



Offset loading with unilateral blood flow restriction during back squat exercise



Julie A. Alcaro, Sungwon Chae, Justin P. Guilkey, Jakob D. Lauver, Timothy R. Rotarius
Department of Kinesiology Coastal Carolina University, Conway, SC

Abstract

PURPOSE: To examine the effects of unilateral BFR and offset loading on muscle activation and oxygenation status during bilateral back squat exercise. **METHODS:** Ten subjects (Age: 25.6 ± 7.6 yrs.; Height: 175.1 ± 12.1 cm; Weight: 81.7 ± 14.5 kg) were asked to complete three different conditions of back squats: traditional (TRAD), offset loading (OS), and offset loading with BFR (OS-BFR) on the non-dominant leg. Each condition was completed once in random order. For TRAD and OS, subjects performed 2 sets of 15 repetitions at 55% of 1-RM, with 2 minutes of seated recovery between sets. For OS-BFR, an occlusion cuff was placed on the non-dominant limb and inflated to 40% of their limb occlusion pressure. Subjects performed 1 set of 30 repetitions of back squat exercise. Surface electromyography (EMG) was used to assess muscle activation and near-infrared spectroscopy (NIRS) was used to assess metabolic stress for each condition. Heart rate (HR) and Feelings Scale were measured after completion of each set for each condition and averaged. Two-way repeated measures ANOVAs were completed to compare mean muscle activation and metabolic stress between loaded and unloaded limbs, with significance established at $p < 0.05$. **RESULTS:** There were no significant differences in muscle activation of the quadriceps between conditions ($p = 0.555$), or between loaded and unloaded limbs ($p = 0.199$). There was no significant difference in metabolic stress between conditions ($p = 0.875$). Additionally, there was no significant difference in metabolic stress between the loaded and unloaded sides (TRAD: 26.6 ± 12.7 vs. 24.3 ± 13.2 ; OS: 25.9 ± 15.9 vs. 24.1 ± 14.2 ; OS-BFR: 22.2 ± 10.8 vs. 26.8 ± 12.8 % Δ BSL, $p = 0.917$). However, there was a significant interaction effect within the OS-BFR condition. The unloaded limb with BFR had a greater metabolic stress during exercise compared to the loaded limb (22.2 ± 10.8 vs. 26.8 ± 12.8 % Δ BSL, $p = 0.048$). Median HR increased to a greater extent from baseline between conditions, with OS-BFR resulting in the greatest HR response during exercise (TRAD: 82 ± 13 ; OS: 85 ± 12 ; OS-BFR: 93 ± 13 bpm, $p = 0.025$). The pleasantness of exercise, expressed as a change from rest, was significantly different between conditions (TRAD: 1.6 ± 1.8 ; OS: 1.5 ± 1.9 ; OS-BFR: -0.2 ± 1.8 , $p < 0.001$). **CONCLUSION:** OS-BFR results in similar metabolic stress and muscle activation compared to TRAD back squat exercise; however, feelings of unpleasantness were greater during OS-BFR compared to other conditions. Thus, it may be possible to utilize unilateral BFR to correct muscle imbalances.

Background

- Resistance training is a fundamental component of athletic conditioning, aiming to enhance muscle strength, power, and endurance.
- Emerging research has explored the impact of resistance training utilizing offset loading, where the load is asymmetrically distributed to impose different demands on each limb (1).
- Offset loading challenges the neuromuscular system, encouraging greater activation and adaptation in the weaker limb, addressing asymmetries that can arise from dominant versus non-dominant limb discrepancies (2).
- Another innovative technique currently being implemented heavily in the resistance training realm is blood flow restriction (BFR).
- BFR training has been associated with increased muscle hypertrophy and strength gains, even under low-load conditions (3).
- Miller et al. (2021) states that BFR has been shown to increase muscle mass and strength in both the occluded and non-occluded limbs, potentially correcting asymmetries by promoting more balanced strength development across the body.
- While both offset loading and BFR independently offer promising approaches to address muscle imbalances, the existing literature has yet to explore their combined effects, particularly during complex exercises like the back squat.
- This gap in the research presents a unique opportunity to investigate how these two methods might interact to influence muscle activation and overall training outcomes.

