Comparison of Physiological Responses to Single and Double Leg Submaximal Cycling in Normoxia and Hypoxia

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BACKGROUND

Endurance athletes have long looked for ways to improve sea level performance through a variety of different means. As a result, the live high-train low paradigm has come to the forefront as a method to induce the favorable cardiovascular, metabolic, and respiratory adaptations of altitude exposure while circumventing decreased training intensity associated with exercise at altitude. However, for many athletes who live at altitude, the live high-train low paradigm is not feasible. Thus, to optimize performance for these individuals it is imperative to find an alternative way for them to aerobically train their muscles at a sea level intensity while living at altitude.

Single leg cycling is a reduced muscle mass exercise that has been used as both a rehabilitative as well as training modality. Single leg cycling has been reported to generate greater leg work rates, blood flow, and greater muscle specific adaptations compared to double leg cycling and other larger muscle mass training modalities. Furthermore, by reducing the active muscle by one half, performance is limited by peripheral factors rather than central cardiac output, which is often the limiter of performance in large muscle mass or whole body exercises. However, it has yet to be determined if the elevated limb blood flow associated with single leg cycling will minimize the reduction in tissue oxygenation that occurs with double leg cycling at moderate altitude.

METHODS

Subjects

Ten (5 males and 5 females) healthy and moderately active (30 minutes of moderate intensity, 3 days a week, for at least 3 months) individuals were recruited to participate in this investigation (height: 177.2 ± 8.0 cm; weight: 74.2 ± 13.2 kg; VO2 max: 43.0 ± 8.3 ml·min·kg⁻¹; age: 25 ± 3 years) who had not been exposed to an altitude above 2,500 meters within two months prior to participation in the study. Participants arrived having abstained from caffeine and alcohol for 24 hours.

Protocol

Flow chart of study

Oxygen concentration was 15% which simulated an altitude of 2,740 meters. Heart rate and arterial oxygen concentration (SaO₂) were recorded every minute of each stage. Lactate, blood pressure, and rating of perceived exertion (RPE) were recorded after the last minute of each stage. Femoral arterial blood velocity and vessel diameter were measured immediately at the end of each stage. The protocol was performed in both normoxic and hypoxic conditions.

Statistical Analysis

A paired samples t-test was used to compared baseline measurements to acclimation (pre-exercise) measurements following 30 minute acclimation period in both normoxia and hypoxia conditions in heart rate, arterial oxygen concentration, lactate, rating of perceived exertion, and mean arterial pressure.

A 3 x 4 repeated measures ANOVA was used to assess the main effects of condition (single leg hypoxia, double leg normoxia, and double leg hypoxia) and work rate (60%, 70%, 80% of VO2 max) as well as their interaction on femoral blood flow, oxygenated and total hemoglobin, tissue saturation index, heart rate, mean arterial pressure (MAP), SaO₂, lactate, and RPE. If the ANOVA was deemed significant, then a Sidak post hoc test was used to accommodate for alpha inflation.

RESULTS

Normoxia: baseline and acclimation indicated no difference in SaO₂, lactate, and MAP (p > 0.34) and a significant increase in heart rate (p = 0.03).

Hypoxia: baseline and acclimation indicated no difference in heart rate and lactate (p > 0.10), a significant decrease in SaO₂, and a significant increase in MAP (p < 0.05). No difference in blood flow was found between DLN vs SLH vs DLH (p > 0.34) & Between SLH vs DLH (p = 0.15).

CONCLUSIONS

Increased blood flow leads to an increase in tissue perfusion with single leg cycling which could allow for greater muscle specific work rates when compared to double leg cycling and can be accomplished with reduced cardiovascular stress.

Elevated hemoglobin saturation and femoral blood flow during the single leg condition in hypoxia are similar to that observed during double leg cycling in normoxia.

Single leg cycling may prove to be a viable training modality that would offset the main disadvantage of living at altitude by enabling an individual to exercise at the same level of intensity achieved at normoxia.

Future investigations could examine higher simulated/actual altitudes, highly trained athletes (exercise induced hypoxia), and work rates past 80% of an individual’s VO2 max.