LOW-INTENSITY EXERCISE PAIRED WITH BLOOD FLOW RESTRICTION AS A TREATMENT OF DELAYED-ONSET MUSCLE SORENESS

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INTRODUCTION: Delayed-onset muscle soreness (DOMS) can disrupt athlete's training, and individual's regular exercise bouts, and daily life due to the potential for excruciating pain, decreased joint range of motion, and modified motor unit patterns and muscle activation (Cheung, Hume, & Maxwell, 2003). DOMS has also been shown to reduce strength and power and increase the potential for injury (Cheung et al., 2003). This makes it crucial to alleviate muscle soreness symptoms so that individuals can return to resistance training quickly. Active recovery, which is the process of exercising at a light intensity 12-48 hours after damaging exercise to stimulate the muscles, is potentially the best way to reduce muscle soreness (Zainuddin, Sacco, Newton, & Nosaka, 2006). Blood flow restricted exercise has been used as a potential alternative for increasing muscular strength and hypertrophy over the last decade due to numerous studies that have shown improvements in these areas (Laurentino et al., 2016; Patterson & Ferguson, 2010; Scott, Loenneke, Slattery, & Dascombe, 2015; Sumide, Sakuraba, Sawaki, Ohmura, & Tamura, 2009; Takada et al., 2012; Takarada et al., 2000; Yamanaka, Farley, & Caputo, 2012). However, research looking at the effectiveness of blood-flow restricted exercise as a recovery method from intense resistance training is lacking. Potential explanations for blood-flow restricted exercise to be a useful method of reducing DOMS may include: increased growth hormone, insulin-like growth factor, and satellite cell stimulation as well as an increased mTOR pathway activation (Park, Kwak, Harveson, Weavil, & Seo, 2015). Therefore, the purpose of this study is to examine if blood-flow restricted resistance exercise is a superior method of decreasing muscle soreness than active recovery without occlusion following an intense bout of resistance exercise.

METHODS: *Subjects:* Fourteen actively resistance-trained individuals (male n=8, 22.69 ± 3.15 years, 168.69 ± 8.08 cm, and 74.21 ± 14.91 kg) participated in this study. All participants had at least six months of resistance training experience and had no current musculoskeletal injuries. This investigation was approved by the university's Institutional Review Board. Informed consent, physical activity readiness questionnaire (PARQ), and health history questionnaire was completed by each participant before testing began. *Design:* Randomized controlled study in which participants' arms were randomly selected to be in the treatment or control group. *Methodology:* Participants warmed up by performing two sets of 15 reps at approximately 20% of estimated one repetition maximum (1 RM) with one minute of rest between the sets. Participants followed the National Strength and Conditioning Association's protocols for 1 RM testing. Participants were asked to refrain from all resistance exercise for 48 hours prior to initial testing as well as any other forms of DOMS treatment once testing began. Once the participants 1 RM values were measured, a familiarization session occurred in which participants performed seated bicep curls at 20% 1 RM under vascular occlusion with proper restricted blood flow cuffs (EDGE Restriction System BFR Cuffs). Following 48 hours without performing any upper-body resistance exercise, the arm circumference of each arm was measured using a BASELINE Evaluation Instruments tape measurer for all participants at the midpoint between the acromial and olecranon processes while the arm was hanging naturally. Participants performed a bout of resistance exercise to induce DOMS by performing 5 sets of 10 repetitions of eccentric seated bilateral biceps curl at 120% of 1 RM. Participants rested 1 minute between sets. Participants then filled out a visual analog scale (VAS) regarding their soreness levels at that time 2, 4, 6, 12, and 24 hours post-exercise. VAS scales ranged from 1 (no pain) to 7 (extreme pain). Additional arm circumference measures were measured 2, 4, 6, and 24 hours post-exercise. Following 24 to 25 hours of rest after DOMS-inducing exercise, participants performed 1 set of 30 repetitions followed by 3 sets of 15 repetitions of seated bilateral biceps curl at 20% 1 RM with one arm under 100 mm Hg blood flow restriction and the other under no restriction. Dominant or non-dominant arm use for blood flow restriction (BFR) was randomized. Participants rested for 30 seconds between sets and occlusion pressure was re-measured and constricted during all rest periods to ensure the occlusion pressure remained constant. Again, a VAS scale was filled out 2, 4, 6, 12, and 24 hours post-exercise and arm circumference was re-measured 2, 4, 6, and 24 hours post-exercise. *Statistical Analyses:* Three paired t-tests were used to determine if there was a significant change in dominant and non-dominant arm circumference before and 24 hours after DOMS-inducing exercise as well as a change in VAS score from 2 hours to 24 hours after DOMS-inducing exercise. Two-hour VAS score was chosen because no VAS score was measured before exercise as it was assumed the participants' scores would indicate no soreness due to a 48-hour rest period prior to the soreness protocol.

