Purpose: To devise an exercise that will demonstrate the localized hypoxic and ischemic conditions of muscle tissue in individuals with myofascial trigger points in the upper trapezius using near-infrared spectroscopy.

OBJECTIVE: To compare the recovery phases for oxygen saturation (StO$_2$), oxygenated hemoglobin (HbOxy), deoxygenated hemoglobin (HbDeOxy), and total hemoglobin concentration (THC) in the upper trapezius in isometric and isotonic shoulder shrug exercises.

Near-Infrared Spectroscopy (ISS OxiplexTS, Champaign, IL) is a non-invasive technique that transmits infrared rays through skin and superficial muscle providing a localized measurement of oxygen and blood flow dynamics.

**Methods and Materials**
- NIRS sensor was held in place on the upper trapezius with two-trials conducted on each side recording a 30-sec baseline period, 30-sec contraction, and 90-sec recovery period.
- All subjects were seated in an office chair with adjustable height:
  - Isometric Exercise: Performed a shoulder shrug while grasping a rope securely attached to the base of the chair.
  - Isotonic Exercise: Performed a shoulder shrug with an 18lb weight.

**Results**

**Total Hemoglobin Concentration Dynamics for Isometric and Isotonic Exercises**

**Oxygen Saturation Dynamics for Isometric and Isotonic Exercises**

**Oxygen Saturation Rates of Recovery for Isometric and Isotonic Exercises**

**Results and Discussion**

- The rates of recovery for StO$_2$, THC, and HbOxy during the isometric exercise were all significantly slower than the isotonic exercise.
- Isotonic exercise demonstrated an overshoot for THC and a more homogenous return of hemoglobin and StO$_2$ to baseline.
- Isometric exercise demonstrated a stepwise gradual return to THC baseline concentration, and almost linear recovery of StO$_2$.
- Intramuscular pressure was greater during the isometric contraction resulting in compression of arterioles, preventing relaxation of smooth muscle in vessel walls obstructing blood flow return and oxygen delivery.
- The isotonic exercise demonstrated better exponential regression fits for all parameters.

**Recovery Rates for Isometric and Isotonic Exercises**

<table>
<thead>
<tr>
<th></th>
<th>Isometric Exercise (sec$^{-1}$)</th>
<th>Isotonic Exercise (sec$^{-1}$)</th>
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</thead>
<tbody>
<tr>
<td><strong>StO$_2$</strong></td>
<td>0.007±0.005 (R$^2$=0.903)</td>
<td>0.005±0.002 (R$^2$=0.720)</td>
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<tr>
<td><strong>THC</strong></td>
<td>0.011±0.002 (R$^2$=0.856)</td>
<td>0.011±0.005 (R$^2$=0.889)</td>
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<tr>
<td><strong>HbOxy</strong></td>
<td>-0.011±0.027 (R$^2$=0.914)</td>
<td>-0.022±0.013 (R$^2$=0.970)</td>
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<td><strong>HbDeOxy</strong></td>
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**Conclusion**

- THC and oxygen recovery were limited during the isometric exercise, preventing the appearance of distinct recovery phases that could be used for comparison.
- The rigid muscle sensor limited placement along the upper trapezius, where measurement closer to the C7 would better demonstrate the location of possible myofascial trigger points.