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Efficacy and Safety of Blood Flow Restriction Therapy in Knee Arthroplasty

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Abstract

Blood Flow Restriction (BFR) treatment is gaining attention as a method for improving recovery and muscle strength following total knee replacement surgery (TKA). This analysis combines results from studies to assess how effective and safe BFR therapy is, in postoperative settings and to highlight any possible drawbacks it may have. Studies suggest that when administered correctly BFR therapy can bring advantages to patients in terms of their recovery process, muscle strength improvement and overall health status. Several research investigations indicate that Blood Flow Restriction (BFR) therapy plays a role in enhancing post-surgery results for individuals with severe post operative muscle weakness or those who do not show improvement, with traditional treatment approaches.

Despite studies showing the benefits of BFR therapy, many limitations remain, such as the differing BFR protocols used across studies, sample sizes and brief follow up periods that make it challenging to establish consistent clinical recommendations for treatment practices. Additionally, while certain research findings suggest no statistical disparities in muscle strength between BFR therapy and traditional treatments, other studies emphasize noticeable enhancements in functional abilities and patient reported outcomes. Indicating that BFR therapy may offer more than just strength restoration benefits.

Considering the results and recognized constraints discussed here, we highlight the need for additional reproducible randomized controlled trials with greater sample sizes and extended follow up durations to be conducted in order to establish stronger evidence that can inform the creation of standardized BFR therapy protocols and ultimately improve patient outcomes following TKA surgery.

Introduction

Total knee arthroplasty (TKA) is a procedure that is frequently performed and is effective in alleviating pain and improving functionality in patients suffering from end-stage knee osteoarthritis or a similar condition requiring surgical intervention on the knee.[1, 2] TKA rehabilitation is vital in ensuring that the results achieved are maximized, especially in relation to muscle strengthening and functional recovery. In most cases post injury rehabilitation is restricted to hypertrophy-based muscle strengthening and functional training targeting high load resistance exercises. But such strenuous physical activity after surgery cannot be expected from all patients, especially those with lower exercise tolerance or higher operative risks.[3] Blood flow restriction (BFR) therapy is one of the

physical rehabilitation techniques that emerged recently and has shown promising results in enhancing recovery and improving strength.[4]

BFR therapy is a mode of rehabilitation in which a tourniquet or a cuff is applied to a muscle during low-load resistance or aerobic exercise that limits the blood flow to a certain degree.[2,5] BFR training has gained popularity due to its effectiveness in promoting muscle growth and strengthening when doing low intensity exercise as opposed to conventional resistance training, which is often not tolerated in the post-operative period.[6]

Despite these promising findings, further investigation is required to prove the efficacy and safety of BFR therapy in TKA patients. The aim of this project is to elucidate the possible role of BFR therapy in postoperative recovery among TKA patients, including muscular strength, functional mobility and rehabilitation while monitoring for adverse events through a detailed review of current literature.

Methods

A literature search was performed using PubMed. The search strategy utilized keywords like “blood flow restriction”, “knee arthroplasty”, and “rehabilitation” to find relevant articles. The inclusion criteria focused on RCTs, systematic reviews, meta-analyses and case studies published during the period of 2014 to 2024. Studies that specifically addressed the role of BFR therapy in the rehabilitation process following knee arthroplasty were reviewed.

Results

The positive effects of BFR therapy in enhancing strength after TKA surgery are already well-established in literature. For instance, Tennent et al who carried out a randomized controlled pilot study with patients after knee arthroscopy, 24 were eligible for the trial, however, only 17 completed it, 10 BFR and 7 control. Each of the patients performed 12 sessions of supervised physical therapy, the BFR group performed an additional 3 exercises under BFR therapy with a measured 1 RM of 30% and 4 sets at 30/15/15/15 reps. The patients who completed the trial showed significant thigh girth increases were measured in the BFR group as well as flexion and extension strength, however, no pain, sport obstacles, and symptoms showed no significant difference between both groups.[1]

Furthermore, Kilgas et al noted significant recovery of quadriceps strength accompanied by improved physical activity in a patient implementing a home-based BFR treatment regimen that included body weight and walking exercises 5x/week for 8 weeks 6 months after TKA, there was a 4% increase in lean leg mass, a 14% increase vastus

lateralis thickness, and a 55% increase in knee extensor strength, paving the way for BFR rehabilitation at home.[7]

Moreover, a randomized pilot study by Przkora et al further supports the efficacy of BFR in preventing the loss of muscle function after total knee arthroplasty. 10 patients were included in this study with 6 randomized to the BFR therapy group and 4 to the conventional therapy group, all patients completed at least 6 sessions. Although there was no statistical significance in strength, at follow up a chair stand test was performed and no one (0/4) in the conventional therapy group was able to complete it while 5/6 of the BFR group were able to.[6]

While some studies found no difference in the increase in strength, other positive measures were found in the BFR group. Hughes et al is one such study, they performed a randomized controlled trial in which 24 patients who underwent anterior cruciate ligament reconstruction were assessed, with half in each group. The patients underwent 16 sessions over an 8-week period. The results showed that the patients who underwent BFR therapy after ACL reconstruction showed no significant differences in strength or thigh thickness when compared to standard therapy, however, they did show significant differences in self-reported scales such as International Knee Documentation Committee, Knee Injury and Osteoarthritis Outcome Score, Lower Extremity Function Scale, and Lysholm Knee Scoring Scale.[8]

