ACL+Blood Flow Restriction Part 2

In the previous email, we discussed the first 2 weeks of recovery from ACL surgery and the potential effects of cell swelling via Blood Flow Restriction to mitigate atrophy. This week we describe a paper by Ohta et al that measures strength, hypertrophy, and arthrometry (joint laxity) changes after 16 weeks of BFR vs work matched controls.
Low-Load Resistance Muscular Training With Moderate Restriction of Blood Flow After Anterior Cruciate Ligament Reconstruction

The aim of this study was to determine the effects of introducing low-load muscular training with blood flow restriction (BFR) during the first 16 weeks after reconstruction of the anterior cruciate ligament. 44 subjects participated in the study, with both groups following the same training schedule (one group with BFR, one without). "The intensity of training was low and performed mainly by the closed kinetic chain exercise method." The study was carried out as a home exercise plan supervised by a rehabilitation professional.

Exercises included:

- Straight leg raise: 2 x per day, 20 reps, 6 days per week (week 1-8)
- Hip abduction: 2 x per day, 20 reps, 6 days per week (week 1-8)
- Hip Adduction: 2 x per day, 20 reps, 6 days per week (week 1-12)
- Quad Sets: 2 x per day, 20 reps, 6 days per week (week 1-12)
- Half squat: 2 x per day, 20 reps, 6 x per week (weeks 5-16)
- Hamstring curls: 1 x per day, 20 reps, 6 x per week (week 9-12); 2 x per day, 20 reps, 6 x per week (weeks 13-16)
- Step ups: 3 x per day, 20 reps, 6 x per week (weeks 5-16)
- Knee-bending walking (squat walks): 60 steps, 3 x per day, 6 x per week (weeks 13-16)

The BFR group performed all exercises with occlusion starting at week 2. A standardized pressure of 180 mmHg was used for all participants.

Objective Measures: Strength (muscular torque) was assessed using Biodex at 60 and 180 degrees per second. Isometric strength was assessed at 60 degrees of knee flexion. Cross sectional area was measured using MRI. KT2000 knee ligament arthrometer was used to measure anterior laxity of the knee.

Results:

At 16 weeks after surgery, significant differences were found between the two groups in knee flexor strength, extensor strength, and quad CSA. No differences in knee laxity were found between groups.
Muscle Cross Sectional Area (MRI)

Only the BFR cohort demonstrated a significant increase in pre to post knee extensor muscle size. From a ratio of 91 (injured/uninjured) pre-surgery to a ratio of 101 post-BFR intervention. There was no significance difference for the knee flexors/adductors.

<table>
<thead>
<tr>
<th>Muscle CSA</th>
<th>Without BFR CSA Pre/Post</th>
<th>With BFR CSA Pre/Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Ext</td>
<td>92/92</td>
<td>91/101*</td>
</tr>
<tr>
<td>Knee Flex</td>
<td>97/102</td>
<td>99/105</td>
</tr>
</tbody>
</table>

- CSA was determined with injured to healthy ratio
- * Indicates statistical significance (p=0.04)

Knee Extensor Strength

The BFR group was able to maintain significantly more knee extension strength compared to the non-BFR group. Just taking the isometric knee strength test as an example. At 16 weeks the non-BFR group was only 63% as strong as the uninvolved limb compared to the BFR group, which was 84% as strong.

<table>
<thead>
<tr>
<th>Knee Ext</th>
<th>Without BFR Pre</th>
<th>With BFR Pre</th>
<th>Without BFR Post</th>
<th>With BFR Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC60</td>
<td>86</td>
<td>84</td>
<td>55</td>
<td>76*</td>
</tr>
<tr>
<td>CC180</td>
<td>90</td>
<td>84</td>
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<td>77*</td>
</tr>
<tr>
<td>IM60</td>
<td>94</td>
<td>92</td>
<td>63</td>
<td>84*</td>
</tr>
</tbody>
</table>

- * Indicates significant difference
Knee Flexion Strength

The BFR group was able to maintain significantly more knee flexion strength compared to the non-BFR group. Again, taking the knee flexion isometric test as an example the BFR group was 72% as strong as the uninvolved limb whereas the non-BFR group was only 62% as strong.

<table>
<thead>
<tr>
<th>Knee Flex</th>
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Discussion

It has been repeatedly reported that restoration of quadriceps strength is crucial to higher-level function after ACL reconstruction (ACLR). It has also been repeatedly reported that quadriceps strength is often lacking months and even years after ACLR. You are also at a 3x higher risk of knee OA after ACLR. So, it goes without saying that restoration of knee extension strength after ACLR should be a primary goal. But, creating sufficient strength gains using low (rehab) loads is difficult. So heavier loads should be used? Uhhhm, No because preservation of the graft in the early stages of rehabilitation is critical.

That is where the beauty of BFR comes into play. ACLR patients are typically lacking strength after surgery, ACLR patients typically lose muscle mass after surgery, ACLR patients are at increased risk of knee OA after surgery, ACLR patients can’t significantly load their knee after surgery because of pain and risk of graft injury. BFR is the way around all of this!
What did this study tell us?

• The BFR patients were significantly stronger than the standard of care (work-matched control) patients.

• BFR resulted in hypertrophy of the quadriceps muscle after surgery.

• There was no difference in joint laxity between either groups (i.e. doing BFR didn’t compromise the ACL repair).

• This was all done with a very conservative HEP, no exercise machines. If they had done this in the clinic with the ability to at least add a 20-30% 1RM load we might have seen more impressive results. There are many ACL+BFR studies currently looking at that theory.

• The patients actually did BFR for quite a long time at each session. The authors noted that the subjects were advised to keep the tourniquets on for 15 minutes (continuous, no breaks) while they did their exercises. They were instructed to deflate after 15 minutes, rest for 10-15 minutes then re-inflate and continue until they finished their exercises.

• By the 5th week the patients were doing 6 exercises at each session under BFR.
Clinical Application

This should give us confidence in knowing that we don’t need to re-write our treatment protocols or change the way we prescribe exercise. By that we mean, there is no need to get fancy. Follow your standard post-operative protocol with BFR (if approved by your MD). Always ask yourself, “Is this exercise being done for strength and hypertrophy?” If so, ask yourself “Can I load the muscle/joint/surgery enough to make an adaptive change?” If not, and you are forced to stick to low loads and BFR.

In conclusion a standard treatment protocol in conjunction with BFR leads to increased muscle strength, hypertrophy and no measured joint laxity compared to work matched controls.

Bibliography:
