PRs.

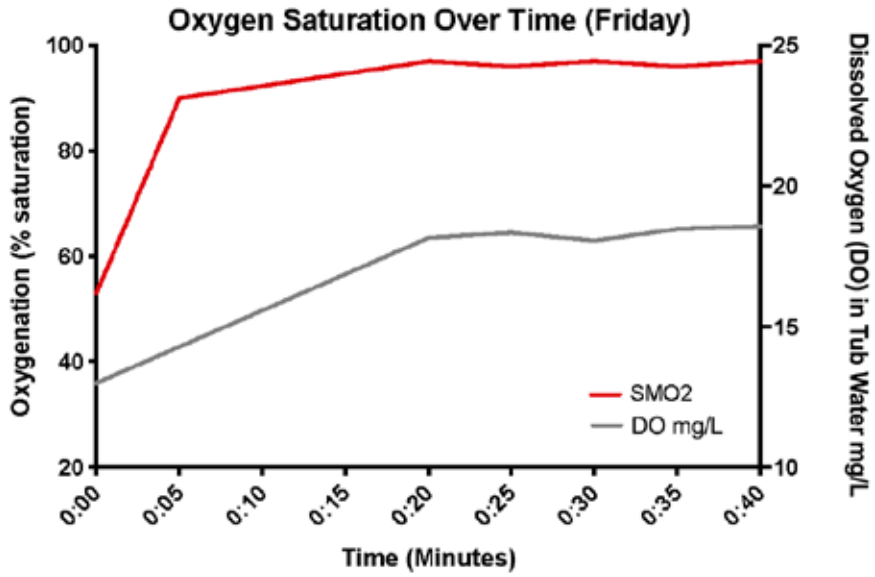

Figure 4. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor and dissolved oxygenation (DO) of the tub water used for treatment during the Bimini NanoJet® infusion.

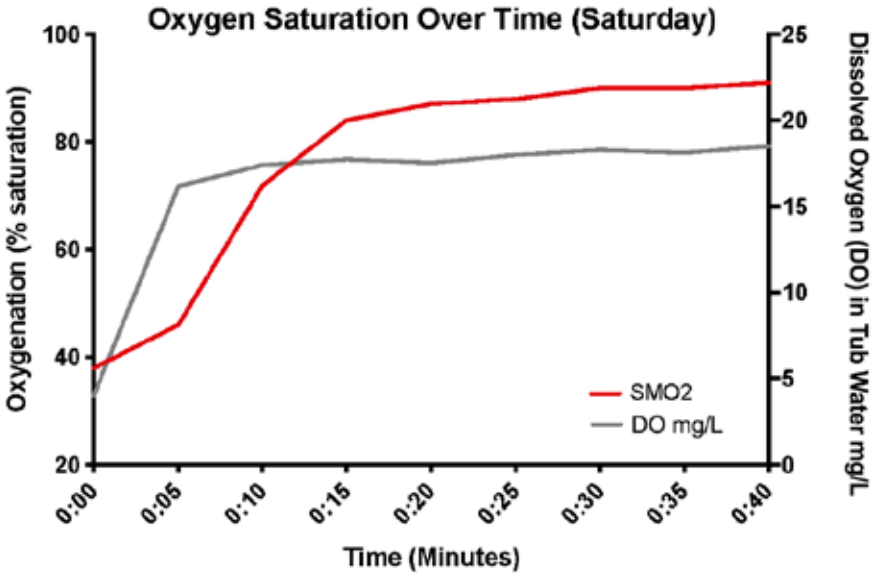

Figure 5. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor and dissolved oxygen of the tub water used for treatment during the Bimini NanoJet® infusion.

Case 6: SP

Description:

SP is a 17-year-old soccer player with no chronic medical conditions. He exercises regularly and frequently plays 90-minute soccer matches. Despite long practices including aerobic and anaerobic exercises, SP has no physical complaints regarding his training regimen.

On exam, SP is an athletic appearing, well nourished, pleasant and cooperative male who appears stated age. He has normal vitals at rest in addition to benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

SP was consented and eager to participate in this study. SP was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician and professional sports physiologist. He was continuously monitored during the study.

