Passive BFR stimulus as a method to prevent muscle loss after an acute injury or operation

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The positive benefits of Blood Flow Restriction (BFR) training using low external loads on muscle strength and function has been well documented. In my experiences I am seeing the majority of BFR users utilizing this training methodology in early stage rehab for restorative muscle size, strength and function. There is however evidence in using BFR passively post-operatively (or injury) as a method to attenuate muscle loss (1–3,5). Immobilisation typically results in disuse atrophy of the muscles due to the lack of mechanical stress that is typical with muscle use. For example, knee surgery (or injury) is perhaps the most common area of note where the attenuation of thigh muscle atrophy is important since the rehabilitation process takes a prolonged period of time in order to regain the original muscular size and strength.

A couple of studies in particular have investigated how the inclusion of passive BFR can assist with preventing the loss of muscle size and strength caused by immobilisation and unloading (1-3,5). In post-ACL operative patients, passive occlusion was applied twice daily for 10 days to see whether it attenuated muscular atrophy compared to a control group of no intervention (4). The BFR stimulus consisted of 5 x 5minutes of occlusion pressure with a 3 minutes rest between stimuli (Table 1).

Table 1: Whole protocol of occlusion stimulus post ACL surgery

	Protocol outline	Daily Protocol
Day 0	Operation	
Day 1 – 2		Rest
Day 3	MRI	Rest
Day 4-13	Occlusion stimulus	• Occlusion stimulus: 5x5min • Rest between stimuli: 3min • Frequency: 9am & 2pm • Pressure: 180-240mmHg (progressive)
Day 14	MRI	

Occlusion stimulus resulted in a significant attenuation of muscle CSA compared to the control group (Table 2). The relative decrease in CSA of knee extensors was also significantly larger in the control group than in the BFR group.

Table 2: Decrease in muscle cross sectional area during the period between the 3rd and 14th days after the operation

Muscle Group	Occlusion	Control (no occlusion)
Knee Extensors	Decrease 9.4%	Decrease 20.7%
Knee Flexors	Decrease 9.2%	Decrease 11.3%

Kubota et al (2008) investigated the changes in muscle thigh CSA and strength in 15 healthy male subjects where their left ankle was immobilized for 2 weeks using a cast. During this period, the subjects walked using crutches and were instructed to keep their immobilized leg non-weight bearing. Using a similar protocol to that of Takarada et al (2000), immobilization/unloading resulted in significant decreases in muscle strength of knee extensors ($p < .01$) and flexors ($p < .05$) muscles in the control group whereas using a BFR stimulus resulted in significantly smaller decrements in strength measures than those in the control group. BFR also resulted in no changes in lower body muscle size, whereas immobilisation (control) resulted in significant decreases in thigh muscle CSA (Table 3).

Table 3. Changes in thigh circumference at 10 and 15cm above the upper border of the patella and changes in maximum leg circumference before and after a 2wk immobilisation period combined with blood flow restriction (BFR) and no intervention (Control).

	10cm above patella		15cm above patella		Max Circumference	
	Pre	Post	Pre	Post	Pre	Post
Control (cm)	48.8	47.6*	53.2	51.7*	39.2	38.1*
BFR (cm)	46.8	46.1	50.8	50.2	37.1	36.7

* $p<0.5$

Lejkowski et al (2011) presented a case study on the inclusion of a BFR protocol for an accelerated post-operative knee rehabilitation program following ACL reconstructive surgery (Table 4). The protocol also included other therapies and techniques as per a program proposed by Wilk et al (6).

Knee Injury and Osteoarthritis Outcome Score (KOOS), a Lower Extremity Functional Scale (LEFS) and thigh muscle girth measurement were taken pre and post surgery as assessment measures. Three months post surgery yielded LEFS scores similar to pre-operative values (66/80 to 65/80). Some improvements in KOOS scores were made when comparing the pain, symptoms, activities of daily living, sport and recreational function. Muscle girth was measured periodically (every 3 weeks) over the 3-month post-surgical period. When compared to the unaffected lower limb, the girth measurements of the thigh and leg remained identical and at no point did they decrease suggesting atrophy. In the discussion, the author highlights the inherent limitations of this paper. However from a practical stand this case study provides a pragmatic application of BFR training into rehabilitative setting.

Table 4. BFR protocol applied following ACL surgery

Period	BFR Protocol	Exercise
Days 1-3	• Cuff location = proximal thigh • Cuff width = 15cm • Inflation of cuff to 100mmHg for 5min • 5 repetitions (3min rest) • 2x/day	Rest
Days 4-7	• Pressure = 100mmHg • 20 reps/fatigue, 2 sets (30sec rest b/w sets) • Deflate cuff at completion of 1st exercise • Rest 5min • Repeat with 2nd exercise	1. Knee extensions (90-40°) 2. Heel slides
Week 2	• As above	1. Knee extensions (90-40°) (extra light band resistance) 2. Heel slides – (extra light band resistance)
Week 3	• As above	1. Front step-up (ht = 45cm) 2. Lateral step-up (ht = 45cm)
Week 4-12	• As above	1. Lateral lunges 2. Vertical squat

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The above examples highlights the role the BFR can play in the acute post-operative (injury) phase.

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