Acute cardiac responses to blood flow restriction strength exercise

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Introduction: Blood flow restriction (BFR) exercise is a novel strength training technique that involves partially restricting blood flow to muscle during exercise (Takarada *et al.*, 2000). BFR is typically combined with light-load strength training (LST) and has been observed to produce similar adaptations to strength and hypertrophy as compared with heavy-load strength training (HST). If BFR strength exercise is to be recommended as a suitable low risk alternative to HST yet with moderately equal outcomes, then a greater understanding of the impact of BFR on the cardiac system is warranted. In particular, investigations of the acute cardiac responses to a single bout of BFR in healthy populations is necessary before being prescribed to clinical and/or elderly populations for whom this exercise would seem most beneficial. To date, relatively few studies have examined the acute response to BFR strength exercise on cardiac function, and only a single study has compared BFR strength exercise to a non-BFR LST intervention (Takano *et al.*, 2005). Typical of a normal exercise bout, heart rate (HR), mean arterial pressure (MAP), and cardiac output (CO) increased in both groups during knee extension exercise at 30% 1 RM (1RM: largest mass lifted in a single repetition; McDonagh & Davies, 1984), and these data were also significantly greater than under resting conditions. HR and MAP were significantly greater during BFR knee extension exercise compared with non-BFR, and there were no differences between groups for CO. While there has not been any direct comparison made, the peak exercising increases in HR, BP, and CO are typically lower than the increases observed with HST.

Although research thus far indicates that BFR strength exercise may be a potential alternative to HST to improve muscle function and overall health, further research is needed to investigate the impact of BFR on measures of resting and exercising cardiac health, so that this type of training may be more widely recommended. To date, no study has investigated the effects of BFR strength exercise of the upper body, and there are currently no studies that have compared the cardiac responses to BFR in comparison with both HST and LST. In addition, due to variations in methodology in BFR literature, no study has compared two common BFR interventions - one where the pressure is applied continuously throughout the duration of the whole exercise bout including rest periods (BFR-C) and another where the pressure is applied intermittently during exercise only (BFR-I). Therefore, the purpose of this study was to determine the acute effect of BFR-C and BFR-I strength exercise of the *biceps brachii* on cardiac function in healthy young people, and compare the results to more traditional strength exercise techniques.

Methods: Healthy males (n=5, 23 ± 2 years, 176.3 ± 2.5 cm, 68.13 ± 2.35 kg) completed a balanced, randomized cross over study consisting of 4 strength exercise interventions, once per wk across 4 wk. The 4 trials were HST (80% 1 RM), LST (20% 1 RM), and two BFR trials in combination with LST; BFR-C and BFR-I. In all trials, subjects performed four sets of unilateral (dominant arm) elbow flexion exercise (*i.e.* a standard dumbbell biceps curl). Measurement of HR, systolic, diastolic, and mean arterial blood pressure (sBP, dBP, and MAP, respectively), CO and stroke volume (SV) were taken prior to exercise at baseline, during the second and fourth sets of the exercise bout, and four times post-exercise for 60 min.

Results: Mean elbow flexion 1 RM mass lifted was 17.04 ± 0.73 kg. The mean pressure used during BFR was 90 ± 4 mmHg and 151 ± 3 mmHg for BFR-C and BFR-I, respectively. Preliminary analysis revealed that there were no significant differences between trials for all measurements at baseline. During exercise (set 2 and 4), HR, MAP, and CO increased significantly from baseline in all trials (P<0.05), however, there were no differences between trials. Independent of the trial, during the post-exercise recovery period HR, MAP, and CO remained elevated above baseline at time points immediate post-exercise (P<0.05), 20 min (P<0.05), and 40 min (P<0.05) and returned to baseline at 60 min.

Discussion: The findings suggest that both BFR-C and BFR-I produce a similar cardiac strain during strength exercise compared with more traditional strength exercise methods. Therefore, BFR strength exercise may be a suitable exercise method for developing strength and hypertrophy in young healthy populations, and of more importance, also in clinical and/or elderly populations where high blood pressures are a contraindication to exercise.

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