

BLOOD FLOW RESTRICTION TRAINING ON DIFFERENT JOINTS AND ITS EFFECT ON SURROUNDING MUSCLES

Abstract

Blood-flow occlusion training, identified as blood-flow restriction training (BFRT) or occlusion-training, is a technique used in exercise and to rehabilitate weak muscles without excessive overloading. The restriction is usually done to the part of the body close to axial skeleton, such as the upper arm or upper thigh, to reduce arterial blood flow while allowing venous return. This causes temporary drop in oxygen supply of the working musculature, creating state of localized oxygen deficit. It leads to increased muscle hypertrophy, improved strength of musculature in not just appendicular skeleton but also in axial skeleton and also reduces stress on the joints. Various studies have been done in past to elaborate the physiology and effectiveness of this novel training in improvement of health of the joints of appendicular and axial skeleton. This chapter gives an insight into the various studies done on blood flow restriction training and its physiological basis.

Keywords: Skeleton, Blood Flow, Appendicular

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I. INTRODUCTION

Musculoskeletal injuries are frequent in desk-bound lifestyle leading to muscle weakness and atrophy. (1) Blood-flow occlusion training, identified as blood-flow restriction training (BFRT) or occlusion-training, is a technique used in exercise and rehabilitation of weak muscles without overloading them. It involves applying a restriction to the blood flow in a working muscle while exercising, typically by using a specialized tourniquet or cuff. It is considered to be effective as well as harmless in musculoskeletal and sports medicine. (1) For athletic population 'American College of Sports Medicine' recommended moderate ~ high resistance loads which is clinically not feasible. (2) Studies suggest that 60-80% of 1 RM is required to improve strength and hypertrophy of muscles. Athletes are recommended to train with moderate to high intensity exercises whereas clinically it is recommended to train with lower load (LL) exercises. (2).

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Figure 1: Cuff placement for upper and lower extremity. The cuff should be placed proximally on the limb, which allows occlusion to occur in the majority of the muscle without interfering with movement (Source: Lorenz et al., 2021).

1. Structural Adaptations of Blood Flow Occlusion Training

- **Increased Muscle Hypertrophy:** The localized hypoxia and metabolic stress created by blood flow restriction training may stimulate amino acid build up within muscle and lead to increased muscle development and hypertrophy. (8)
- **Improved Strength and Endurance:** Despite using lighter loads, blood flow occlusion training has shown to improve strength and muscular endurance. It is thought to increase muscle recruitment and activate higher threshold motor units. (9)

Sarcopenia populations, elderly people with chronic health issues, or those with injuries who might not be able to handle severe loading may not be good candidates for high-intensity loads applied in conventional strength training programmes. (16)

- **Reduced Joint Stress:** Blood flow occlusion training allows individuals to achieve muscle gains with lighter loads, thereby reducing stress on the joints. This can be beneficial for people recovering from injuries or with joint-related limitations. (10) Accelerated post-injury rehabilitation- BFRT has been used as a part of rehabilitation protocols to expedite the recovery process in individuals with injuries. It can help maintain muscle bulk & power during stages of immobilization or lower training intensity. (10)
- 2. Physiology of Muscular Adaptations:** Inconsistencies within air supply and demand, which often happens with high- or moderate-intensity workouts in skeletal muscle. The increase in muscle blood flow, which can rise to 80% of total cardiac output (CO) during demanding dynamic workouts of an extensive muscle group, meets the increase in oxygen demand by skeletal myocytes. (3) Skeletal muscle metabolites like lactic acid and protons are produced by the increased skeletal muscle blood flow, which is difficult to resist. (4,5) As lactic acid generation encourages the creation of growth hormone, the acidic levels in the muscles' sarcoplasm rise as a result. Growth hormones' activities then result in muscular hypertrophy and hyperplasia. (6)

Additionally, the recruitment of fast-glycolytic muscle fibres is accelerated by exercise-induced decreases in muscle oxygen tension. (7) The majority of the muscle is made up of fast-glycolytic fibres. It is thought to increase muscle recruitment and activate higher threshold motor units (7,12). Sarcopenia populations, elderly people with chronic health issues, or those with ailments who might not be able to handle severe loads may not be good candidates for high-intensity loads applied in conventional strength training programmes.

II. EVIDENCE BASED ROLE OF BFRT ON DIFFERENT JOINTS

Blood flow occlusion training (BFRT) can have varying effects on different joints depending on the specific joint involved and the exercise performed.

1. Peripheral Joints

- **Knee Joint:** BFRT can be used to target the muscles around the knee joint, such as the quadriceps and hamstrings. Studies have demonstrated that BFRT in conjunction with low-impact resistance workouts can enhance muscle strength and increase in bulk at the knee joint, which is advantageous for those with knee injuries or restrictions. (9)

Some studies have explored the effects of BFRT on knee-related outcomes. RCTs published in the Journal of Arthroscopy and related surgeries found that BFRT in conjunction with low-impact load workout suggestively improved thigh

(Quadriceps) muscle power and hypertrophy among individuals who failed to respond to traditional rehabilitation post knee surgeries. (11) However, further investigation is required to evaluate the long-standing consequences and optimum protocols for BFRT in knee-related conditions.

