Proceedings of the 3rd International Conference on Modern Medicine and Global Health
DOI: 10.54254/2753-8818/89/2025.20326

Blood Flow Restriction Training in the Rehabilitation of Hamstring Injuries

Qihang Lin[1,a,*]

[1]Guangzhou Medical University, Guangzhou, 511436, China
a. qihanglin0923@outlook.com
**corresponding author*

Abstract: Blood flow restriction (BFR) training is a novel technique of assisted rehabilitation that has been of interest to an increasing number of scholars in recent years. BFR training shows promising applications in the rehabilitation of hamstring injuries. Currently, research indicates that low-load BFR training is a useful substitute for conventional high-load resistance training. The effectiveness of BFR training in the recovery process of hamstring injuries, however, has not received much research. This paper reviews all the recent relevant literature with the aim of exploring the current efficacy, potential mechanisms, and potential safety issues with the application of BFR training in the rehabilitation of hamstring injuries. There are still many controversial and unresolved issues in the field, such as the optimal protocol for BFR application to injured hamstrings, specific potential mechanisms, and safety considerations for BFR training. It is hoped that this paper will trigger the attention of more scholars to address these issues in future research.

Keywords: Hamstring injuries, blood flow restriction, rehabilitation, mechanism, safety issues.

1. Introduction

Hamstring injuries have long been one of the most common injuries in lower limb sports. In professional male football players, hamstring injuries are one of the high-risk lower limb injuries, which, in addition to affecting performance and losing days in the game for athletes, place a significant financial burden on football clubs [1]. Recent studies have reported trends in hamstring injuries, with the rate of hamstring injuries (number of injuries and total days missed) doubling over the 21 years of the study, and in addition to this, the rate of hamstring injuries has increased over the last eight seasons in both matches and training [2]. Therefore, numerous studies have focused on how to assist athletes with hamstring injuries to recover faster and reduce their risk of reinjury. Many novel treatments have been proposed and attempted for clinical and rehabilitation applications.

Blood flow restriction (BFR) training has gained increasing attention in recent years as a novel adjunctive rehabilitation therapy. A tourniquet system, such as a cuff or an inflated blood pressure cuff, is used to perform BFR training. It is positioned over the proximal limb and pumped to a predetermined range of pressure, compressing certain muscle groups to partially block regional arterial blood flow and largely restrict venous blood flow [3]. Resistance training at 70% of a person's concentric one-repetition maximum (1RM) is an effective way to increase muscle hypertrophy and strength, according to the American College of Sports Medicine (ACSM). In response, it has been

DOI: 10.54254/2753-8818/89/2025.20326

suggested that the use of BFR can promote the development of muscle hypertrophy with results comparable to traditional strength training regimens, and that resistance training at 20% to 50% 1RM is the way to achieve this result [4]. When compared to high-load resistance training, low-load BFR training has been shown to be just as effective in raising maximal muscular strength in healthy adults [5]. The conclusion is that low-load BFR training is a useful substitute for high-load resistance training, which is important for injury recovery.

The hamstring muscle, as the primary muscle group of the proximal posterior thigh, is a suitable candidate for BFR training. Recent research, however, has concentrated on the effectiveness of BFR training in conjunction with resistance training that involves low-level loading and knee surgery rehabilitation applications. Little literature has focused on the rehabilitative applications of BFR training in hamstring injuries. Therefore, this article reviews the mechanisms of BFR training, the applications of BFR training in the rehabilitation of hamstring injuries, and the safety issues and concerns of BFR training. This will assist in providing physiotherapists or clinicians with more effective training guidance and aid injured athletes to return to play more rapidly.

2. Mechanism

Based on the current research literature, there are hypotheses such as accumulation of metabolites, stimulation of peripheral chemoreceptors, muscle swelling, increased protein synthesis through altered biomolecular pathways and exercise-induced hyperalgesia [4,6-8].

