Blood Flow Restriction Training

Michael Lafont, SPT, C/O 2018
Florida Gulf Coast University, Department of Rehabilitation Sciences, Fort Myers, FL, USA
Ahmed Elokda, PhD, PT, FAACVPR; Renee Jeffreys-Heil, PhD, RCEP

Abstract

Background: Anterior cruciate ligament (ACL) injuries are among the most common in sports, and can severely impair function and quality of life. Restoration of strength to pre-operative levels can have significant impact on return to sport and pre-injury activities. Unfortunately, a number of post-operative resistance and exercise restrictions are placed in order to limit the amount of stress placed on a joint. Since high resistance, or 70-85% of an individual's 1-repetition maximum (1-RM), is typically required for muscle training to achieve muscle hypertrophy and increases in muscular strength, restrictions on resistance can slow the strength recovery process. Blood flow restriction (BFR) training facilitates muscle hypertrophy at low resistance levels (as low as 20-30% 1-RM) providing a viable alternative to traditional low-resistance, high repetition activities that are performed post-ACL surgery.

Case Description: The patient is a sixteen-year-old female athlete who tore her ACL and lateral meniscus while playing soccer. Patient participates in numerous activities, therefore functional status from an activity-participation standpoint was greatly impaired. She underwent a left ACL reconstruction along with meniscus repair. This was the patient's second ACL reconstruction (first was on the right knee). Patient was compliant with all aspects of physical therapy and was consistent in her attendance.

Outcomes: Patient demonstrated increases in thigh girth, from 40 cm to 41.5 cm, to 42 cm in the affected lower extremity at 0 weeks, 4 weeks, and 8 weeks, respectively. Patient also demonstrated improvement in functional strength per decreased quadriceps lag during straight leg raise with the affected lower extremity, and improvement of manual muscle testing strength at 4 weeks (4- out of 5) and at 8 weeks (4+ out of 5). Lastly, patient increased knee flexion range of motion from 85 degrees to 102 degrees to 130 degrees in the affected lower extremity at 0 weeks, at 4 weeks, and at 8 weeks, respectively. Patient outcomes were on par with expectations for the injury and all rehabilitation goals were met for the allotted timeline. Given time constraints of this case report, patient was not yet cleared for high-level, sport-specific activities.

Discussion: Blood flow restriction training coupled with therapeutic exercise proved to be an effective treatment modality as part of a comprehensive ACL reconstruction and meniscus repair protocol. Patient experienced no setbacks and is expected to make a full recovery and full return to sport within the typical 9 to 12-month recovery time.

Purpose

The purpose of this case is to examine the viability of BFR training as a treatment modality in the post-operative management and rehabilitation of an ACL reconstruction and meniscus repair in a young, female soccer player

Introduction

- Anterior cruciate ligament injuries are among the most common injuries amongst the athletic and active population, with a staggering 200,000 injuries occurring annually ("Anterior Cruciate Ligament Injury," 2017). Unfortunately, there are a number of post-operative restrictions that limit the amount of stress that may be applied to the joint, thereby limiting the amount of resistance that can be lifted by an individual in this early post-operative phase. To improve the strength of a muscle, it must undergo hypertrophy. According to the American College of Sports Medicine (ACSM), muscle hypertrophy occurs when muscle training with resistance that is between 70 and 85% of an individual's one-repetition maximum (Pescatello, Arena, Riebe, & Thompson, 2014).
- The traditional high-resistance training required for hypertrophy is not feasible, nor safe for post-operative patients due to the stress it places on a recently repaired structure, which leaves typical high repetition, low resistance activities as the primary options for exercise. Without using the requisite resistance levels during therapeutic exercise, muscle hypertrophy occurs at a much more delayed pace, delaying a return to sport. Blood flow restriction training provides an alternative to typical strengthening methods, as it promotes muscular hypertrophy at a lower resistance than is required without BFR (Pearson & Hussain, 2014).
- Blood flow restriction training allows for muscle hypertrophy at resistances as low as 20-30% of an individual's 1 RM, permitting hypertrophic mechanisms to occur while minimizing the tension placed on a musculotendinous unit and reducing the forces applied to a joint (Pearson & Hussain, 2014).

Background

Type II muscle fibers, which are the fibers associated with muscle hypertrophy, are activated by one of two ways: mechanical tension and metabolic stress. High mechanical tension is not feasible during the acute postoperative phase due to the stress is places on the joint and its associated structures. Blood flow restriction training utilizes partial vascular restriction along with low-load resistance to induce muscle hypertrophy through increased metabolic stress as opposed to high mechanical tension (Hylden, Burns, & Stinner, 2015). Metabolic stress occurs when there is an accumulation of metabolites, which can trigger a cascade of hypertrophic factors.