During the study, SP wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. A heart rate (HR) monitor was worn on the right humerus over the brachial artery. These sensors provided real time capture and continuous monitoring of SMO2 and HR.

Prior to SP entering the bathtub equipped with a Bimini NanoJet® infuser, Bimini ran for 10 minutes reaching an oxygen content of 13 parts per million (ppm). SP's initial SMO2 was 50 prior to infusion. SP was positioned in a resting position with his bilateral lower extremities and lower trunk were submerged, other than the very top of the Moxy sensor which were kept above the surface for data capturing purposes. Treatment time was 20 minutes. Tub temperature maintained between 98.2 to 97 degrees Fahrenheit throughout 20-minute treatment protocol.

Five minutes into the treatment, O2 content of the tub was 16.15 ppm. At 10 minutes into treatment O2 was 18.26 ppm. At 15 minutes into treatment O2 reached 18.51. At 20 minutes, at the end of treatment, O2 was 18.5. After the 20-minute treatment, SP was transferred out of the bath where he stood to dry off and recover. The study period was completed at this time.

Results:

Prior to SP entering the tub his SMO2 was recorded as 50% via the Moxy NIRS sensor. After 5 minutes in the active Bimini NanoJet® infusion tub, his SMO2 reached 93%. Between 5 and 20 minutes, SP's SMO2 maintained between 90-92%.

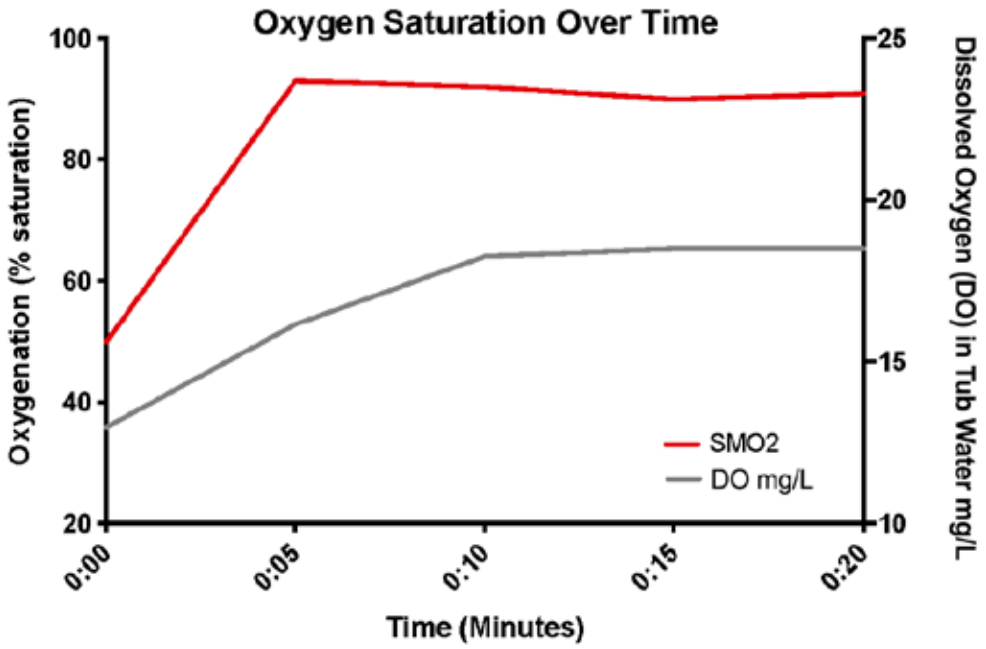

Figure 6. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor and dissolved oxygen of the tub water used for treatment during Bimini NanoJet® infusion.

Case 7: CM

Description:

CM is a teenage male with no chronic medical conditions. He exercises regularly.

On exam, CM is an athletic appearing, well nourished, pleasant and cooperative male who appears stated age. He had normal vitals with benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

CM was consented and eager to participate in this study. CM was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician and professional sports physiologist. He was continuously monitored during the study.

During the study, CM wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. This sensor provided real time capture and continuous monitoring of SMO2.

