## Efficacy of Blood Flow Restriction After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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INTRODUCTION: Anterior cruciate ligament reconstruction (ACLR) is among the most common procedures performed in orthopaedic sports medicine. Rehabilitation after ACLR is recommended for 6-9 months to maximize recovery, optimize return to sport, and reduce risk of graft rupture. Many rehabilitation techniques have been suggested to accelerate recovery, including blood flow restriction (BFR) therapy. BFR creates a transient hypoxic environment through occlusion of the operated limb, inducing numerous metabolic and vasodilatory pathways involved in muscle hypertrophy and strength. Although BFR has shown improved muscle hypertrophy in animal studies, the clinical efficacy in humans is unclear. The purpose of this study is to perform a systematic review and meta-analysis of randomized controlled trials (RCTs) evaluating the efficacy of BFR after ACLR. The authors hypothesize that BFR will lead to improved muscle strength, hypertrophy, and clinical outcomes compared to non BFR rehabilitation.

METHODS: A literature search was performed according to the 2020 Preferred Reporting Items for Systematic Reviews and Meta Analyses guidelines by querying PubMed, MEDLINE, Scopus, the Cochrane Database for Systematic Review, and the Cochrane Central Register for Controlled Trials databases from inception through December 2023 to identify RCTs evaluating outcomes of BFR training after ACLR compared to non-BFR rehabilitation. The search was performed independently by two authors, with a third author assigned to resolve any disagreements. A meta-analysis was performed using random-effects models with standardized mean difference (SMD) for pain, muscle strength, muscle volume, while mean difference (MD) was used for standardized patient-reported outcome measures.

RESULTS: The literature search generated 770 articles, with 243 articles undergoing title and abstract screening after removal of duplicates. 18 articles were selected for full-text review. Following full-text review, eight RCTs, consisting of 245 patients, meeting inclusion criteria. 115 patients underwent non-BFR rehabilitation while 130 patients underwent BFR after ACLR. The mean patient age was  $27.2 \pm 6.7$  years, and the majority of patients being male (63.3%, n=138/218). No significant differences in patient characteristics were noted between the BFR and non-BFR rehabilitation groups. The length of the BFR rehabilitation protocol was most commonly between 8-12 weeks (range, 14 days – 16 weeks). The most common limb/arterial occlusion pressure in the BFR group at 80%. Time from surgery to beginning of the BFR protocol ranged from 2 days to 10 weeks. Compared to non-BFR rehabilitation, BFR resulted in significant improvement in isokinetic muscle strength (SMD: 0.77, p=0.02, I2: 58%), IKDC score (MD: 10.97, p=<.00001, I2: 77%), and pain (SMD: 1.52, p=.04, I2: 87%), but not quadriceps muscle volume (SMD: 0.28, p=0.43, I2: 76%).

DISCUSSION AND CONCLUSION: The primary findings from this study were that incorporation of BFR was associated with improvements in isokinetic muscle strength, IKDC scores, and pain, when compared to non-BFR rehabilitation, with no significant difference in quadriceps muscle volume. High heterogeneity of BFR protocols exists among studies, although most studies use a protocol between 8-12 weeks at an occlusion pressure of 80%. Further research is

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