Purpose

To examine the difference in muscle activation during back squat exercises during offset loading with and without unilateral blood flow restriction

References

- Ottinger CR, Tufano JJ, Cochrane-Snyman KC, Gheith RH, McBride JM. Offset loading in a bilateral squatting movement pattern influences ground-reaction force and muscle activity in the dominant and nondominant limb. *Int J Sports Psych Performance*, 18: 523-529, 2023.
- Jarosz J, Golas A, Krzysztofik M, Matykiewicz P, Stronska K, Zajac A, Maszczyk A. Changes in muscle pattern activity during the asymmetric flat bench press. *Int J Environ Res Public Health*, 17: 3912-3921, 2020.
- Saeterbakken AH, Solstad TEI, Behm DG, Stien N, Shaw MP, Pedersen H, Andersen V. Muscle activity in asymmetric bench press among resistance-trained individuals. *Eur J Appl Physiol*, 120: 2517-2524, 2020.
- Miller BC, Tirko AW, Shipe JM, Sumeriski OR, Moran K. The systemic effects of blood flow restriction training: A systematic review. *IJSPPT*, 16: 978-990, 2021.

Methods

- Ten (25.6 ± 7.6 yrs; 175.1 ± 12.1 cm; 81.7 ± 14.5 kg) healthy participants were recruited.
- Subjects were randomly assigned conditions (TRAD, OS, OS-BFR) and each subject repeated each condition.

Visit 1

- A 5-RM maximum test was conducted following standard National Strength and Conditioning Association guidelines, and a 1-RM was calculated from the results of the 5-RM test.

Visit 2 and 3

- During the subsequent experimental conditions, participants completed in random order traditional back squats (TRAD), offset loaded back squats (OS), or offset loaded back squats with unilateral blood flow restriction (OS-BFR).

TRAD

- Participants were asked to perform 2 sets of 15 repetitions of traditional back squats at 55% of 1-RM. Two minutes of recovery was given between each set.

OS

- Participants were asked to perform 2 sets of 15 repetitions of back squats with an offset load at 55% of 1-RM. For this condition 53.75% of the adjustable load was placed on the dominant leg, while 46.25% of the adjustable load was placed on the non-dominant leg.

OS-BFR

- Participants completed 1 set of 30 repetitions of back squats with the same offset load as OS. Blood flow restriction was applied to the leg on the de-loaded side of the barbell for the duration of the set. The restriction pressure was set to 40% of limb occlusion pressure (LOP).

Data Analysis

- EMG, NIRS, heart rate, and affective valence were assessed throughout each condition.

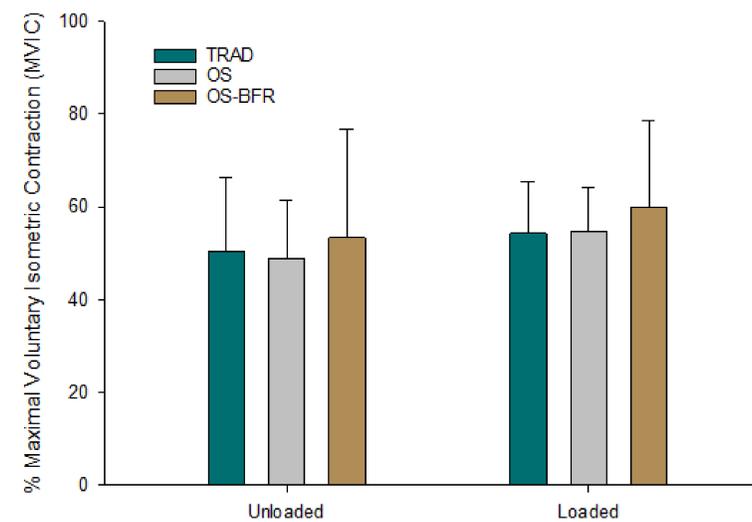


Figure 1. Mean muscle excitation of vastus lateralis in each leg between conditions. Data represented as mean \pm SD

PRACTICAL APPLICATIONS

Strength and rehabilitation specialists may want to consider utilizing unilateral BFR and offset loading as a potential training tool to correct muscle imbalances due to the greater metabolic stress, as assessed by NIRS, particularly during bilateral lifts such as the back squat. Caution is advised as the greater HR response to OS-BFR and the adverse response of the Feelings Scale may indicate poor adherence to this type of training protocol.