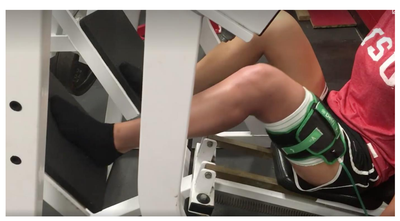
Under hypoxic conditions, such as those during a BFR resistance exercise, metabolite levels, specifically blood lactate, have been shown to be significantly elevated when compared to the same exercise under normoxic conditions (Takarada, Nakamura, Aruga, Onda, Miyazaki, & Ishii, 2000; Pearson & Hussain, 2014) This accumulation of metabolites under BFR or hypoxia creates an osmotic gradient that favors the flow of blood into the intracellular space (Pearson & Hussain, 2014). This swelling compromises the structural integrity of the cell, which leads to cell signaling via integrin-associated osmosensors (Low, Rennie, Taylor, 1997; Pearson & Hussain, 2014) These sensors are found to subsequently activate anabolic protein kinase pathways that favor protein synthesis over protein degradation and, ultimately, muscle hypertrophy.

Clinical Evaluation

Past Medical History	☐ Unremarkable
Past Surgical History	☐ Right ACL reconstruction (7/2015)
Subjective	☐ Minimal complaints of pain (2 out of 10 at worst) ☐ Feeling of "fullness" in joint ☐ Wants to return to playing soccer and participating in prior activities (running, swimming, biking, other sports)
Objective	☐ **ROM:** (L) 85 degrees/(R) 137 degrees ☐ **MMT:** Withheld ☐ **Thigh girth**: (L) 40 cm/(R) 44 cm
Assessment	☐ Limited ROM, both into flexion and extension ☐ Poor quadriceps control, per 5-degree quad lag during SLR ☐ Decreased thigh girth on left limb versus right ☐ Presence of edema/swelling in left knee joint
Plan	☐ Reduce swelling ☐ Increase ROM ☐ Increase thigh girth ☐ Improve muscle strength

Treatment

Week	Rehab Goals	Exercises	Comments
Weeks 1, 2	• Full passive extension • Flexion to 90* • Good quad control (minimal quad lag)	• Neuromuscular electrical stimulation (neuromuscular re-education) • Side-lying hip abduction • Light resistance band ankle plantarflexion (knee bent) • Straight leg raise (SLR)	• "Russian stim" protocol for neuromuscular electrical stimulation • Green Theraband utilized for ankle plantarflexion • Body weight resistance for hip abduction and SLR • All exercises performed with BFR
Weeks 3, 4	• Decreased subjective reports of pain • ROM to 90* with no stiffness at end range • Full knee extension	• Straight leg raise • Side-lying hip abduction • Prone hip extension • Light resistance band ankle plantarflexion (knee bent) • Long-arc quads (90-30*)	• All exercises performed with BFR • Side-lying hip abduction with 1 lb cuff weight
Weeks 5, 6	• ROM 0-90* • No joint effusion	• Straight leg raise with BFR • Side-lying hip abduction with BFR • Bilateral bridging • Leg press/shuttle • Long-arc quads (90-30*) • Low resistance cycling	• All exercises performed with BFR • Side-lying hip abduction with 2 lb cuff weight • Leg press with 20 lbs
Weeks 7, 8	• Pain-free full ROM • Ambulate with normal gait mechanics without assistive device	• Leg press	• All exercises performed with BFR • Leg press 30 lbs



Outcomes

Week	Left (Affected) Thigh Girth (18 cm above superior patellar pole)	Right (Unaffected) Thigh Girth (18 cm above superior patellar pole)	MMT (Left)/(Right)	Knee Flexion ROM Left/Right	Knee Extension ROM
Week 0	40 cm	44 cm	**(L) Unable to assess/** (R)(5/5)	**(L) 85 degrees** (R) 137 degrees	**(L) -5 degrees** (R) 2 degrees
Week 4	41.5 cm	44 cm	**(L) 4-/5** (R) 5/5	**(L) 102** (R) 137	**(L) 0 degrees** (R) 2 degrees
Week 8	42 cm	44 cm	**(L) 4+/5** (R) 5/5	**(L) 130** (R) 137	**(L) 0 degrees** (R) 2 degrees

Conclusion

The largest improvement in thigh girth appeared to come between week 0 and week 4, as the girth of the affected limb increased from 40 cm to 41.5 cm. This was likely due to a large increase in the amount of activity and implementation of exercise. Blood flow restriction has been shown to mitigate disuse atrophy therefore coupling BFR with therapeutic exercise in the early post-op stages can certainly have a drastic effect on the development of muscle size (Takarada, Takazawa, & Ishii, 2000).

It is, however, difficult to isolate the effect of a single treatment method as part of a comprehensive treatment plan, but the results do demonstrate BFR to be an effective treatment option in the post-operative management of ACL and meniscus tears. Subsequent studies should focus on use of objective measurement (e.g Biodex machine) during the early post-operative phase. Longer studies will also allow for return to sport to be more properly tracked once clearance for more advanced activities has been granted. In the current case report, the patient demonstrated significant functional improvement overall and is expected to make a full recovery and full return to sport within the expected timeline.