- **Shoulder Joint:** BFRT can be applied to the upper arm, which indirectly affects the muscles surrounding the shoulder joint. By performing exercises such as shoulder presses, lateral raises, or rows along-side blood flow occlusion, individuals can promote muscle growth and strength in the shoulder region. This may be useful for individuals recovering from shoulder injuries or those with limited shoulder mobility. (13)

In a study done in 2017, the effects of BFRT on muscular activation and hypertrophy in the shoulder muscles were examined. The results were published in the *Journal of Strength and Conditioning Research*. The findings showed that BFRT boosted muscular activation and promoted deltoid muscle growth when paired with low-load resistance training. (14)

While BFRT has been used to target the muscles around the shoulder joint, such as the deltoids and rotator cuff muscles, the evidence for its direct impact on shoulder-related outcomes is still emerging. Further studies are needed to evaluate its effectiveness and safety in shoulder rehabilitation and performance.

- **Elbow Joint:** Blood flow occlusion training is not typically performed directly on the elbow joint itself, but rather on the upper arm. However, by targeting the muscles around the elbow joint, such as the biceps and triceps, individuals can still achieve muscle hypertrophy and strength gains. Exercises like bicep-muscle curls and triceps-muscle extensions can be performed with BFRT. Studies exploring the effects of BFRT on elbow-related outcomes are scarce, and more research is needed to establish its benefits and safety in elbow rehabilitation or performance. (14,15) Limited researches specifically focus on the effects of BFRT on the elbow joint. However, studies have demonstrated the effectiveness of BFRT in promoting muscle hypertrophy and strength gains in the biceps and triceps muscles, which indirectly affect the elbow joint.
- **Hip Joint:** BFRT can be applied to the upper thigh, indirectly targeting the muscles around the hip joint. This can be beneficial for individuals with hip injuries or limitations. Exercises such as squats, lunges, and hip extensions performed with blood flow occlusion can enhance muscle growth and strength in the hip region.

Another recent research investigated the effectiveness of BFRT on muscle activation & hypertrophy in the hip muscles, findings indicated that BFRT, in conjunction with low-load strength training, led to increased muscle activation and hypertrophy in the hip muscles. (16)

Another study published in the *European Journal of Applied Physiology* in 2020 demonstrated that BFRT combined with low-intensity resistance training

resulted in significant increases in muscle fibre size and power in the hip extensors. (17) Various studies suggest that BFRT has equal effects in improving various micro repetitive traumas as shown in conventional physiotherapy treatment. (18)

Overall, it is essential to recognize that the evidence regarding the direct effects of BFRT on joint-specific outcomes. While BFRT may indirectly influence joint function through improvements in muscle strength and hypertrophy, more research is needed to establish its efficacy and optimal application for different joint-related conditions. More studies are required in future to assess the efficacy and safety of BFRT in hip rehabilitation or performance enhancement.

2. Axial Joints: While blood flow restriction training (BFRT) has been extensively studied for its effects on peripheral joints like the knees, shoulders, and hips, there is limited research specifically focused on its role in axial joints, such as the spine and pelvis. However, some potential benefits and evidence-based considerations regarding BFRT in axial joints can be seen.

- **Spine:** In past numerous studies have been undertaken on BFRT treatment in adjunct to resistance workout and have shown to improve trunk muscle strength and hypertrophy, which can benefit spinal stability and support. A study published in the Journal of Orthopaedic & Sports Physical Therapy in 2019 demonstrated that BFRT combined with low-load exercises improved trunk muscle endurance and reduced lower lumbar discomfort in patients suffering from long-term lower back discomfort. (19) Another study published in 2018 concluded that BFRT combined with resistance training resulted in greater activation of the lumbar muscles compared to traditional resistance training alone. (20)
- **Pelvis:** Limited research exists on the specific effects of BFRT on the pelvis. However, since BFRT can enhance muscle hypertrophy and strength in the lower limbs, it indirectly contributes to pelvis stability and functional movements. It is important to note that due to the lack of extensive research specifically focusing on axial joints; the evidence supporting the role of BFRT in these areas is relatively limited compared to peripheral joints. As with any exercise technique, proper technique, individualized programming, and guidance from a qualified professional are crucial to ensure safety and maximize benefits.

III. CONCLUSION

Blood flow restriction training is found highly beneficial for enhancement of muscle power and endurance especially in limb musculature. It is found to be effective in improving atrophy of muscles as it causes increase in blood flow of appendicular skeleton which is difficult to resist, produces bio-metabolites within appendicular musculature such as lactic acid and protons. Acidic levels within the muscles sarcoplasm increases due to Lactic acid production which stimulates the production of growth hormone, this leads to actions of growth hormones causing muscle hypertrophy and hyperplasia.

IV. SUMMARY

Increased and effective usage of blood flow restriction treatment has gained interest of various healthcare providers to perform it clinically for improving health of patients. While focusing on the treatment and muscle group treated one should have evidence-based background knowledge regarding the treatment and its outcomes. This chapter provides management using blood flow restriction training in various different joints and its significance with different joint muscles. Elaborate explanation about the basic physiology which helps in improving strength, endurance and size of the muscles which helps in planning treatment protocols for various musculoskeletal conditions with realistic goals.

This chapter also provides evidences for using blood flow restriction training in various joints and surrounding muscles with supporting and contradicting researches, so as to help the reader to interpret and identify its implications and help them in focusing on BFRT before planning an intervention for improving strength and endurance of muscles.

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