# The Impact of Blood Flow Restriction Combined with Vertical Countermovement Jumps on Heart Rate, Blood Pressure and Ratings of Perceived Exertion

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## Abstract

Blood flow restriction (BFR) is commonly combined with low loads and high repetitions during resistance exercise to increase muscle size and strength. Plyometric training such as vertical countermovement jumps are also typically performed with a high number of repetitions. Little research has investigated how BFR impacts vertical countermovement jumping. As plyometric training alone increases systolic blood pressure (SBP) and heart rate, it is important to determine if the use of BFR increases blood pressure and heart rate while simultaneously measuring perceived overall exertion. **PURPOSE:** Analyze the effects of BFR on the cardiovascular system and ratings of perceived exertion (RPE) during maximal vertical countermovement jumps. **METHODS:** Participants consisted of 12 male resistance-trained subjects (age: 24 ± 2 years). A cross-over randomized experimental design was used. On their first visit, participants were randomly assigned to either the non-BFR or BFR conditions, returning within a week to perform the other condition. Each visit consisted of 4 sets of 20 repetitions of maximal vertical countermovement jumps with BFR while the other visit consisted of 4 sets of 20 repetitions of maximal vertical countermovement jumps without BFR. There was a two-minute rest between each set with the BFR cuffs inflated throughout the BFR condition. However, following the second set, the cuffs were deflated before measuring SBP and then reinflated. BFR cuffs were placed at the most proximal part of the thigh and inflated to 60% of the participant's personalized arterial occlusion pressure. SBP was measured at rest and after the second and fourth sets. Heart rate and RPE were measured at rest and after each set. Two-way repeated measures ANOVA was used to analyze the data. **RESULTS:** A significant time main effect for SBP was found from pre to mid-exercise and pre-to-post-exercise (126 ± 5 mmHg vs. 170 ± 5 mmHg, p< 0.001 & 126 ± 5 mmHg vs. 162 ± 5 mmHg). The effect size (omega-squared, $\omega^2$) was 0.614. A significant time main effect for heart rate was found from resting to set 1, set 2, set 3, and set 4 (70 ± 2.6 bpm vs. 170 ± 2.6 bpm, 179 ± 2.6 bpm, 180 ± 2.6 bpm, 181 ± 2.6 bpm, p< 0.001) and the set 1 heart rate was significantly different from sets 2, 3 and 4 (170 ± 2.6 bpm vs. 179 ± 2.6bpm, 180 ± 2.6 bpm, 181 ± 2.6 bpm, p< 0.001). The effect size ($\omega^2$) for the heart rate main time effect was 0.958. Ratings of perceived exertion were not significantly different between control and BFR after each set (Set 1: 13.4 ± 1.6 vs. 12.6 ± 2.3, Set 2: 14.2 ± 1.6 vs. 14.3 ± 1.8, Set 3: 15.4 ± 1.4 vs. 15.3 ± 1.1, Set 4: 16.0 ± 1.5 vs. 16.5 ± 1.1, p >0.05). The effect size for the condition*time main effect for RPE was 0.028. **CONCLUSIONS**: Vertical countermovement jumps with BFR do not seem to create greater stress on the cardiovascular system and ratings of perceived exertion when compared to maximal vertical countermovement jumps without BFR. **PRACTICAL APPLICATIONS:** BFR can be combined with maximal vertical countermovement jump exercise without eliciting greater increases in heart rate or blood pressure than are found with normal maximal vertical countermovement jump exercise.

## Introduction

Many different athletes use plyometrics training to improve their explosiveness and sports performance (1). One possible way to progress plyometric training may be the use of blood flow restriction (BFR). Studies have shown that BFR combined with resistance training does not improve vertical jump performance (2, 3) but other studies have shown that BFR may cause post-activation potentiation (4, 5). However, it is unclear the impact that BFR may have on the cardiovascular system when combined with plyometric exercise. The purpose of this study is to investigate how combining BFR with plyometrics training impacts heart rate, blood pressure and ratings of perceived exertion (RPE) after one exercise bout.

## Methods

**Experimental Design:** A cross-over randomized experimental design was used.

**Participants:** 12 resistance-trained males (age: 24 ± 2 years).

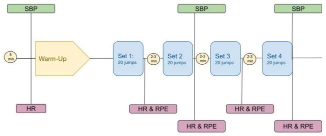


**Figure 1.** Timeline for experimental session. HR =Heart rate, SBP = systolic blood pressure, RPE = ratings of perceived exertion.