One hypothesis suggests that the hypoxia induced by BFR training leads to metabolic effects producing increased amounts of lactate, reactive oxygen radicals, and nitrogen oxides [9]. The accumulation levels of metabolic byproducts produced by low-load BFR training in many studies were similar to those produced by conventional high-load training [7]. The increased accumulation of metabolites (lactate and hydrogen ions) during BFR training and the resulting decrease in intramuscular pH stimulated group III and IV afferent fibers, leading to neuromuscular fatigue and decreased strength. This causes additional motor units to be recruited as compensation [10]. Low-load resistance training in BFR settings has been shown to engage type II fast-twitch muscle fibers, which are merely selectively recruitable during high resistance training [11]. In addition, the accumulation of metabolites affects protein synthesis and catabolism [9]. Muscle hypertrophy occurs when intracellular protein synthesis and catabolism reach a positive protein balance, and a decrease in the rate of protein catabolism correlates with a slowing of muscle atrophy [10]. Furthermore, an acute release of growth hormone (GH) is linked to the metabolic response, which may raise insulin-like growth factor-1 (IGF-1). Because muscle mass requires more blood, this could enhance vascular endothelial growth factor and encourage the development of vascular [7]. The accumulation of metabolites promotes an increase in growth hormone, which also promotes, on the other hand, an inflammatory response and an increase in the production of myokines (e.g., interleukin 6), which leads to the activation of muscle satellite cells [10]. Satellite cells, which are multipotent cells found in muscular attachments, are in charge of muscle growth and repair [11]. The acute inflammatory response can also release growth hormone during the repair process, leading to satellite cell activation and muscle cell proliferation [3]. The satellite cells, which are thought to be activated only in higher resistance training situations, also proliferate when BFR is combined with low load resistance training [11].

The build-up of metabolites during BFR training is thought to activate peripheral chemoreceptors found in the aortic body and carotid arteries as well as the central ones found in the ventrolateral medulla. During BFR training, the cuff pressure stimulates baroreceptors, which lowers venous return and reduces end-diastolic volume (preload). These factors may be responsible for the physiologic changes and changes in muscle adaptations induced by BFR training. Furthermore, studies have demonstrated a potential link between positive protein homeostasis and chemoreceptor activation or muscle swelling caused by exercise after BFR training [7].

Research has indicated that enhancing protein synthesis via biomolecular pathways can also be achieved by targeting the mammalian targets of rapamycin complex 1 (mTORC 1), inhibiting atrophic genes like Muscle RING Finger1 (MuRF1) and atrogin-1, and blocking the myostatin (MSTN) pathway [7]. Muscle hypertrophy requires the stimulation of muscle protein synthesis, which is mostly dependent on the mechanistic target of rapamycin (mTOR) pathway. Myostatin expression plays a critical role in this process as well since it promotes muscle fibrosis and functions as a negative regulator of the development of muscles [6,11].

A recent study reported that plasma beta-endorphin concentration was elevated following BFR resistance training, which may be a potential mechanism by which BFR training induces exercise-induced hypoalgesia [8].

The benefits of BFR training as applied to the rehabilitation of hamstring injuries have been reported in the literature; nevertheless, the discussion of its mechanisms is not conclusive, and the majority of the mechanisms' theories require confirmation through additional research.

3. Applications

BFR training arterial occlusion pressure is different in the protocols applied in different experiments. Some studies indicate that the range of total arterial occlusion pressure during BFR training is typically between 40% and 60% of the overall pressure of the extremities. 50% of the total occlusion pressure is typically used as the standard pressure for the study design in the majority of current BFR training procedures. Meanwhile, current BFR training occlusion pressure protocols tend to be individualized and use Doppler ultrasound for more accurate monitoring. The standard protocol for BFR training includes four rounds of 30-15-15-15 repetitions. This protocol highlights the benefits of BFR paired with low-load training at a lower load level and overall exercise volume than standard resistance training. Rest periods between two training groups usually ranged from 30 seconds to 2 minutes, with most experiments using one-minute or 1.5-minute rest periods between groups. To target the hamstring muscles, the most proximally located part of the thigh should receive the application of the cuffs or elastic bands employed in BFR training [7].

3.1. Low load training with BFR

The third part of the London International Consensus and Delphi study on Hamstring Injuries reported that the important role of loading in the rehabilitation of hamstring injuries [12]. For acute hamstring injuries, early and adequate loading has been demonstrated to enhance regenerative stimulation and minimize muscle atrophy in an effective manner. Earlier entry into rehabilitation (2 days post-injury versus 9 days post-injury) enables faster recovery from injury [13]. Nevertheless, the pain, inflammation, and hematoma that accompany early injuries negatively affect load-training performance, and early loading may present a risk of re-injury to acute hamstring injuries. Therefore, low-load BFR training seems to be a good option if one wants to load early and avoid the negative effects of high-load resistance training.

