



BLOOD FLOW RESTRICTION TRAINING ON LOWER EXTREMITY FUNCTION: A SCOPING REVIEW OF EFFECTIVENESS, APPROPRIATENESS, AND IMPLEMENTATION ON MUSCLE HYPERTROPHY AND/OR STRENGTH DURING REHABILITATION

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OBJECTIVE: To evaluate the evidence surrounding the use of blood flow restriction training on muscle strength and/or hypertrophy for lower-extremity musculoskeletal conditions during rehabilitation.

STUDY DESIGN: Scoping review.

LITERATURE SEARCH: Authors searched PubMed, Web of Science, and CINAHL

STUDY SELECTION CRITERIA: We used studies published from 2010 to 2020 that were written in English, subjects at least 16 years of age (mean) with musculoskeletal conditions of the lower extremity resulting in muscle atrophy and/or decreased strength, participation in rehabilitation, and use of blood flow restriction treatment.

DATA SYNTHESIS: A diverse representation of study designs were included (systematic reviews, RCT, cohort studies, cross-sectional studies, and case series/reports). We used Arksey & O'Malley's framework and the PRISMA ScR extension to guide data synthesis. Both qualitative and quantitative studies were assessed. Quantitative studies were divided into 6 groups: study characteristics, subject characteristics, BFR protocol, intervention parameters, treatment time, and outcomes section. Qualitative studies were used to assess BFR safety/adverse events, implementation, indications/contraindications, BFR mechanisms, and current protocols/evidence.

RESULTS: Our search identified 1,474 publications, in which 20 studies met the inclusion criteria and were used in analysis. Fourteen were quantitative studies, which represented 443 participants with nine different musculoskeletal conditions. Significant variability was found among equipment, treatment time, BFR protocol, and intervention parameters. Most studies showed BFR to be beneficial. The six qualitative studies provided insight on safety and risk reduction, and highlighted inconsistency in treatment methodology and implementation.

CONCLUSION: Despite substantial variability in implementation, BFR appears to be a beneficial adjunct to rehabilitation for the purpose of improving muscle strength. Current protocols are evidence-based; however, future research should develop a better understanding of BFR mechanisms and best practice for specific conditions.

Blood flow restriction training can provide better improvements in muscle strength than traditional resistance training...while providing less risk.

Study	Condition/Diagnosis	Muscle Strength (BFR Group)		Muscle Hypertrophy (BFR Group)		Outcome Measure (Improved in BFR Group)	BFR Recommended?
		Improved	Significantly Improved compared to Control	Improved	Significantly Improved compared to Control		
Barber-Westin et al. ³²							
Ohta et al. ¹³ *	ACL	Yes	Yes	Yes	Yes	-	Yes
Takarada et al. ¹⁴ *	ACL	-	-	Yes	Yes	-	Yes
Iversen et al. ¹⁵ *	ACL	-	-	No	No	-	No
Bryk et al. ¹⁶ *	Knee OA	Yes	No	-	-	Yes	Yes
Ferraz et al. ¹⁷ *	Knee OA	Yes	Yes	Yes	Yes	Yes	Yes
Segal et al. ¹⁸ (males)	Knee OA	No	No	-	-	No	No
Segal et al. ¹⁹ (females)	Knee OA	Yes	Yes	No	No	No	Yes
Tennent et al. ²⁰ 2017 *	Knee Arthroscopy	Yes	Yes	-	-	Yes	Yes
Giles et al. ²¹ *	PF	Yes	No	No	No	Yes	Yes
Kilgas et al. ²²	ACL	Yes	-	Yes	Yes	-	Yes
Hughes et al. ²³	ACL	Yes	No	Yes	No	Yes	Yes
Curran et al. ²⁴	ACL	-	No	-	No	No	No
Lafont et al. ²⁵ *	ACL	Yes	-	Yes	-	Yes	Yes

Key: * (repeated); - (not reported)
 Abbreviations: ACL, anterior cruciate ligament reconstruction; BFR, blood flow restriction; fx, fracture; OA, osteoarthritis; PFP, patellafemoral pain; TKA, total knee arthroplasty

Study	Condition/Diagnosis	Muscle Strength (BFR Group)		Muscle Hypertrophy (BFR Group)		Outcome Measure (Improved in BFR Group)	BFR Recommended?
		Improved	Significantly Improved compared to Control	Improved	Significantly Improved compared to Control		
Lima et al. ²⁶	Knee OA	-	-	Yes	-	-	-
Tennent et al. ²⁷ 2018 *	Knee Arthroscopy	Yes	-	-	-	-	Yes
Hylden et al. ²⁸	Chronic quadriceps and hamstring weakness	Yes	-	-	-	-	Yes
Di Lemme et al. ²⁹	Comminuted intra-articular fx of the right talus	Yes	-	Yes	-	Yes	Yes
Gaunder et al. ³⁰	TKA	Yes	-	-	-	-	Yes
Yow et al. ³¹	Achilles Tendon Rupture	Yes	-	-	-	-	Yes
Mirando et al. ³² (Bryk et al., Ferraz et al., Tennent et al. 2017, Giles et al.)	*	*	*	*	*	*	Yes
Ladlow et al. ³³	Lower limb injury	Yes	-	Yes	-	Yes	Yes
Arve and Warren ³⁴ (Ohta et al., Takarada et al., Iversen et al., Lafont et al., Tennent et al. 2017/2018)	*	*	*	*	*	*	Yes
Lipker et al. ³⁵ (Ohta et al., Takarada et al., Iversen et al.)	*	*	*	*	*	*	Yes

Key: * (repeated); - (not reported)
 Abbreviations: ACL, anterior cruciate ligament reconstruction; BFR, blood flow restriction; fx, fracture; OA, osteoarthritis; PFP, patellafemoral pain; TKA, total knee arthroplasty

Study	Indications/Contraindications	Safety Concerns/AE	Implementation/Application	Clinical Evidence	BFR Mechanisms
DePhillipo et al. ³⁶	Yes	Yes	Yes	Yes	No
DePhillipo et al. ³⁷	Yes	Yes	Yes	Yes	No
Anderson et al. ³⁸	No	Yes	Yes	Yes	No
Patterson and Brandner ³⁹	Yes	Yes	Yes	Yes	No
Lambert et al. ⁴⁰	Yes	No	No	Yes	Yes
Vopat et al. ⁴¹	Yes	Yes	Yes	Yes	Yes

Abbreviations: AE, adverse reactions, BFR, blood flow restriction