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The Utilization of Blood Flow Restriction in the Rehabilitation of a Professional Baseball Pitcher Status Post Subscapularis Strain: A Case Report

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The Utilization of Blood Flow Restriction in the Rehabilitation of a Professional Baseball Pitcher Status Post Subscapularis Strain: A Case Report

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Abstract

Background: Rotator cuff injuries are among the most common types of injuries in professional baseball and account for the greatest amount of time missed from play. Blood flow restriction (BFR) therapy provides the opportunity to initiate hypertrophy and strength gains early in rehabilitation while minimizing unnecessary stress on healing tissues. BFR training aims to expedite both the rehabilitation process and return to play. However, this remains a relatively new intervention that is not well known to many physical therapists. Thus, the purpose of this case report is to highlight a patient who had a positive outcome using BFR during rehabilitation and to discuss the available research on this intervention. **Case Description:** The report follows a 21-year-old professional baseball pitcher who underwent BFR therapy as part of his treatment following a subscapularis strain. **Outcome Measures:** Following rehabilitation, the athlete's shoulder strength and range of motion were found to be greater than 96% of the uninvolved limb. The athlete was discharged home with an offseason strength and interval throwing program. **Discussion:** This case study examines the current evidence on the topic of BFR training and demonstrates the safe use of the intervention in a professional baseball setting.

Keywords: Shoulder; musculoskeletal pain; athlete; baseball; subscapularis; sports medicine; orthopedics; physical therapy; rehabilitation

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Background

Rotator cuff strains are the 2nd most common injury in all of professional baseball. These injuries are most significant in regards to time missed from play. Furthermore, pitchers are the most commonly injured position, accounting for approximately 39% of all injuries to minor and major league baseball players [2]. The goal of rehabilitation with any injury in professional athletics is to expedite the return to sport while maximizing performance. Performing low-intensity exercise while under blood flow restriction (BFR) is a possible intervention that may assist in returning injured athletes to their prior level of performance.

Professional athletes undergoing rehabilitation for an injury are limited in the amount of forces the injured tissues may experience. These stresses must be monitored in order to prevent further injury or decline in function. However, the American College of Sports Medicine states loads must be between 70-100% of an individual's one repetition maximum (1RM) in order to induce hypertrophy and usually takes around 6 weeks to show the increase in muscular cross sectional area [1]. While these loads are too excessive for the acute phases of rehabilitation, BFR training may provide an alternative treatment with similar hypertrophy effects. BFR training utilizes pressure cuffs at the most proximal extremity location in order to partially restrict venous return from the distal muscles while allowing full arterial supply [8]. The use of BFR while training at 15-30% 1RM has been shown to induce similar muscular hypertrophy and strength gains as higher intensity training [10,20].

BFR training may provide an alternative to high intensity training during the acute phases of rehabilitation. The efficacy of the use of BFR to produce hypertrophy and strength gains has been highly studied in untrained populations. However, the evidence is relatively limited for using BFR during a rehabilitative process of highly trained professional athletes. For example, a 2016 review on the application of BFR with an athletic population resulted in just 11 studies [16], whereas, a 2017 systematic review included 20 relevant studies on the application of BFR in a population with musculoskeletal conditions [6]. Thirteen of these 20 articles emphasized the use of BFR in older adults at risk of sarcopenia. It is clear that evidence is lacking for the utilization of BFR training on athletes with musculoskeletal conditions. The purpose of this case report is to evaluate the current literature on BFR training and provide an example of its use in the rehabilitation of a professional baseball pitcher.

Case Description

History

The athlete was a 21-year old right-handed professional baseball pitcher who reported to the affiliate athletic trainer with pain in his anterior shoulder from the late cocking phase through his release point while pitching. He first noticed the pain two weeks prior during a pitching performance, but continued to throw without seeking assistance. He stated the pain increased with baseball activities and decreased with rest. The athlete denied any clicking, popping, or instability. Of note, there were no notable findings in the athlete's pre-season physical.

Physician Examination and Evaluation

The athletic trainer completed a full evaluation on the day he was approached by the athlete. The evaluation found pain with active shoulder internal rotation and passive shoulder external rotation. Manual muscle testing for subscapularis strength was unable to be completed due to excessive pain. All other manual muscle tests for strength revealed no major deficits. The medical staff determined magnetic resonance imaging (MRI) would be beneficial to further evaluate and determine the source of pain, and was scheduled for the following day.

