The Effect of Blood Flow Restriction Training on Ankle Sprain Repair: A Narrative Review

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Abstract

Introduction: Ankle Sprain (AS) is one of the most common musculoskeletal injuries in athletes. Without proper intervention, acute AS have a high recurrence rate, which is associated with the development of chronic ankle instability. Currently Limited evidence exists to support the best intervention in related to individuals with AS. Blood Flow Restriction Training (BFRT) has emerged as a promising approach in physiotherapy for individuals with AS. The aim of present study was to review the effectiveness of BFRT treatment in individuals with AS narratively. **Materials and Methods:** This narrative review was conducted to reviewing the available research's about the role of BFRT in treatment of individuals with AS. The search encompassed studies published from 2000 to 2024 across multiple electronic databases, including Google Scholar, PubMed, Scopus, and Science Direct using relevant keywords. **Results:** Evidence suggests that the BFRT can be used as a new method in the treatment and rehabilitation process of individuals with AS. **Conclusion:** Research has shown that utilizing BFRT can lead to significant improvements in recovery rates, strength gains, and overall patient satisfaction.

Key words: Ankle Sprain; Blood Flow Restriction Training; Physiotherapy

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Introduction

Ankle Sprains (AS) are among the most common musculoskeletal injuries, often resulting in pain, swelling, and functional mobility dysfunction (1). Depending on the severity of the sprain, Individuals who have sprained ankles complain of pain in the outer part of the ankle and various degrees of swelling and bleeding under the skin and impaired weight bearing on the foot. Ankle sprains typically fall into three categories :Grade I: Mild tearing of ligaments, Grade II: Partial tearing of ligaments, and Grade III: Complete tearing of ligaments, often requiring surgical intervention (2, 3) .Chronic instability may cause the ankle bones to move excessively with daily activities, and this issue can lead to persistent the chronic discomfort and swelling, further weakening or stretching of the ligaments, damage to the ligaments, damage to joint cartilage, degenerative changes, changes in lower extremity function, possibly osteoarthritis, and poor balance especially in older adults (4). The most common mechanism of injury in lateral ankle sprains occurs due to forced plantar flexion and inversion of the ankle in a situation where the body's center of gravity rotates over the ankle.. The inversion mechanism is particularly common in activities related to sports and leading to overstretching or tearing of the ankle ligaments. The injury of AS not only impact on athletes' performance but also lead to disruption of the rehabilitation process .Following the resolution of symptoms subsequent to a period of rest, the muscles surrounding the ankle may remain weakened due to trauma or inadequate rehabilitation, encompassing muscles around the foot and ankle such as the gastrocnemius and tibialis anterior (5). Muscle weakness or incomplete ligament healing can result in inadequate ankle stability (6). Additionally, neural control over muscle movement may be compromised, leading to insufficient muscle coordination and an increased risk of ankle joint instability (7). Consequently, post-rehabilitation strengthening exercises targeting ankle strength and stability assume particular significance.

Proper rehabilitation is crucial to avoid repeated injuries and long-term complications. Conservative treatment is the first step for chronic ankle instability. Recovery can be achieved through various physiotherapy interventions including strengthening exercises, neuromuscular training, improving proprioceptive abilities, balance training, mobilization, and improve Range of Motion (ROM) (8). Recently, Blood Flow Restriction Training (BFRT) has emerged as a promising approach in physiotherapy, potentially expediting recovery and enhancing strength gains without straining the affected area (9). BFRT is a specialized training technique designed to stimulate muscle growth and enhance strength by employing cuffs or elastic bands to restrict blood flow in the limbs. In a standard BFRT protocol, a cuff is placed proximal to the affected limb and sufficient pressure is applied to block venous flow while preserving arterial flow (usually 40-80% of limb occlusion pressure) (10).

This study will explore the effects of BFRT on AS repair, drawing on recent studies to provide a detailed analysis of its effectiveness (11).

Materials and Methods:

This study is a narrative review. Studies published in the past 24 years in English that measured ankle sprain characteristics (i.e., muscle strength, pain, swelling, and muscle function) before and after BFR training were included. Patients of all ages with a history of AS were included too. Articles were excluded if they reported applied the intervention solely to healthy participants. Duplicate studies as well as published in languages other than English were also excluded.

