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Efficacy of Blood Flow Restriction Training on Muscle Growth and Pain Management Post-ACL Reconstructive Surgery

Abby Borg
ab610@humboldt.edu

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Introduction

- The anterior cruciate ligament (ACL) maintains the stability of the knee during sudden stops, changes in direction, and pivoting movements
- 400,000 ACL reconstruction (ACLR) surgeries take place in the United States each year [3]
- Females are especially susceptible to ACL tears and there is a high rate of re-rupture among those who return to their sport after surgery [4]
- Decrease in muscle mass post-operation can be as high as 33% [1]
- Blood flow restriction training (BFRT) is a proposed intervention to promote muscle hypertrophy like a heavy load resistance program
- **The purpose of this review was to determine the outcomes of BFRT on muscle hypertrophy and pain management post-ACL reconstruction**

Methods

- Research was found using the Google Scholar database
- Aimed to use the newest research with most sources published from 2019-2024
- Keywords: blood flow restriction training & ACL rehabilitation, BFRT & hypertrophy, BFRT & injury & athlete, ACL & reinjury & female athletes, and ACL & return to sport
- Additional literature was found through cross-referencing bibliographies of the primary articles found from these search engines
- Specific populations searched for included ACL rehabilitation patients, especially female soccer players

Topic 1: Quadriceps Atrophy Following ACLR

•Cross sectional area (CSA) and peak quadriceps strength significantly smaller in the injured limb versus the non-injured limb following ACLR surgery [11]
•Poor muscle function has been shown to be linked to higher rates of re-rupture when athletes return to sport (RTS) [5]
•Quadriceps function is a predictor of psychological readiness to RTS [2]

Test	Limb	Mean ± *SD*	Range	*p*	*d*
Knee extensors eccentric peak torque (N·m·kg^{-1})	ACLR	3.28 ± 0.79	1.89–4.72	0.0001	0.84
	Noninjured	3.97 ± 0.83	2.48–5.5		
Knee extensors concentric peak torque (N·m·kg^{-1})	ACLR	2.76 ± 0.55	1.76–4.31	0.0001	0.99
	Noninjured	3.37 ± 0.68	2.15–5.0		
Knee extensors isometric peak force (N·m·kg^{-1})	ACLR	2.9 ± 0.2	2.6–3.7	0.0001	2.53
	Noninjured	3.7 ± 0.4	3.0–4.8		
Central activation ratio (%)	ACLR	18.8 ± 7.9	11.1–32	0.0038	2.14
	Noninjured	4.6 ± 5.1	0–13		
Single hop for distance (% leg length)	ACLR	183.9 ± 26.1	141–226	0.0001	0.53
	Noninjured	197.7 ± 26.1	145–247		
Cross-over hop for distance (% leg length)	ACLR	692.0 ± 128.7	550–974	0.0002	0.38
	Noninjured	741.1 ± 129.6	560–1,012		

*ACLR = anterior cruciate ligament reconstruction.

Table 1. Strength differences in ALCR and non-injured limb among a group of professional soccer players at time of RTS [5]

Topic 2: BFRT Effects on Quadriceps Muscle Growth

Study	Sample	Method	Results
(Roman et al., 2023)	N=32 ACLR Age 12-18 BFRT n=16 Control n=16	12 week training program: 3 BFRT exercises per session/ 2x week	⬆ Isometric knee extension strength ⬆ Isometric knee flexion strength ⬆ Peak torque ⬆ Self-Reported Function
(Lambert et al., 2019)	N= 14 ACLR Age 16-30 BFRT n=7 Control n=7	12 week training program: 2x/ week 80% LOP for BFRT group	⬇ Bone mass loss ⬇ Lean mass loss ⬇ Time to RTS
(Hughes et al., 2019)	N= 24 ACLR HL-RT n=12 BFR-RT n=12	8 week training program: 2x/ week unilateral leg press HL-RT: 70% 1RM BFR-RT: 30% 1RM	Comparable skeletal muscle hypertrophy in both groups ⬆ Physical function and ROM for BFR-RT

Table 2. Summary of studies related to BFRT and muscle function [10] [9] [8]

- 30-15-15-15 repetition scheme with 30 sec rest between each set [8] [9] [10]
- Types of exercises: quadriceps set (isometric), side-lying hip abduction, prone hip extension, long-arc quadriceps, single-leg press, hip bridge, step-ups, split squat, medial step-down [10] [9]
- BFRT in early phases of rehabilitation can show strength improvements at both 3 months and RTS after ACLR [10]
- BFRT seems to have protective effects on bone [9]

Image from Mike Reinold

Topic 3: BFRT & Pain Management

- Effects of exercise-induced hypoalgesia (EIH) were found in participants who did BFRT [6]
- BFRT at 80% limb occlusion pressure (LOP) resulted in greatest increase in pressure pain threshold (PPT) by 48% when compared to 40% LOP, HL-RE, and LL-RE [7]
- Beta-endorphin levels significantly increased in BFRT groups [6]
- Higher muscle discomfort in BFRT group, but this had no impact on exercise adherence [6] [7]
- Knee joint pain immediately and 24-hours post training was significantly lower than HL-RE [7]

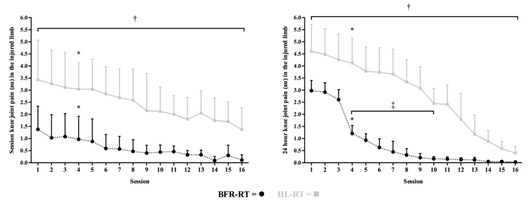

Figure 1. Knee joint pain in the injured limb during session and 24-hours post-session over 8-week training period [7]

Conclusions

- Improving quadriceps function is an important factor for RTS
- The combined effects of muscle growth and reduced pain makes BFRT a promising rehabilitation tool among ACLR population especially in early-stages
- BFRT creates a hypoxic environment that mimics heavy load conditions which stimulates muscle growth
- Similar strength benefits can be achieved through BFRT with lighter loads than traditional training
- High pressure (80% LOP) BFRT is effective in reducing pain which may increase exercise adherence

Limitations:
- Small sample sizes
- BFRT is not a stand-alone rehabilitation tool

Future Research

- What is the optimal frequency and duration of BFRT after ACLR
- How does BFRT impact athletes psychologically
- Interactions between perceived training intensity, motivation, and psychological readiness among the population of athletes
- More attention for research on female athletes since they are disproportionally affected by this injury

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