## Methods

**Blood Flow Restriction:** The BFR cuffs were inflated to 60% of the subject's arterial occlusion pressure (AOP).

**Procedure:** Subjects performed 4 sets of 20 repetitions of maximal vertical countermovement jumps either with or without BFR cuffs.

**Measurements:** Heart rate and RPE were measured after every set. Resting SBP was measured after the second and fourth set. There was a two-minute rest following every set.

**Statistical Analysis:** Two-way repeated measures ANOVA was used to analyze the data with alpha level set at p<0.05.

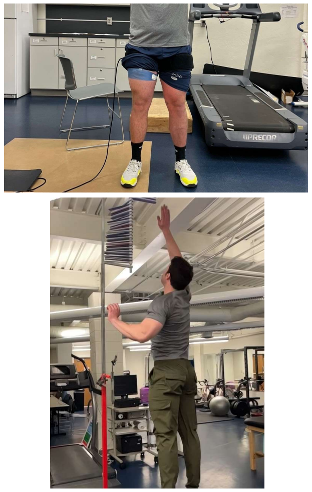

**Figure 2.** Blood flow constriction condition placement and Vertec used for maximal vertical countermovement jumps.

## Results

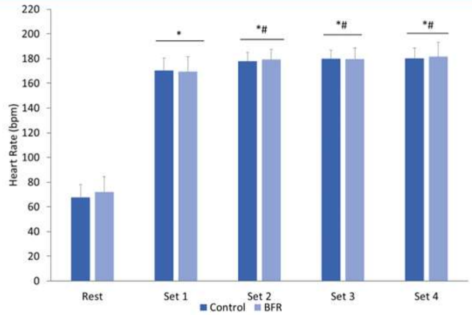


**Figure 3.** Heart rate after each set. BFR = Blood flow constriction condition. *p<0.05 vs. rest. # p<0.05 vs. Set 1.

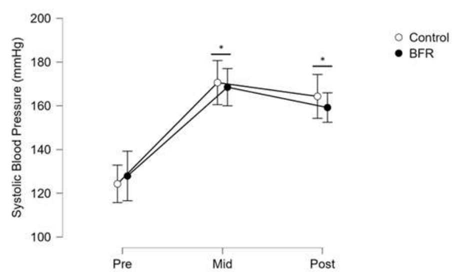


**Figure 4.** Systolic blood pressure before exercise, after the 2nd set (mid) and post exercise. BFR = Blood flow constriction condition. *p<0.05 vs. pre.

## Results

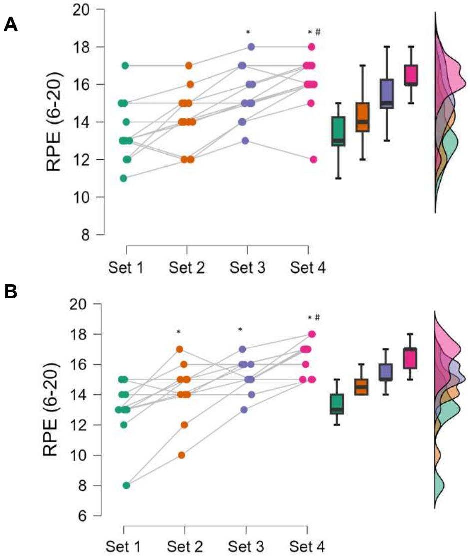


**Figure 5**. Raincloud plots of ratings of perceived exertion after each set (RPE). A. Control condition. B. Blood flow restriction condition. Box and whisper plots represent min, 25th percentile, 50th percentile, 75th percentile and max values. Distribution curves of data are presented on the right for each set. *p<0.05 vs. Set 1. # p<0.05 vs. Set 2.

## Conclusion

- In maximal vertical countermovement jumps, both BFR and control saw an increase in cardiovascular stress (HR, SBP and RPE) with increasing sets, but no substantial difference was found between the two.
- Heart rate, RPE and SBP were similar with and without BFR when doing maximal vertical countermovement jumps.
- Future research should investigate chronic adaptations of combining BFR with plyometrics.

## Practical Applications

BFR can be combined with maximal vertical countermovement jump exercise without eliciting greater increases in heart rate or blood pressure than are found with normal maximal vertical countermovement jump exercise.

## References

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