Prior to CM entering the bathtub equipped with a Bimini UFB infuser, Bimini ran for 10 minutes reaching an oxygen content of 17 parts per million (ppm). CM's initial SMO2 was 50% prior to infusion. CM was positioned in a resting position with his bilateral lower extremities and lower trunk were submerged, other than the very top of the Moxy sensor which was kept above the surface for data capturing purposes. Treatment time was 40 minutes. Tub temperature maintained between 95.9 to 97.9 degrees Fahrenheit throughout the treatment protocol. After the 40-minute treatment, CM was transferred out of the bath where he stood to dry off and recover. The study period was completed at this time.

Results:

Prior to CM entering the tub his SMO2 50% oxygenated read via the Moxy NIRS sensor. From 5 minutes to 45 minutes CM's SMO2 reached 80% (See Figure below).

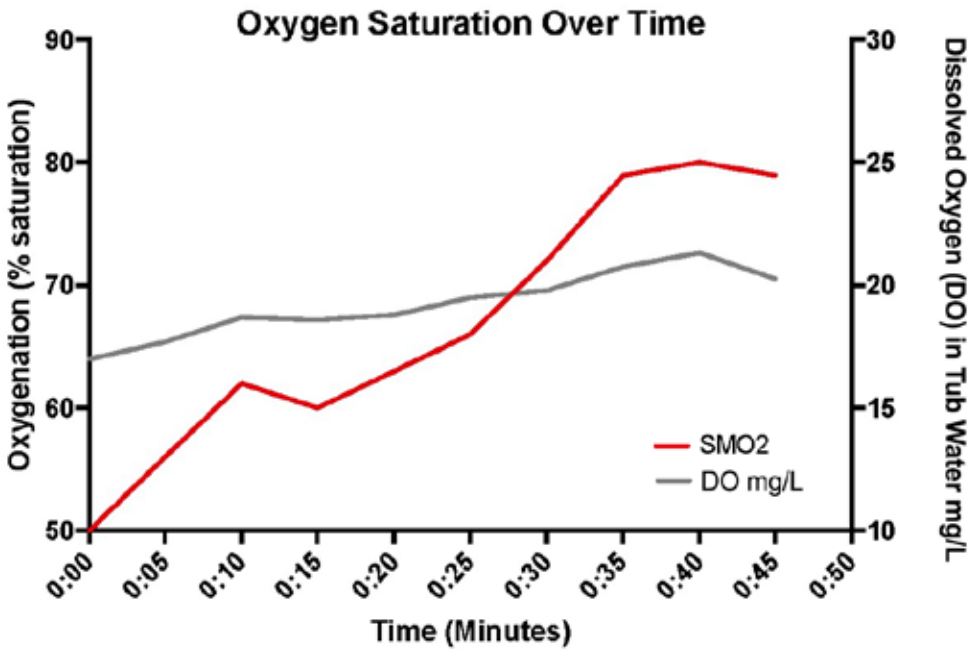

Figure 7. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor and dissolved oxygen of the tub water used for treatment during Bimini NanoJet® infusion.

Case 8: FC

Description:

FC is a 31-year-old male, former elite athlete with no chronic medical conditions. He exercises 7 days a week with a primary focus on endurance exercise.

On exam, FC is an athletic appearing, well nourished, pleasant and cooperative male who appears stated age. He is bradycardic at rest with benign cardiac and pulmonary exams. He exhibits full range of motion in his extremities and no signs of pain or injury with exercise.

Methods:

FC was consented and eager to participate in this study. FC was evaluated and cleared for participation prior to the study by a board-certified sports medicine physician and professional sports physiologist. He was continuously monitored during the study.

During the study, FC wore a neoprene sleeve on the right thigh that held the Moxy SMO2 sensor in place over the right rectus femoris. A Nonin NIRS sensor was placed in the left groin over the femoral vessels and secured with water resistant adhesive. These sensors provided real time capture and continuous monitoring of SMO2 and rSO2.

