Impact of Acute Hypoxic Exposure on Neuromuscular Responses During Step Intensity Dynamic Constant External Resistance Leg Extension Exercise

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Introduction

Acute hypoxic exposure can induce systemic deoxygenation and increased sympathetic nerve activity. Exercise physiology research on hypoxia has been shown to increase the rate of metabolic byproducts accumulation which negatively impacts the extra-cellular environment primarily in aerobic exercise performance such as cycling and running. Little research exists regarding the effects of hypoxia during high-intensity, strength-based movements and the research that has been performed have conflicting results. Although the effects of hypoxia on the muscle response to normobaric and hypoxic conditions on the lower body are well investigated, further exploration examining the lower body during leg extensions performed at varying intensities is warranted. Therefore, having a better understanding of how strength-based activities are impacted by acute hypoxic exposure will provide better information on how we should modulate workloads and performance metrics in occupations and athletes that go from low to high altitudes.

Purpose

Examine the influence of acute exposure to normobaric hypoxia on electromyographic (EMG) root mean square (RMS) and mean power frequency (MPF) on the vastus lateralis (VL) during leg extensions performed at various step intensities.

Methods

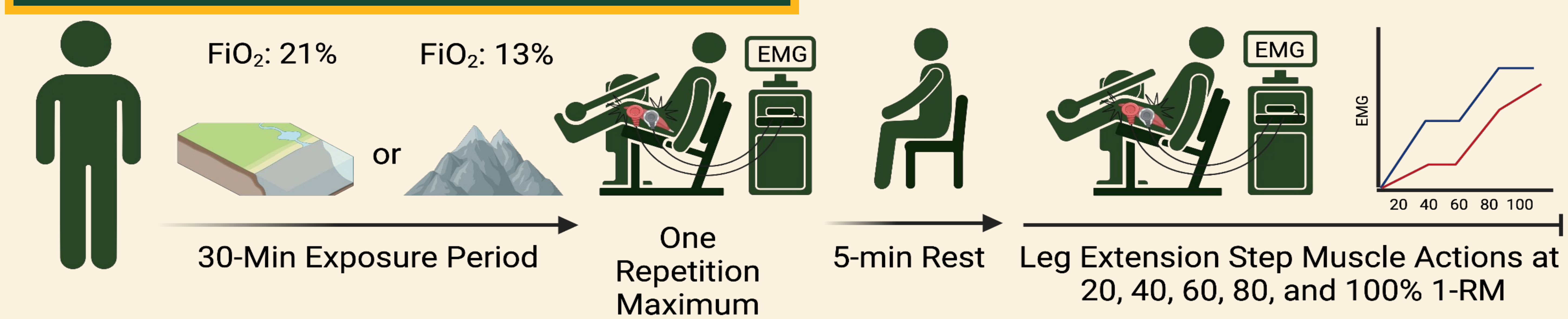

Figure 1. *Overview of study protocol. The participants were randomly exposed to either the N or H_{13} conditions for 30 min prior to performing the strength-based step muscle actions unilaterally in a randomized order at 20%, 40%, 60%, 80% and 100% of their 1RM leg extension.*

13 recreationally active men (age: 21.2 ± 2.9 yr., height: 174.8 ± 12.8 cm, weight: 83.2 ± 14.1 kg) were exposed to two simulated altitude conditions on different visits: Normoxic (N; Fraction of inspired oxygen [FiO_2] = 21%) and hypoxic (H_{13}; FiO_2 = 13%, simulating ~12,500 ft.). EMG RMS and MPF was collected from the VL during randomized step muscle actions following a 30min hypoxic exposure period (Figure 1 & 2). A 2 (Condition: N and H_{13}) x 5 (step muscle actions: 20%, 40%, 60%, 80% and 100% of their 1RM leg extension) two-way repeated measure ANOVA was performed on EMG RMS and EMG MPF normalized to their N 1RM.

