MEASURES OF NEAR-INFRARED SPECTROSCOPY GUIDING INTER-SET RECOVERY DURATION DURING BARBELL BACK SQUATS

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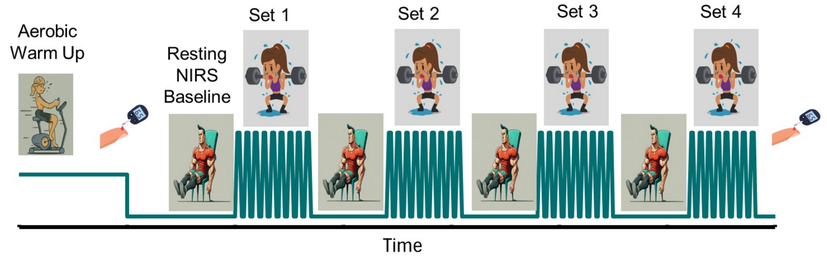
Introduction

- Near-infrared spectroscopy (NIRS) is a noninvasive technique that employs near-infrared light to muscle oxygenation in real-time. Muscle oxygenation is related to phosphocreatine recovery following strenuous exercise and can be used to understand muscle recovery and guide rest duration before a subsequent bout.
- Tissue saturation index (TSI) and deoxygenated hemoglobin (HHb) are two measures collected by NIRS devices that are meaningful for muscle recovery.
- TSI is the ratio of oxygenated hemoglobin to total hemoglobin indicating the balance of oxygen utilization and oxygen delivery (e.g. blood flow). Previous research has primarily used TSI as a NIRS measurement of muscle recovery following exercise but could be flawed due to changes in muscle blood flow following exercise.
- HHb indicates muscle oxygen utilization independent of muscle blood flow, which could make it a better metric of muscle recovery following exercise.
- Using NIRS devices and understanding muscle oxygenation during recovery could help customize inter-set recovery durations and optimize the balance between work and rest periods, which offers a valuable tool for designing personalized exercise regimens and enhancing athletic performance.

Experimental Conditions

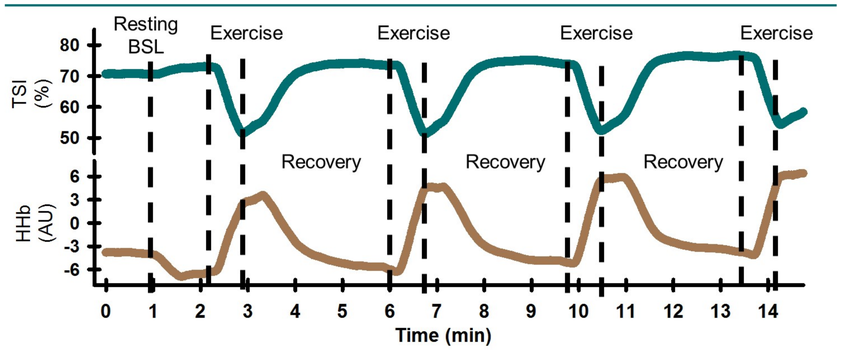
- Experimental conditions (ABS, DEOXY, TSI) were performed in a random order.
- Participants completed 4 sets of 8 repetitions of barbell back squats at 75% 1RM and were instructed to complete the concentric movement as fast as possible.
- Lactate was taken by a finger stick after the warmup (Pre) and immediately following the fourth set (Post).
- A continuous wave Portamon NIRS device was secured on vastus lateralis and was recorded continuously. Before the first set, participants rested and the final 30 seconds were averaged as a baseline to normalized NIRS values.



Inter Rest Duration

- **Absolute Rest Duration (ABS)** – 3-minute inter-set recovery
- **Deoxygenated Hemoglobin (DEOXY) and Tissue Saturation Index (TSI)** – Recovery ended when a plateau in NIRS measure was observed for five seconds, and the next set commenced. Recovery duration was the time from the end of the set until the plateau was observed.
- All inter-set recoveries were in the seated position.