Moreover, BFR therapy has also shown improvements in patients who have failed to respond to conventional therapy. Noyes et al performed a study in which they measured the improvement in hamstring and quadricep torque strength in patients with severe post-operative strength deficits. 27 patients underwent 9 BFR therapy sessions, with 14 of them undergoing an additional 9. Both groups showed a statistically significant improvements in strength with the 18-session group showing continued improvements. The failure rate (<20% improvement) in responding after 18 sessions were 24% for hamstring strength and 14% for quadriceps strength.[9]

However, one study by Majors et al found no statistically significant difference. Majors et al performed a retrospective review on 48 patients with painful TKA, 36 patients completed standard therapy and 12 underwent BFR therapy, they saw similar non-statistically significant improvements in flexion strength in both groups, however, the conventional group showed a statistically significant increase in extension strength. Moreover, there were no improvement in avoidance of revision surgery.[10]

On the other hand, BFR therapy has also shown efficacy in the absence of surgery. Ladlow et al performed a randomized control trial on 28 lower limb injured patients, in which patients in the BFR group performed 4 sets of the leg press and 4 sets of knee extensions and the conventional therapy group 4 sets of 3 exercises (deadlifts, back squats, and lunges). Over a 15-day period the BFR group completed 23 8-minute sessions, and the conventional therapy group performed 9 1-hour sessions. While no difference in

strength or muscle thickness was found between the high load therapy and the low load BFR therapy group, the BFR group showed improved balance and functional capacity measured through a multistep locomotion test. They also reported reduced muscular discomfort by the third week of therapy.[3]

In respect to pain outcomes, Giles et al. (2017) performed a double-blind randomized trial on patients with patellofemoral pain 69 participants completed the study with 34 in the BFR group and 35 in the conventional therapy group. Both groups performed leg extension and leg press exercises over an 8-week period. The BFR group had a 93% greater reduction in pain with activities of daily living.[11]

Discussion

BFR therapy has risen in popularity in rehabilitative medicine for its potential in muscle strengthening and recovery, particularly after total knee arthroplasty (TKA). Current literature suggests that BFR therapy is both efficacious and safe for use among different patients and in different rehabilitation settings. The results of studies such as Hughes et al and Kilgas et al highlight the positive effects of BFR therapy on muscle strength and functional outcomes after knee arthroplasty.[7,8] Interestingly, these improvements were reported not only in the clinical study but also in the home-based rehabilitation program thereby extending the relevance of BFR therapy. This consistency across different designs of studies and on different settings highlights the benefits of BFR therapy and its potential in becoming a gold standard, especially in cases where high-load resistance training is contraindicated.[5] However, of note is that the home-based rehabilitation program was a case study and further research into the viability and safety of home-based rehabilitation should be conducted.

Another use of BFR therapy is in patients who had failed to respond to conventional therapy. Noyes et al performed BFR therapy on 27 patients who had undergone conventional post-operative therapy with no improvements. After undergoing BFR therapy statistically significant increases in both hamstring and quadricep torque strength was achieved.[9]

While research to date is promising, BFR therapy in rehabilitation is a relatively novel technique and many avenues still need to be explored. One of these is BFR therapy's recovery optimizing timing and dosage. The range of duration of BFR therapy in literature is typically 2 to 16 weeks.[12] While efficacy has been seen at shorter period such as 3 weeks with Ladlow et al and at longer durations such as 8 weeks in Hughes et al, an optimized period has not been identified for determining peak outcomes for patients, moreover, there is little in existing literature about the long-term outcomes or about the best practices for its implementation with other rehabilitation techniques.[3,8]

Further studies have also started to focus attention on the possibility of BFR therapy in controlling postoperative pain and inflammation. BFR therapy has shown to provide large

improvement in pain with activities of daily living in the study Giles et al, highlighting the importance of this outcome and its relation to improvements in overall patient outcomes.[11] This could present some potential in improving pain in postoperative rehabilitation and a possible decrease in painkiller usage in these patients. The mechanisms of these effects are not fully understood, and this presents one avenue of further research.

One of the most important factors to consider in BFR therapy use is whether there is an increased risk of venous thromboembolism (VTE), as well as other safety concerns such as muscle damage.[5,12] However, despite these concerns, most studies indicate that the risk of adverse effects with BFR therapy use is similar to that of conventional therapy, indicating that BFR therapy is appropriate for post TKA rehabilitation when performed in a supervised and controlled basis.[13] A technical note by DePhillipo et al noted that BFR therapy is safe and effective in the post knee surgery patient as long as the tourniquet is properly fitted and monitored.[14] Additionally, Nascimento et al carried out a systematic review on the influence of BFR exercise on hemostasis and found that there was no overall increase in risk of VTEs in healthy individuals, however, it must be noted that careful considerations must be given to individual patient conditions, particularly those concerning blood clotting mechanisms.[2,4]

Moreover, while the literature shows that BFR therapy offers promising use in rehabilitation, several limitations exist, the variability in protocol between studies, the small sample sizes, and the short follow up duration make it difficult to establish protocols and guidelines which makes formulating clinical recommendations more difficult.[4] In order to advance the body of knowledge and establish guidelines that result in the best patient outcomes, reproducible randomized controlled trials should be conducted.

Conclusion

Research on Blood Flow Restriction (BFR) therapy for postoperative recovery after total knee arthroplasty has shown many benefits in recovery, muscle strength, and overall patient well well-being. While current research document the efficacy and safety of BFR therapy when correctly applied, they suffer from certain limitations such as small sample sizes, short durations, and variation in protocol parameters. These parameters underscore the requirement for larger and more longitudinal studies with the intention of improving the application of BFR therapy, standardizing protocols, and establishing evidence based clinical guidelines. Addressing these gaps is crucial for fully realizing the potential of BFR therapy in enhancing postoperative rehabilitation and setting new standards in patient care.

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