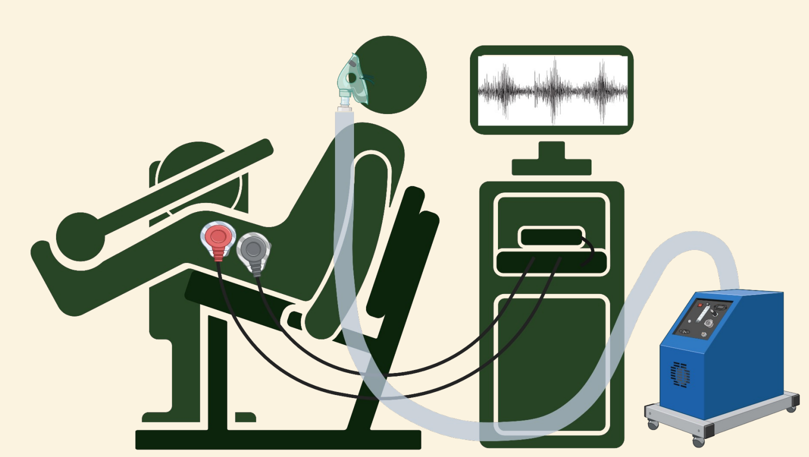

Figure 2. *Testing setup for study protocol.*

Results

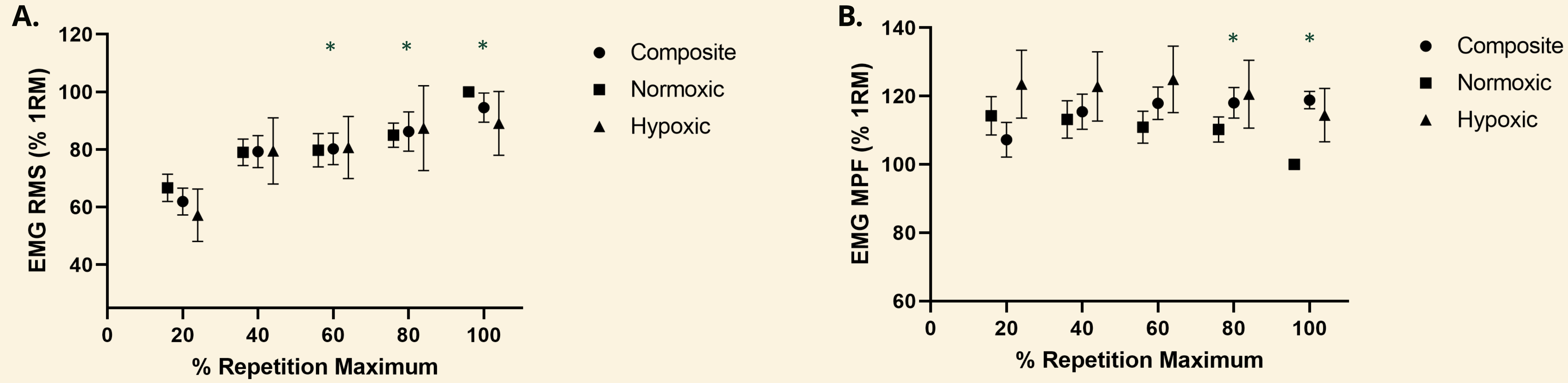

Figure 3. **(A.)** *Normalized electromyographic (RMS) and* **(B.)** *electromyographic (MPF)* of the vastus lateralis muscle *under normoxic* (FiO_2: 21%) *and hypoxic* (FiO_2 = 13%) *conditions during leg extension step muscle actions. Values are presented as mean* ± SEM.
* Indicates the composite was significantly greater than previous intensities *($p < 0.05$).*

For EMG RMS, there was no significant interaction (p = 0.37) or main effect for Condition (p = 0.74). There was a main effect for Intensity (**p < 0.01**) which indicated that 20% < 40% = 60% < 80% < 100% 1RM (p < 0.01 - 0.03). Means and standard deviation for EMG RMS at each step muscle actions were (mean±SEM: 20% = 61.9 ± 4.7, 40% = 79.3 ± 5.6, 60% = 80.2 ± 5.5, 80% = 86.2 ± 6.9, 100% = 94.5 ± 5.1% 1RM).

For EMG MPF, there was no significant interaction (p = 0.83) or main effect for Condition (p = 0.17). There was a main effect for Intensity (p = 0.02**)** which indicated that 20% = 40% = 60% < 80% < 100% (p < 0.01). Means and standard deviation for EMG RMS at each step muscle actions were (mean±SEM: 20% = 107.2 ± 5.1, 40% = 115.4 ± 5.1, 60% = 117.9 ± 4.8, 80% = 118 ± 4.5, 100% = 118.8 ± 2.8% 1RM).

Conclusions

These results indicate that acute hypoxic exposure did not affect the neuromuscular responses during step muscle actions. However, there was an increase with each intensity for EMG RMS, except between 40% - 60 % 1RM, suggesting an increase in muscle activation with an increase in intensity. EMG MPF remained similar from 20% - 80% and then increased at 100% 1RM suggesting an increase in neuromuscular excitation at maximal intensities. This EMG MPF response can likely be attributed to neural priming for the exercise that relied on higher frequencies and conduction velocities to modulate force at low intensities versus high intensities.

Practical Applications

These findings are useful for researchers and certified strength & conditioning specialists who are looking for methodologies to track the impact that intensity and acute hypoxia has on an athletes' performance. Specifically, that neuromuscular responses track with increased intensity, but may not be ideal for evaluating the impact of hypoxia on muscular performance in an unfatigued state.