Representative TSI and HHb



Purpose

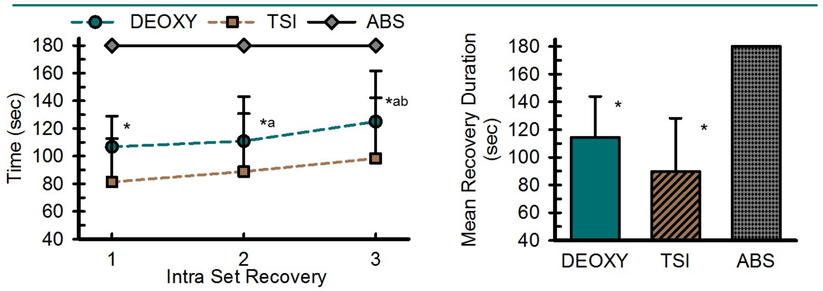
This study examined different NIRS measures of muscle oxygenation TSI or HHb to determine inter-set rest durations compared to a standard 3-minute inter-set duration.

Subject Characteristics

N	Age (yrs)	HT (cm)	WT (kg)	Predicted 1-RM (lbs)*	75% Predicted 1-RM (lbs)**
6 (M = 2; F=4)	24.9 ± 3.9	173.0 ± 5.6	69.0 ± 3.9	241.3 ± 64.8	181.0 ± 48.6

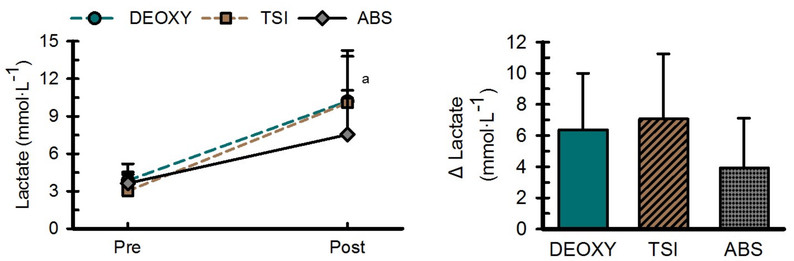
*Data presented as mean ± SD. *One RM prediction test was performed prior to experimental conditions and calculated from load and repetitions to fatigue. ** 75% Predicted 1-RM was rounded up to the nearest 5 lbs to use as load in experimental conditions.*

Inter Set Recovery Duration



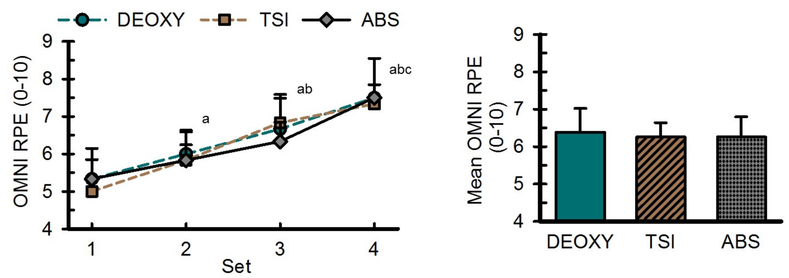
Recovery durations for DEOXY and TSI were from the last repletion until a plateau was observed. All ABS recoveries were 180 seconds by design. Mean recovery duration is the average duration over the four sets. Data are mean ± SD. = different from ABS (p<0.05); a = different from 1 (p<0.05); b = different from 2 (p<0.05)*