The primary objective of a study involving forty healthy adults was to assess over time the impact on eccentric hamstring strength of low-load BFR training contrasted with traditional resistance training. In this study, low-load (30% of 1RM) BFR training (80%of arterial blood flow was occluded) was done primarily on a leg curl machine. The eccentric resistance training for the BFR training group started at 30% of 1 RM and was done in four rounds of 30-15-15-15 repetitions each, with a 30-second rest interval in between. For a duration of six weeks, training was conducted twice a week, separated by one to two days. Lean mass BIA, unilateral subjective soreness, unilateral leg power,

DOI: 10.54254/2753-8818/89/2025.20326

and unilateral eccentric hamstring strength were all assessed using various measures in the interim. In terms of hamstring muscular power, strength, lean body mass, and perceived discomfort, the trial concluded that low-load BFR eccentric resistance training was as effective as high-load conventional resistance training. Aside from these potential methods for increasing muscle growth, the study also showed evidence of myocyte stress and inflammation, increased creatine kinase, heat shock protein expression, and macrophage activation. Meanwhile, prolonged cell swelling was observed in the low-load eccentric training group, which was not found in the traditional training group. This may be related to the previously mentioned mechanisms involved (rapamycin pathway and hypoxic metabolic response), which the researchers believe is facilitated by a combination of multiple factors [3]. The present recommendations lack a clear data base for the timing of the introduction of eccentric training, which is generally delayed because of concerns about the occurrence of re-injury [13]. Therefore, in order to be able to apply it early in the treatment, the low-load eccentric training can be an effective solution to this problem. This study's limitation is that it was done on healthy individuals rather than hamstring injury patients, which could have caused bias in the results. Nonetheless, the study's findings showed that low-load BFR training can effectively promote hamstring muscle growth and strength in place of high-load training, which is consistent with the goal of rehabilitation for hamstring injuries. Further research is necessary to determine the precise processes by which low-load BFR training enhances hamstring muscle growth and strength for individuals with hamstring injuries.

Another study concerned the application of low load (25% to 35% of 1-RM) BFR training (60% to 80% of the total artery occlusion pressure) to improve the peak torque strength of the hamstring after knee surgery. The trial included twenty-seven patients who had previously had knee surgery, such as meniscal repair, partial or total knee arthroplasty, and anterior cruciate ligament (ACL) reconstruction, and who had substantial quadriceps and/or hamstring impairments. The trial used different training machines to perform leg presses, knee extensions, mini squats and hamstring curls. Every exercise started at 30% of 1 RM and was performed in four rounds of 30-15-15-15 repetitions, with a one-minute break in between. The cuff was inflated and placed around the upper thigh, near the inguinal region, during all 4 exercises, and pressure was measured using ultrasound Doppler. For a total of nine sessions, each patient underwent two or three exercises per week, and a further session of BFR training was conducted on fourteen patients, totaling eighteen sessions. The trial's findings showed that after nine low-load BFR training sessions, peak torque and hamstring deficiencies considerably improved and kept getting better after eighteen sessions [14]. Increasing peak torque and improving deficits in the hamstring muscles can also be one of the key goals of hamstring injury treatment, as well as the therapeutic effects of loading training, and low loading training combined with BFR can help patients into rehabilitation earlier and expose them to less risk of re-injury. The therapeutic benefit of low-load (30% of 1RM) BFR (80% of total occlusion pressure) training was examined in conjunction with conventional load training for the quadriceps and hamstrings following ACL reconstructive surgery in a randomized controlled trial with 28 participants. The trial's findings showed that hamstring muscle strength improved more rapidly with low-load BFR training contrasted with traditional load training. Furthermore, the trial reported that low-load BFR training resulted in greater pain relief in the early stages of rehabilitation and subsequently improved physical function and quality of life for patients, which is also significant in the rehabilitation of hamstring injuries [15]. A case report study (a 25-year-old male professional soccer player after ACL reconstruction surgery) reported a significant increase in maximal hamstring strength, especially in the last 30° of flexion, static and dynamic, after ACL reconstructive surgery using a protocol of low-load (30% of 1RM) BFR training. In addition, the distinction of the injured and healthy extremities was less than 28% after a month of low-load BFR training, indicating a quicker return to sport and a lower chance of re-injury [16]. These results provide a crucial foundation for using BFR training to treat hamstring