Prior to FC entering the bathtub equipped with a Bimini NanoJet® infuser, the NanoJet® ran for 10 minutes reaching an oxygen content of 19 parts per million (ppm). FC's initial SMO2 was 56% and his initial rSO2 was 83% prior to infusion. FC was positioned in a resting position with his bilateral lower extremities and lower trunk were submerged, other than the very top of the Moxy and Nonin sensors which were kept above the surface for data capturing purposes.

Treatment time was 40 minutes. Tub temperature maintained between 96.2 to 94.5 degrees Fahrenheit throughout the treatment protocol. After the 40-minute treatment, FC was transferred out of the bath where he stood to dry off and recover. The study period was completed at this time.

Results:

One hour before treatment FC completed a 2-hour tempo cycling ride completing 41 miles with an average temperature of 63 degrees Fahrenheit. Prior to FC entering the tub his SMO2 was recorded as 56% via the Moxy sensor and his rSO2 was 83% via the Nonin NIRS sensor. From 5 minutes to 45 minutes both FC's SMO2 and rSO2 increased, reaching 80% and 90% respectively (See Figure below). The following day, after treatment, FC Snowboarded for 6 hours with no reported fatigue.

(See Figure below). The following day, after treatment, FC Snowboarded for 6 hours.

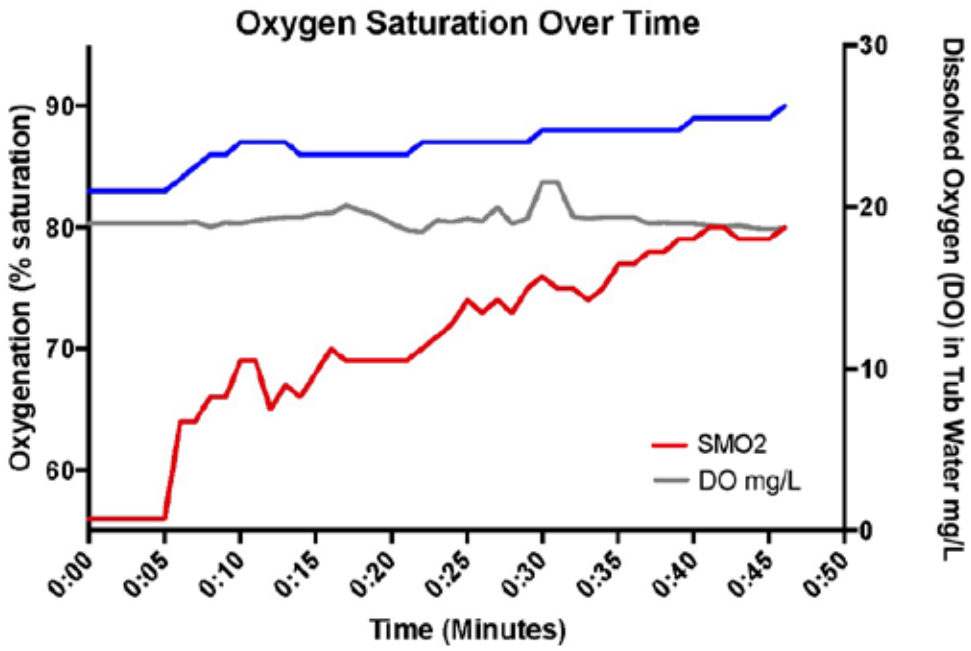

Figure 8. Real time oxygenation values of the Bimini NanoJet® Oxygen content, the right rectus femoris (SMO2) and the left femoral mixed venous sampling (rSO2)

Discussion:

This study is in line with our prediction that the Bimini NanoJet® Ultra-Fine Bubble (UFB) hydrotherapy, a nanobubble oxygenation technology, will increase muscle oxygen levels and therefore decreased pain, inflammation and recovery time from exercise. Through objective data collected from multiple cases we have shown an increase in muscle SMO2 and mixed venous rSO2 when the Bimini NanoJet® is utilized. Additionally, some of these cases provided subjective data describing ease of exercise after completing this treatment.

Utilizing the non-invasive technology NIRS, we were able to detect mixed venous blood oxygen saturation of tissues 1-3 cm below the skin by measuring the absorption spectra of the tissue chromophores oxyhemoglobin and deoxyhemoglobin. With most cases, after just 5 to 20 minutes in the Bimini NanoJet® hydrotherapy tub, individuals were increasing their muscle oxygen saturation from around 50% to over 90%. rSO2 sampling increased 9.6% over the course of the treatment in our final case.

