

## Abstract

Oral supplementation with L-citrulline has been demonstrated to augment plasma concentrations of L-arginine, and in turn, nitric oxide, a potent signaler of vasodilation. Consequently, L-citrulline has gained popularity as an ergogenic aid due to its potential to enhance blood flow to working muscle tissue during exercise at a minimum effective dose of 3g. However, few studies have examined the acute effect of a higher dose (8g) of L-citrulline on muscle oxygenation during resistance exercise. **PURPOSE:** The purpose of this study was to evaluate the acute effect of L-citrulline supplementation on muscle oxygenation parameters during a strength-endurance bench press protocol in recreationally resistance-trained men and women. **METHODS:** In a cross-over design fashion, 18 recreationally resistance-trained men (n=11) and women (n=7) (21.4 ± 1.8 years; 172.3 ± 7.5 cm; 76.9 ± 10.8 kg) were randomly assigned to supplement with a beverage containing 8 grams of L-citrulline or a placebo one hour prior to completing a strength-endurance bench press protocol consisting of 5 repetition-maximum sets at 75% 1RM. A near-infrared spectroscopy muscle oxygen sensor was placed on the participants' muscle belly of the anterior deltoid to continuously measure the concentration of oxygenated hemoglobin (HbO<sub>2</sub>) relative to total hemoglobin (tHb). Muscle oxygen saturation (SmO<sub>2</sub>) was calculated using the equation: SmO<sub>2</sub> (%) = HbO<sub>2</sub>/tHb. Muscle oxygenation dynamics were assessed via the percent change in SmO<sub>2</sub> during each set (Δ%SmO<sub>2</sub>), muscle oxygen resaturation rate (SmO<sub>2</sub>RecSlope), and the highest measured SmO<sub>2</sub> value achieved during each recovery period between sets (SmO<sub>2</sub>Peak). Muscle oxygenation data were evaluated on a set-to-set basis using both a frequentist and Bayesian 2 (sex) x 2 (condition) x 5 (set) three-way analysis of variance (ANOVA) with significance accepted an alpha (p) level ≤ 0.05. Significant main effects were evaluated with a Bonferroni post-hoc correction. **RESULTS:** No significant main effect of sex, main effect of condition, or interaction of any type was present. However, significant main effects of time (p < 0.001) were observed for SmO<sub>2</sub>RecSlope and SmO<sub>2</sub>Peak such that SmO<sub>2</sub>RecSlope during set 5 was significantly reduced when compared to sets 1-3 (p < 0.05). Additionally, SmO<sub>2</sub>Peak was significantly decreased during set 5 compared to sets 1-4 (p < 0.05) and during set 4 compared to set 1 (p = 0.044). **CONCLUSION:** Although muscle oxygenation dynamics were attenuated during later sets of the strength-endurance bench press protocol, a single 8-gram dose of L-citrulline had no ergogenic effect in recreationally resistance-trained men and women. **PRACTICAL APPLICATION:** These data suggest that acute L-citrulline supplementation does not enhance muscle oxygenation dynamics during strength-endurance upper-body resistance exercise. Further research should evaluate the effect of chronic or short-term L-citrulline supplementation on muscle oxygenation dynamics and resistance exercise performance.