DOI: 10.54254/2753-8818/89/2025.20326

strains. After ACL repair surgery, muscle atrophy and chronic muscle weakness due to prolonged muscle inactivity and neurological mechanisms which involve the hamstring muscles [15]. The results of several of the aforementioned trials demonstrated the effectiveness of low-load BFR training in improving this deficit. However, more future trials need to focus on the effectiveness of low-load BFR training applied to isolated hamstring injury rehabilitation.

Hamstring tendinopathy is also a common type of hamstring injury, with most presenting with pain, muscle weakness and loss of function [13]. Load training is also crucial in its rehabilitation. Although often managed as a comorbidity, investigating whether BFR training is significantly effective for isolated hamstring tendinopathies is a current priority that needs to be addressed. However, there are no recent studies focusing on this issue. Apart from the effects on hamstring muscle strength that have already been discussed, there is plausible evidence that low-load BFR training is linked to pain modulation mechanisms through endogenous opioids, endocannabinoids, and exercise-induced hyperalgesia. These mechanisms may be useful in reducing pain in hamstring tendinopathy [8]. This suggests that low-load BFR training could be used to treat hamstring tendinopathy in addition to traditional rehabilitation treatments. Two recent randomized controlled trials have focused on the efficacy of low-load BFR training in the treatment of lateral elbow tendinopathy and rotator cuff tendinopathy. Trials focusing on lateral elbow tendinopathy reported significantly improved results with the application of BFR training, whereas trials focusing on rotator cuff tendinopathy concluded that there was no advantage to BFR training in terms of pain and functional improvement [17,18]. In addition to taking into account the different BFR training protocols used in different experiments, there can be variations in the effects due to various muscular and neural mechanisms, and BFR training is not effective in all cases of tendinopathy. Consequently, more research should be done to determine the effectiveness of BFR training for hamstring tendinopathies as well as to investigate the development of a tailored training protocol.

3.2. Running exercise with BFR

In addition to restoring muscle function (strength and range of motion) during the restoration and recovery phase of hamstring injuries, the implementation of a progressive running protocol is another important treatment for rehabilitation of hamstring injuries. A recent trail focuses on the effects of running exercise combined with blood flow restriction (RE-BFR) on strength and sprint performance. Twelve male sprinters were included in this trial. Every participant completed five rounds of two-minute runs on a treadmill interspersed with one-minute rest periods during each running session. Running was performed at a predetermined training level of 50% heart rate reserve. The average running pace was 8.4 ± 1.7 $km \cdot h^{-1}$. Participants that underwent RE-BFR warm-up applied a compression cuff with a cuff pressure level of 149.8 ± 5.0 mm Hg to the most proximal section of each leg during the running exercise. The cuff remained inflated during the rest period between sets. The results of this trial showed that RE-BFR substantially improved the physiological responses and hamstring muscular strength, which is also beneficial for the recovery process of hamstring injuries. Meanwhile, in this trial, RE-BFR was demonstrated to be effective in preventing hamstring injuries during warm-up exercises. This means that during the rehabilitation phase of a hamstring injury, RE-BFR may also be used in a progressive running protocol which can reduce the risk of re-injury. It is worth noting that this trial considered the nature of the stimuli to be different for resistance training and running training, and therefore could not compare the two types of training. The researchers came to the conclusion that the mechanism by which RE-BFR increases hamstring muscle strength and improves physiological responses may be connected to the recruiting of additional motor units based on the enhanced level of stimulation of muscles response in this trial [19]. There are other literature suggesting that potential mechanisms include the acute release of anabolic hormones and biomolecular regulatory pathways that control protein renewal [7]. Consequently, further research should concentrate on how RE-BFR training affects the recovery process of hamstring injuries and any potential mechanisms that may be involved. Additionally, more efficient RE-BFR protocols should be tested and established.