Clinical Implications

BFR appears to play a role in the acute postoperative stage of ACL reconstruction with meniscal repair, however, the significance of its clinical impact can only be partly evaluated without the use of objective measurements related to strength (i.e. Biodex). However, there are a number of subjective improvements that occur as a result of initiating BFR in the early stages, such as return to a "normal" gait pattern and improved quadriceps activation.

To truly comprehend the clinical impact BFR can have, studies must focus on the longitudinal nature of a full return to sport timeline. Much of the sport-specific testing that occurs later in the rehab timeline was withheld given the acute nature of the surgery in this instance. Without a Biodex or other technology to measure strength in the first two to three months, thigh girth and resistance level (i.e. weight the patient is able to lift during given activities) are the main measures that can be obtained. Once higher-level activities are cleared, there will be more methods to assess the patient's functional strength. Since the primary objective of a typical rehab protocol is to return to prior level of function and prior activities, assessment of BFR training in the latter stages of rehabilitation will also be required in order to provide a full and comprehensive clinical picture of how quickly a patient can return to high-level activities, and how this compares to a rehabilitation protocol that does not utilize BFR.

References: See Handout with Reference List

Title (Experimental Study)

Authors
Florida Gulf Coast University, Department of Rehabilitation Sciences, Fort Myers, FL, USA

Abstract

XXXXX

Introduction

XXXXX

Objectives

XXXXX

Results

XXXXX

Please evaluate the following statements based on their importance.
23 Responses

	1	2	3	4	5	N/A	Average Rating
An applicant's GPA	**9** *(39.13%)*	**4** *(17.39%)*	**7** *(30.43%)*	**1** *(4.35%)*	**1** *(4.35%)*	**1** *(4.35%)*	2.1
Clinical affiliation experience in this specific setting	**1** *(4.35%)*	**1** *(4.35%)*	**1** *(4.35%)*	**8** *(34.78%)*	**12** *(52.17%)*	**0** *(0.00%)*	4.3
A master's degree in PT/OT	**4** *(17.39%)*	**2** *(8.70%)*	**3** *(13.04%)*	**8** *(34.78%)*	**6** *(26.09%)*	**0** *(0.00%)*	3.4
A DPT/OTD	**8** *(36.36%)*	**5** *(22.73%)*	**3** *(13.64%)*	**5** *(22.73%)*	**1** *(4.55%)*	**0** *(0.00%)*	2.4
Certification in a specialty area (e.g. massage, CSCS, etc.)	**5** *(21.74%)*	**2** *(8.70%)*	**9** *(39.13%)*	**4** *(17.39%)*	**3** *(13.04%)*	**0** *(0.00%)*	2.9
Membership in APTA/AOTA	**5** *(21.74%)*	**7** *(30.43%)*	**5** *(21.74%)*	**3** *(13.04%)*	**3** *(13.04%)*	**0** *(0.00%)*	2.7
Strong professional skills	**1** *(4.35%)*	**0** *(0.00%)*	**0** *(0.00%)*	**3** *(13.04%)*	**19** *(82.61%)*	**0** *(0.00%)*	4.7
Time management skills	**1** *(4.35%)*	**0** *(0.00%)*	**0** *(0.00%)*	**3** *(13.04%)*	**19** *(82.61%)*	**0** *(0.00%)*	4.7
Reputation of the applicant's PT/OT education program	**1** *(4.35%)*	**4** *(17.39%)*	**8** *(34.78%)*	**7** *(30.43%)*	**3** *(13.04%)*	**0** *(0.00%)*	3.3
Letters of Recommendation	**2** *(8.70%)*	**4** *(17.39%)*	**8** *(34.78%)*	**4** *(17.39%)*	**5** *(21.74%)*	**0** *(0.00%)*	3.3
Completion of relevant continuing education courses	**1** *(4.35%)*	**1** *(4.35%)*	**6** *(26.09%)*	**9** *(39.13%)*	**6** *(26.09%)*	**0** *(0.00%)*	3.8
Peer-reviewed research publications	**7** *(30.43%)*	**5** *(21.74%)*	**9** *(39.13%)*	**1** *(4.35%)*	**1** *(4.35%)*	**0** *(0.00%)*	2.3

Answer	Total Score	Overall Rank
clinical affiliation experience in this specific setting	73	1
strong professional and time management skills	73	2
certification in a specialty area (e.g. - massage, CSCS, etc.,)	28	3
letters of recommendation	18	4
a master's degree in PT/ OT	14	5
reputation of the applicant's PT/ OT education program	8	6
an applicant's GPA	7	7
a DPT/ OTD	5	8
membership in APTA/ AOTA	4	9

Note: Total Score is a sum of the ranked item options. Top positioned options have higher rank.

Methods

XXXX

Discussion

XXXX

Conclusions

XXXXX

References: See Handout with Reference List