## Results

**Table 1.** Participant characteristics (N=18)

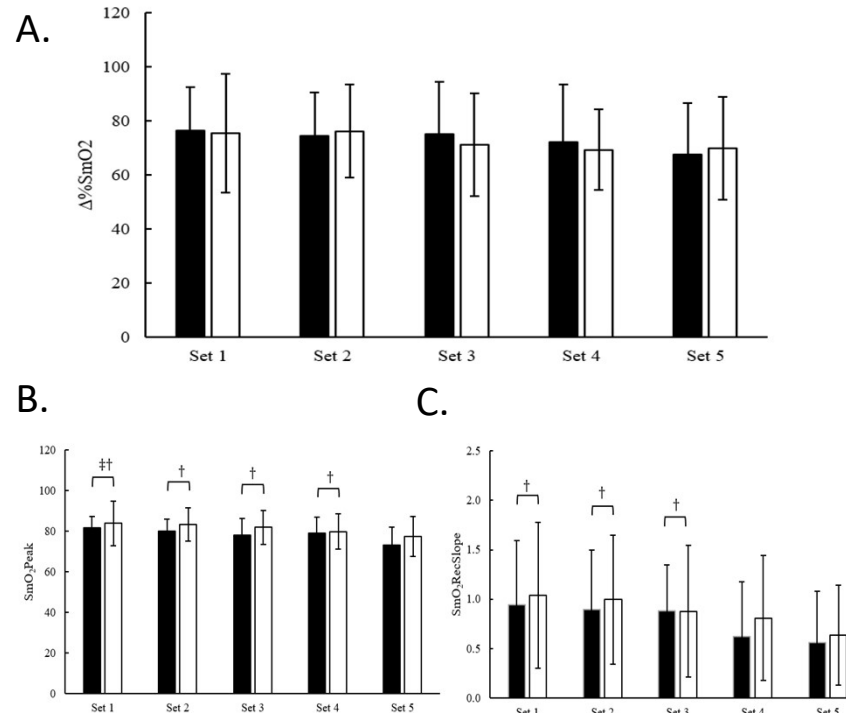
Characteristic	Men	Women
Age (y)	21.4 ± 2.0	21.4 ± 1.9
Height (cm)	176.4 ± 6.3	165.9 ± 3.7
Body mass (kg)	83.0 ± 8.4	67.3 ± 6.1
Resistance training experience (y)	5.1 ± 2.5	4.6 ± 2.1
Bench press 1RM (kg)	98.7 ± 16.9	58.6 ± 14.3
Relative strength (1RM/Body mass)	1.2 ± 0.2	0.9 ± 0.2

Data are presented mean ± standard deviation (SD)

## Main Findings

# Acute supplementation of 8g L-citrulline did not alter muscle oxygenation parameters compared to placebo in recreationally resistance-trained men and women.

## Results Cont.



**Figure 1.** Effect of L-citrulline on five sets of bench press (75% 1RM; 2 min rest intervals) for **A**) Δ%SmO<sub>2</sub>, **B**) SmO<sub>2</sub>Peak, and **C**) SmO<sub>2</sub>RecSlope (mean ± SD).

Note: PL = black bars; CIT = open bars; ‡ = Significantly (p < 0.05) different from set 4. † = Significantly (p < 0.05) different from set 5.

## Methods

- Recreationally resistance-trained individuals were recruited to participate in this investigation.
- 1RM Bench press was estimated via the Brzycki equation during a familiarization session.
- Participants reported to the laboratory for 2 experimental visits where they received a 500mL beverage with CIT [8g of pure L-citrulline powder mixed with non-caloric lemonade flavoring (Nutricost Vineyard, UT, USA)] or PL (water mixed with non-caloric lemonade flavoring).
- Participants then completed 5 repetition-maximum sets at 75% 1RM on the bench press with 2 minutes of rest between sets.
- Muscle oxygenation was monitored continuously with a near-infrared spectroscopy (NIRS) sensor that was attached to the anterior deltoid of participants' dominant arm.
- Concentrations of oxygenated hemoglobin (HbO<sub>2</sub>) relative to total hemoglobin (tHb) were recorded.
- Change in muscle oxygenation (Δ%SmO<sub>2</sub>), peak muscle oxygenation interspersing sets (SmO<sub>2</sub>Peak), and the slope at which muscle oxygenation recovered post-set (SmO<sub>2</sub>RecSlope) were identified for statistical analysis.
- Data were analyzed using frequentist and Bayesian two-tailed, three-way (Sex x Condition x Time) analyses of variance conducted to assess the main effects and interactions of condition and time of performance measures across time and within conditions. Significance was accepted at an alpha level p ≤ 0.05.



## Conclusions and Practical Application

- CIT supplementation did not alter muscle oxygenation parameters during the bench press protocol.
- Future research should continue evaluating acute and chronic effects of L-citrulline supplementation on blood flow and muscle oxygenation during resistance training and other forms of high-intensity training.