3.3. Safety issues and concerns

Positive outcomes have been found in most studies on the possible safety hazards of BFR training, including those pertaining to the exertional rhabdomyolysis, muscle damage, ischemia-reperfusion injury, and cardiovascular system. It is unlikely that BFR training poses an additional risk for most of these events when compared to traditional exercise [20]. Although the results were positive, the potential negative side-effects and safety issues associated with BFR training are still not well established, and therefore there are still many studies focusing on this issue.

A recent literature review mentioned that estimated BFR training may increase the normotensive response during resistance exercise by 5-10 mmHg, so the literature emphasizes that there is no denial of the hypothesis that BFR may potentially increase acute cardiovascular risk [20]. Indeed, the literature has indicated that the possible impact of BFR training on the cardiovascular health vary according to the type of activity and level of restriction [7]. It has been demonstrated that group III and IV afferent fibers react to painful stimuli in relation to the width of the cuff. This suggests that, in comparison to narrow cuffs, wide cuffs place greater restrictions on the vascular system and may exacerbate elevated sympathetic autonomic nervous system and vascular resistance. When it comes to limiting cuff pressures, the retrograde shear rate and associated risk of endothelial function damage rise with increasing cuff pressure during training. It is therefore important to conform to the normal cuff pressure range to avoid unnecessary high pressures leading to complete arterial occlusion. BFR cuff pressures should be altered on an individual basis and need to be estimated as a percentage of arterial occlusion pressure during exercise to achieve the premise that endothelial function is not compromised. It has been recommended that clinicians establish the limiting pressure for each patient at 40–60% of the arterial occlusion pressure [21]. BFR loading training causes increases in heart rate, diastolic blood pressure, and systolic blood pressure (SBP) during loading exercises that are typically on par with or even lower than those obtained with unrestricted loading training. However, because the vein's return to the central circulatory is obstructed, certain metabolic byproducts of BFR resistance training including dihydrogen phosphate, hydrogen ions, lactate, and inorganic phosphate, are trapped and locally accumulated in active muscle tissues. This can result in some of the potential consequences of excessive blood pressure through the pressor reflex [7].

Cyclical BFR load resistance training protocols have been demonstrated to be effective in protecting vital organs when ischemia-reperfusion injury occurs. This treatment has the advantage of reducing sympathetic activity in comparison to standard training regimens; this is demonstrated by lower cardiac output, plasma levels of norepinephrine, heart rate, output per beat, and total peripheral resistance. Furthermore, cyclical BFR aerobic training protocols have also been demonstrated not to result in higher arterial pressures compared to traditional aerobic training protocols, even with increased sympathetic activity [21]. To ascertain the intervals for cyclic BFR training, further research is necessary.

It is yet unknown whether there could be another problem with rhabdomyolysis or perhaps injury to the muscles. Typically, BFR training is unlikely to cause substantial muscle damage since the low training loads (20–50% of 1 RM) do not produce a significant amount of mechanical stress. However, the current literature remains controversial [7].

Further research is required to identify the exact mechanisms of BFR training, as there is still uncertainty about its safety when applied to treat hamstring injuries. Those who may be at high risk for cardiovascular disease, musculoskeletal injuries, factors related to lifestyle (such as obesity, pregnancy, diabetes mellitus), family history of disease, and medication (such as use of medications that increase coagulation risk) should avoid using BFR training or use it cautiously under the supervision of a physiotherapist or clinician until the safety of the training is fully established [21].

4. Conclusion

In the rehabilitation of hamstring injuries, blood flow restriction (BFR) training has shown great promise. When used in the early stages of hamstring injury rehabilitation, low-load BFR training can be a useful substitute for conventional high-load training. Low-load BFR training could additionally be able to reduce hamstring tendinopathy pain. BFR also plays an important role in running exercise for hamstring injury rehabilitation. Until it has been determined that BFR training is completely safe for patients with hamstring injuries, it is recommended that it be contraindicated in those with risk factors and used appropriately in others under the guidance of a physiotherapist or clinician. In the future, more trials should clarify the mechanisms of BFR training applied to hamstring injuries, which will be a prerequisite for exploring optimal BFR training protocols for hamstring injuries. For application in the future in the recovery process of hamstring injuries, individualized BFR training protocols (covering BFR compression, cuff type and width, training time and intervals, etc.) would be an intelligent choice. The application of BFR training may have different results in the short-term and long-term rehabilitation of hamstring injuries, which also requires further research to confirm. Trials with inclusion of larger sample sizes are required to provide reliable evidence. Identifying potential safety issues with BFR training as early as possible and proposing appropriate solutions will facilitate faster recovery and reduce the risk of re-injury for more patients.