RESULTS

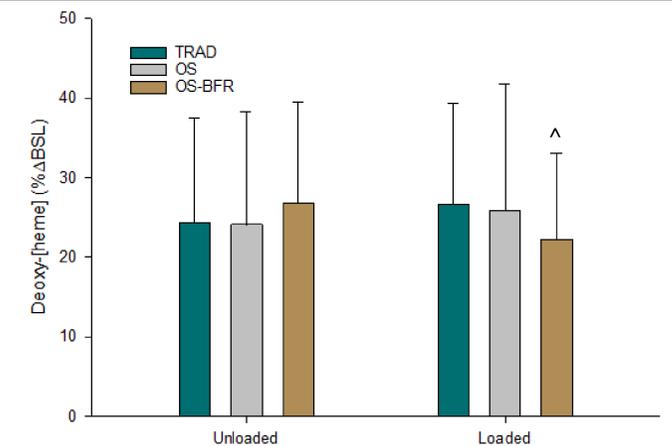


Figure 2. Average deoxy-[heme] during the final 10-s of back squat exercise. Presented as a change from baseline values. Data represented as mean \pm SD. [^] denotes significant difference between loaded and unloaded, $p < 0.05$.

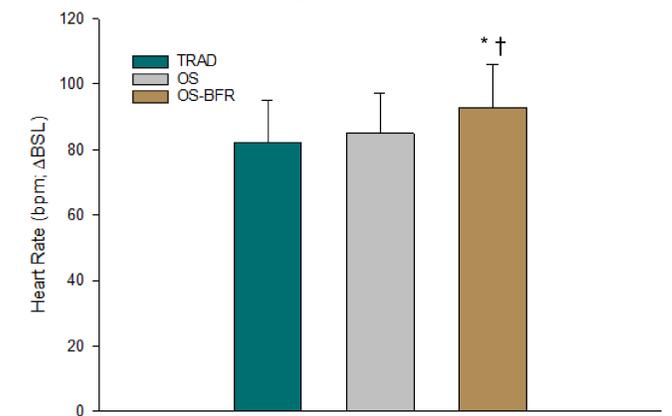


Figure 3. Heart rate response during each back squat exercise condition. Presented as a change from resting heart rate. Data represented as mean \pm SD. ^{*} denotes significant difference from TRAD; [†] denotes significant difference from OS, $p < 0.05$.

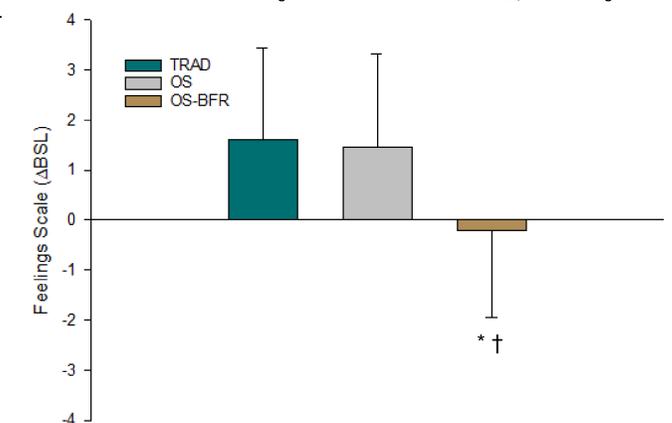


Figure 4. Affective valence, as assessed by the Feelings Scale, following the completion of each exercise condition. Presented as a change from rest and represented as mean \pm SD. ^{*} denotes significant difference from TRAD; [†] denotes significant difference from OS, $p < 0.05$.

Conclusion

OS-BFR resulted in a greater metabolic stress in the unloaded limb without subsequent changes in muscle activation. Additionally, the HR response was greater during OS-BFR, which may have led to a more negative affective response to exercise.