The utilization of both the Moxy device, recording muscle oxygen saturation, and the Nonin device, recording regional oxygen saturation over the femoral vessels, increased our accuracy and made regional oxygen saturation measurements possible. We found both the rSO2 and SMO2 to increase in healthy athletes. SMO2 increased 86% on average and rSO2 increased 4.5% during an unpublished preliminary trial. Eight individuals were tested using the Bimini NanoJet® to provide hyperoxygenation to bilateral lower extremities with or without Bimini NanoJet® oxygenation. Results below represent timing and data from the Bimini NanoJet® exposure of 8 individual SMO2 trials, a mean non-linear regression fit line, and results from our single rSO2 trial (Figure 9).

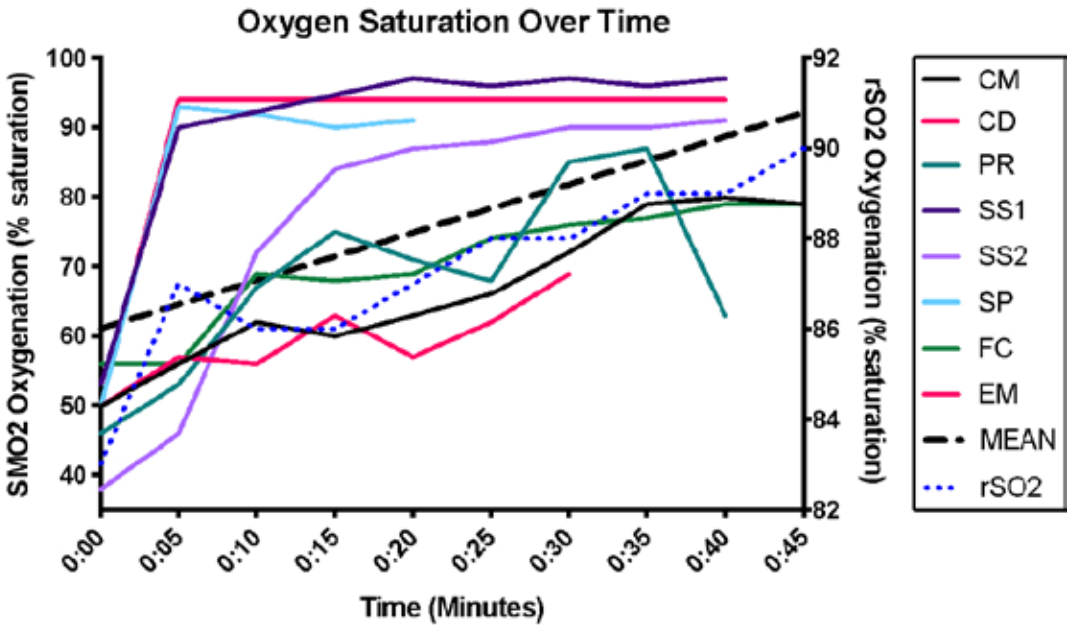

Figure 9. Real time oxygenation values of the right rectus femoris utilizing an SMO2 sensor. Real time oxygenation values of the bath water used for treatment during the time of Bimini NanoJet® UFB infusion. N=8.

While this study looked at participants who are young and healthy, there are implications for patients who are septic or hospitalized. Tissue oxygenation hydrotherapy holds a promise for increased athletic recovery, improved athletic performance, illness recovery, and physiologic improvement for those with infections or system illnesses.

Athletes push their bodies to the limit every day in hopes of constant progression. In doing so they risk injury, fatigue, pain and ultimately the potential consequence of having to take time away from their passion to recover. We know that the smallest decrease in recovery time makes a world of difference. Athletes need ample oxygen for proper healing and recovery. From the microscopic level of cellular physiology to the holistic picture of each athlete's overall well-being, Bimini's NanoJet® UFB provides a new approach to improving recovery utilizing one submicron infusion at a time.

Acknowledgements:

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