References

[1] López-Valenciano, A., Ruiz-Pérez, I., Garcia-Gómez, A., Vera-Garcia, F. J., De Ste Croix, M., Myer, G. D., & Ayala, F. (2020). Epidemiology of injuries in professional football: A systematic review and meta-analysis. British Journal of Sports Medicine, 54(12), 711–718. https://doi.org/10.1136/bjsports-2018-099577

[2] Ekstrand, J., Bengtsson, H., Waldén, M., Davison, M., Khan, K. M., & Hägglund, M. (2023). Hamstring injury rates have increased during recent seasons and now constitute 24% of all injuries in men's professional football: The UEFA Elite Club Injury Study from 2001/02 to 2021/22. British Journal of Sports Medicine, 57(5), 292–298. https://doi.org/10.1136/bjsports-2021-105407

[3] Jones, M. J., Dominguez, J. F., Macatugal, C., Coleman, K., Reed, B., & Schroeder, E. T. (2023). Low Load With BFR vs. High Load Without BFR Eccentric Hamstring Training Have Similar Outcomes on Muscle Adaptation. Journal of Strength and Conditioning Research, 37(1), 55–61. https://doi.org/10.1519/jsc.0000000000004211

[4] Wortman, R. J., Brown, S. M., Savage-Elliott, I., Finley, Z. J., & Mulcahey, M. K. (2021). Blood Flow Restriction Training for Athletes: A Systematic Review. The American Journal of Sports Medicine, 49(7), 1938–1944. https://doi.org/10.1177/0363546520964454

[5] Grønfeldt, B. M., Lindberg Nielsen, J., Mieritz, R. M., Lund, H., & Aagaard, P. (2020). Effect of blood-flow restricted vs heavy-load strength training on muscle strength: Systematic review and meta-analysis. Scandinavian Journal of Medicine & Science in Sports, 30(5), 837–848. https://doi.org/10.1111/sms.13632

[6] Curran, M. T., Bedi, A., Mendias, C. L., Wojtys, E. M., Kujawa, M. V., & Palmieri-Smith, R. M. (2020). Blood Flow Restriction Training Applied With High-Intensity Exercise Does Not Improve Quadriceps Muscle Function After Anterior Cruciate Ligament Reconstruction: A Randomized Controlled Trial. The American Journal of Sports Medicine, 48(4), 825–837. https://doi.org/10.1177/0363546520904008

[7] Freitas, E. D. S., Karabulut, M., & Bemben, M. G. (2021). The Evolution of Blood Flow Restricted Exercise. Frontiers in Physiology, 12, 747759. https://doi.org/10.3389/fphys.2021.747759

[8] Hughes, L., & Patterson, S. D. (2020). The effect of blood flow restriction exercise on exercise-induced hypoalgesia and endogenous opioid and endocannabinoid mechanisms of pain modulation. Journal of Applied Physiology, 128(4), 914–924. https://doi.org/10.1152/japplphysiol.00768.2019

[9] Reina-Ruiz, Á. J., Martínez-Cal, J., Molina-Torres, G., Romero-Galisteo, R.-P., Galán-Mercant, A., Carrasco-Vega, E., & González-Sánchez, M. (2023). Effectiveness of Blood Flow Restriction on Functionality, Quality of Life and Pain in Patients with Neuromusculoskeletal Pathologies: A Systematic Review. International Journal of Environmental Research and Public Health, 20(2), 1401. https://doi.org/10.3390/ijerph20021401

[10] Lorenz, D. S., Bailey, L., Wilk, K. E., Mangine, R. E., Head, P., Grindstaff, T. L., & Morrison, S. (2021). Blood Flow Restriction Training. Journal of Athletic Training, 56(9), 937–944. https://doi.org/10.4085/418-20