The Concept behind Blood Flow Restriction Training:

BFRT involves applying pressure to the limb using a cuff or band and restricting blood flow during low-intensity exercise. The goal of this technique is to stimulate the muscles as if they were engaged in high-intensity exercise, leading to increased strength and muscle hypertrophy. According to the literatures, using this technique can have the following effects:

1. Metabolic Stress: The BFRT results in a buildup of metabolic by products, triggering muscle growth.
2. Hormonal Response: BFRT promotes the release of growth hormone and other anabolic markers that facilitate tissue repair.
3. Muscle Fiber Recruitment: Low-load exercises with BFRT activate high-threshold motor units, enhancing the training effect (12).

Metabolic stress by occluding venous out-flow whilst sustaining arterial in-flow during the muscle training can leads to a hypoxic environment and accumulation of anaerobic metabolites (increased lactate accumulation in the muscles) (13).

This physiological state triggers a series of metabolic reactions, including the release of growth hormones, which aid in promoting muscle growth factors. Additionally, BFRT restricts blood flow and reduces oxygen supply to the muscles, resulting in increased accumulation of metabolites such as lactate, which stimulates the neuromuscular system and enhances mechanical tension in the muscles, leading to increased muscle strength and volume at lower loads (14). As a result, low-intensity exercises such as ankle dorsiflexion, plantar flexion, lateral movements (duration: 15-20 minutes per session, and frequency: 3-4 times weekly (9, 15) can cause muscle hypertrophy through endocrine and intramuscular mechanisms (16).

It has been shown that combining BFRT with low-intensity resistance training (RT) can achieve similar results to high-intensity resistance training (17), and so due to its characteristics of low intensity and high stimulation, BFRT solves the problem of patients' inability to bear heavy loads by their limbs or joints.

Result

Evidence suggests that the BFRT can be used as a new method in the treatment and rehabilitation of individuals with AS. Numerous studies since 2020 have examined the role of BFRT in recovery from AS. A systematic review and meta-analysis showed that patients undergoing BFRT had a 30% increase in strength, decreased pain and swelling scores, and increased ankle ROM compared to control groups participating in traditional rehabilitation methods (18).

Discussion

In a study conducted by Burkhardt *et al.* (19) they found that individuals with Chronic Ankle Instability (CAI) showed increased activation of the vastus lateralis and soleus when using BFRT for dynamic balance exercises, but BFRT had no effect on the activation of the tibialis anterior (TA) and peroneus longus (PL). However, subsequent studies have proved that when combined with BFRT, resistance valgus and dorsal exercise increased the activation degree of PL and TA in individuals with AS. Therefore, there is controversy about the effect of BFRT on the muscle activation of TA and PL in individuals with CAI.

In a clinical trial, Shen Liu *et al.* (20) showed that the routine rehabilitation in combination of BFRT group significantly increased TA activity in dorsiflexion after a 4-week rehabilitation intervention, and the improvement was better than that in the routine group, which is consistent with the main effect of BFRT, namely better muscle activation compared with traditional resistance exercise. In individual with CAI, increasing TA activation during exercise is a coping strategy that can help individuals with CAI regain normal gait. They also examined the static and dynamic balance ability of individuals with CAI in their study and found that, although the balance ability improved more in the routine rehabilitation in combination of BFRT group, the comparison between groups after the intervention was not statistically significant. It suggests that BFRT does not enhance the balance improvement effect of conventional rehabilitation training (20). Another result of this study was that the recurrence probability of pain in the routine rehabilitation in combination of BFRT group was significantly lower than that in the routine rehabilitation group within one year after intervention, indicating that BFRT could not only improve the degree of pain immediately after intervention, but also have long-term effects. Also, previous studies have shown that BFRT can improve short-term pain in patients with anterior fork surgery and knee joints after intervention (10, 21, and 22). The integration of BFRT into rehabilitation programs offers key benefits such as: enhanced recovery rates due to improved muscle conditioning, low impact exercise which reduce strain on the injured ligaments while still promoting strength gains, and increased motivation which can boost patient morale and adherence to rehabilitation (23, 24). Before implementing BFRT, regular assessments are critical and so, physiotherapists should assess injury severity to classify the ankle sprain using the grading system, and also determine suitability for BFRT to exclude any contraindications such as vascular disorders or severe swelling (25).

Conclusion:

Research has shown that utilizing BFRTcan lead to significant improvements in recovery rates, strength gains, and overall patient satisfaction, and so it can be used as a relatively new and effective technique alongside traditional rehabilitation techniques to improve AS recovery. Further research and the development of standardized protocols will help to clarify the specific role of BFRT in enhancing rehabilitation outcomes. This will ensure that patients receive the best possible care and that physiotherapists can confidently incorporate BFRT into their treatment plans.

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All authors have contributed equally to the preparation of this article.

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