Additionally, two repeated measure analyses of variance were used to determine if there was a significant difference between treatment and non-treatment arms between soreness at 24 hours post DOMS-inducing exercise and after light resistance exercise with vascular occlusion. A significance level of 0.05 was used to establish the potential differences and Statistical Package for Social Sciences 23 was used to calculate all analyses.

RESULTS: The main findings of this study indicate that there were no significant differences in arm circumference between the treatment condition and control at any time point after recovery conditions compared to 24 hours after DOMS-inducing exercise (see *Table 1*). There were also no significant differences in VAS scores between treatment condition and control at 24 hours after DOMS-inducing exercise and any time point after recovery exercise (see *Table 2*).

TABLE 1. Changes in arm circumference after soreness protocol between treatment and control conditions.

	Before	2h	4h	6h	24h
Treatment (cm)	31.62 ± 3.90	32.08 ± 4.20	31.48 ± 4.42	31.52 ± 4.24	32.4 ± 4.10
Control (cm)	31.8 ± 4.07	31.96 ± 4.21	31.73 ± 4.25	31.87 ± 4.17	31.98 ± 4.16

Note: All data reported in mean ± SD. Before occurred directly prior to soreness exercise.

TABLE 2. Changes in VAS score after soreness protocol between treatment and control conditions

	Before	2h	4h	6h	12h	24h
Treatment (cm)	4.08 ± 1.14	4.25 ± 1.01	3.77 ± 1.05	3.62 ± 1.27	3.64 ± 1.23	3.92 ± 1.56
Control (cm)	4.08 ± 1.14	3.67 ± 0.75	3.31 ± 1.20	3.23 ± 1.30	3.36 ± 1.49	4.17 ± 1.68

Note: All data reported in mean ± SD. Before occurred directly prior to soreness exercise.

DISCUSSION: To the researcher's knowledge, this is the first study looking at blood flow restricted exercise as a method for reducing delayed-onset muscle soreness. Massage therapy (Zainuddin, Sacco, Newton, & Nosaka, 2005), foam rolling (Pearcey et al., 2015), neuromuscular electrical stimulation (Taylor et al., 2015), and active recovery (Zainuddin et al., 2006) have all shown promising effects in alleviating muscle soreness with active recovery perhaps showing the best results. Therefore, this study was meant to examine a potential difference in effectiveness between active recovery with and without blood flow restriction. The main findings of this study suggest that blood flow restricted exercise at a low intensity is no more effective at reducing subjective or objective measures of delayed-onset muscle soreness than active recovery without occlusion.

CONCLUSIONS AND PRACTICAL APPLICATIONS: The findings of this study suggest that blood flow restricted exercise at light intensity may not be beneficial as a method of reducing DOMS. Future research is needed to examine potential placebo effects of blood flow restricted exercise at a low intensity as well as potential changes in biomarkers of skeletal muscle damage which could suggest different results than the current study.

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