[11] Cognetti, D. J., Sheean, A. J., & Owens, J. G. (2022). Blood Flow Restriction Therapy and Its Use for Rehabilitation and Return to Sport: Physiology, Application, and Guidelines for Implementation. Arthroscopy, Sports Medicine, and Rehabilitation, 4(1), e71–e76. https://doi.org/10.1016/j.asmr.2021.09.025

[12] Paton, B. M., Read, P., Van Dyk, N., Wilson, M. G., Pollock, N., Court, N., Giakoumis, M., Head, P., Kayani, B., Kelly, S., Kerkhoffs, G. M. M. J., Moore, J., Moriarty, P., Murphy, S., Plastow, R., Stirling, B., Tulloch, L., Wood, D., & Haddad, F. (2023). London International Consensus and Delphi study on hamstring injuries part 3: Rehabilitation, running and return to sport. British Journal of Sports Medicine, 57(5), 278–291. https://doi.org/10.1136/bjsports-2021-105384

[13] Thorborg, K., Opar, D., & Shield, A. (Eds.). (2020). Prevention and Rehabilitation of Hamstring Injuries. Springer International Publishing. https://doi.org/10.1007/978-3-030-31638-9

[14] Noyes, F. R., Barber-Westin, S. D., & Sipes, L. (2021). Blood Flow Restriction Training Can Improve Peak Torque Strength in Chronic Atrophic Postoperative Quadriceps and Hamstrings Muscles. Arthroscopy: The Journal of Arthroscopic & Related Surgery, 37(9), 2860–2869. https://doi.org/10.1016/j.arthro.2021.03.040

[15] Vieira De Melo, R. F., Komatsu, W. R., Freitas, M. S. D., Vieira De Melo, M. E., & Cohen, M. (2022). Comparison of Quadriceps and Hamstring Muscle Strength after Exercises with and without Blood Flow Restriction following Anterior Cruciate Ligament Surgery: A Randomized Controlled Trial. Journal of Rehabilitation Medicine, 54, jrm00337. https://doi.org/10.2340/jrm.v54.2550

[16] Ceccarelli, C., Andreani, A., Soave, A., Salomon, M., & Maselli, F. (2024). Use of blood flow restriction for increasing the strength of the ischiocrural muscles in anterior cruciate ligament rehabilitation: A case report. Physiotherapy Research International, 29(1). https://doi.org/10.1002/pri.2059

[17] Karanasios, S., Korakakis, V., Moutzouri, M., Xergia, S. A., Tsepis, E., & Gioftsos, G. (2022). Low-Load Resistance Training With Blood Flow Restriction Is Effective for Managing Lateral Elbow Tendinopathy: A Randomized, Sham-Controlled Trial. Journal of Orthopaedic & Sports Physical Therapy, 52(12), 803–825. https://doi.org/10.2519/jospt.2022.11211

[18] Kara, D., Ozcakar, L., Demirci, S., Huri, G., & Duzgun, I. (2024). Blood Flow Restriction Training in Patients With Rotator Cuff Tendinopathy: A Randomized, Assessor-Blinded, Controlled Trial. Clinical Journal of Sport Medicine, 34(1), 10–16. https://doi.org/10.1097/JSM.0000000000001191

[19] Chen, Y.-T., Hsieh, Y.-Y., Ho, J.-Y., & Lin, J.-C. (2021). Effects of Running Exercise Combined With Blood Flow Restriction on Strength and Sprint Performance. Journal of Strength and Conditioning Research, 35(11), 3090–3096. https://doi.org/10.1519/jsc.0000000000003313

[20] Cristina-Oliveira, M., Meireles, K., Spranger, M. D., O'Leary, D. S., Roschel, H., & Peçanha, T. (2020). Clinical safety of blood flow-restricted training? A comprehensive review of altered muscle metaboreflex in cardiovascular disease during ischemic exercise. American Journal of Physiology-Heart and Circulatory Physiology, 318(1), H90–H109. https://doi.org/10.1152/ajpheart.00468.2019

[21] da Cunha Nascimento, D., Schoenfeld, B. J., & Prestes, J. (2020). Potential Implications of Blood Flow Restriction Exercise on Vascular Health: A Brief Review. Sports Medicine, 50(1), 73–81. https://doi.org/10.1007/s40279-019-01196-5