Lactate



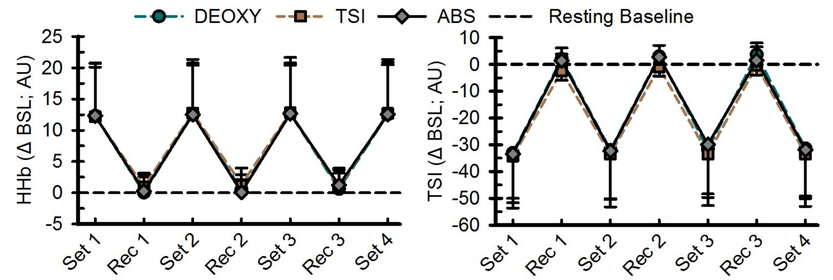
Lactate was measured by a capillary finger stick taken after warm-up immediately prior to set 1 (Pre) and immediately following set 4 (Post). Δ Lactate is the change in blood lactate from pre to post. Data are mean ± SD. a = all conditions are different from pre (p<0.05)

Perceived Exertion



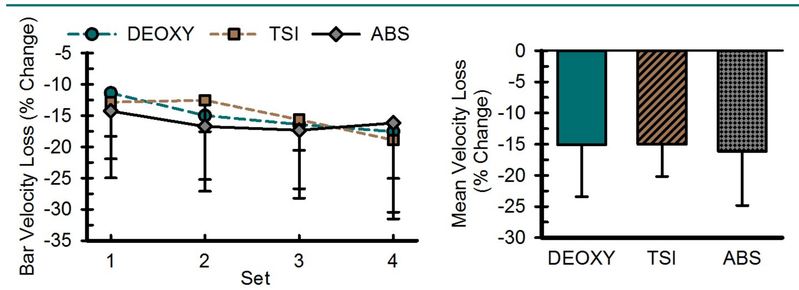
Rating of Exertion was provided by subject immediately following set using the OMNI (0-10) RPE chart. Mean OMNI RPE is RPE averaged over the four sets. Data are mean ± SD. a = all conditions were different from 1; b = all conditions were different from 2; c = all conditions were different from 3.

HHB and TSI



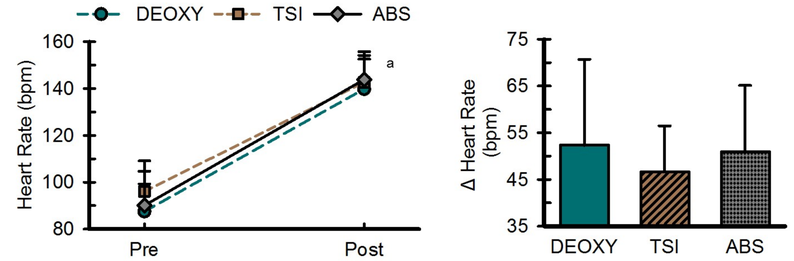
HHb (Left Panel) and TSI (Right Panel) at the end of exercise (Set) and inter-set recovery (Rec). Data are mean ± SD and displayed as a change from resting baseline in arbitrary units (AU).

Bar Velocity Loss



Bar velocity loss is change in bar velocity during the concentric component from the first rep to the last rep. Mean velocity loss is bar velocity loss averaged over the four sets. Data are mean ± SD.

Heart Rate



Heart rate was taken immediately before (Pre) and following (Post) each set. Data are averaged over four sets.. Δ heart rate is the change from pre to post, averaged over the four sets. Data are mean ± SD. a = all conditions are different from pre (p<0.05)

Conclusion

- NIRS guided inter-set recovery resulted in a shorter recovery duration compared to the 3-min recovery, and HHb resulted in the shortest recovery duration.
- Muscle oxygenation was similar across conditions during exercise and recovery.
- Physiological stress, perceived exertion, and mechanical fatigue were not affected during barbell back squats, despite the different recovery durations.

Practical Applications

Measuring muscle oxygenation levels, specifically TSI or HHb, during exercise can be a useful tool in individualizing recovery duration. HHb resulted in shortest recovery durations, there were no differences in physiological (heart rate), perceptual (RPE), or fatigue/performance (bar velocity) measures between HHb and TSI amd either could be used to guide strength training. Integrating real-time muscle oxygenation levels into training sessions could enable the tailoring of training protocols to metabolic responses, fostering more personalized and efficient strength training.