The team orthopedic physician evaluated the athlete and reviewed the MRI results 5 days after the initial encounter. The physician reported normal shoulder joint alignment and component motion. Range of motion measurements revealed active right shoulder internal rotation of 39 degrees

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compared to 50 degrees on the left. All other range of motion values were within normal limits and comparable bilaterally. The physician also noted palpable tenderness along the subscapularis tendon.

Diagnosis

Results of the MRI indicated a 2-3 centimeter mass characteristic of a dense hematoma in the inferior subscapularis muscle along its inferior myotendinous junction in relation to a recent myotendinous strain. A chronic tear along the base mid-aspect of the posterior labrum and chronic detachment with cortical remodeling along the mid-anterior labrum was also noted. MRI of the elbow and spine revealed no significant findings. The team physician determined a subscapularis strain was the most likely source of pain and discussed the expected outcomes with the athlete. Non-operative conservative management was recommended to provide the greatest outcome and the athlete consented. The athlete arrived at the team's rehabilitation facility to initiate physical therapy 6 days after the initial encounter. The physical therapy initial evaluation did not indicate any other major findings.

Intervention

The concept behind BFR training, to appropriately stress muscle tissue physiologically while minimizing the mechanical stress placed on the same tissue, is the basis for rehabilitation of injured athletes. In order to properly perform BFR training, cardiopulmonary and vascular conditions, such as severe hypertension or peripheral vascular compromise, must be ruled out to decrease any possible adverse effects. These conditions were ruled out in both the athlete's preseason physical and the physician evaluation. Therefore, it was determined that the patient may benefit from blood flow restriction therapy in conjunction with conventional physical therapy in order to assist in the patient's return to prior performance.

The upper extremity exercises performed while using BFR are described in the table below. A Delfi Personalized Tourniquet System for Blood Flow Restriction was used to apply the BFR. This is the only commercially available, FDA-approved BFR device known due to its unique ability to individualize pressure. It utilizes a tourniquet cuff, set on top of a limb protection sleeve for skin integrity, that is placed at the most proximal location of the limb. For our exercises, the tourniquet was placed as close to the axilla as possible. The personalized tourniquet system automatically calculated the athlete's individual limb occlusion pressure (LOP), the lowest pressure that stops the arterial flow of blood to the distal limb, while the athlete rested in a supine position. Current literature reports the recommended pressure for applying BFR training of the upper extremity is 50% of the LOP. This has been shown to produce the greatest effects with minimal vascular risk [17]. Therefore, 50% of the individual's LOP was utilized for all of our BFR exercises. Due to this value varying throughout time, the LOP and thus 50% of the LOP were calculated by the tourniquet system before each type of exercise within a single session and between sessions.

Evidence shows that performing BFR exercise at a frequency of 3 days per week is more effective than greater frequencies [9]. Therefore, all BFR exercises described below were performed 3 days each week. Within each session, the BFR exercises were performed in 4 sets consisting of 30, 15, 15, and 15 repetitions. Research is inconclusive in the optimal volume for BFR exercise, but the 30, 15, 15, 15 protocol is widely used throughout the literature and has been thought to allow for the largest accumulation of metabolites [16]. The target tempo for each exercise repetition was 1-second concentric and 1-second eccentric. A 30 second rest was allowed between each set, while maintaining the tourniquet pressure. This rest cycle has been indicated to have the greatest effect size compared to other rest periods [9]. Each exercise began with only the load of the limb weight and was progressed throughout the program as tolerated. Overall, this protocol results in a total of 75 repetitions over about 4 minutes for each BFR exercise. The pressure was released after performing 4 sets of an exercise and the athlete was allowed to rest. The LOP was then re-calculated and pressure was applied for the next BFR exercise.

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Intervention Timeline

Table 1. Brief overview of 18-week rehabilitation progression

Weeks 1-2	▪ Focus on isometric rotator cuff strengthening and scapular strengthening ▪ BFR AROM wrist flexion, extension, radial deviation, ulnar deviation, pronation, supination
Weeks 3-4	▪ Rotator cuff and scapular strengthening expanded to pain-free ROM ▪ 2# dumbbell added to BFR wrist AROM
Weeks 5-6	▪ Added BFR supine manual perturbations at 90 degrees shoulder flexion ▪ Manual resistance added to BFR wrist exercises
Weeks 7-8	▪ BFR PNF D1/D2 patterns added ▪ Initiated single and double upper extremity plyometric exercises
Weeks 9-10	▪ Manual resistance added to BFR PNF D1/D2 ▪ Initiated interval throwing program (ITP) 2x/week
Weeks 11-12	▪ Upper extremity exercise added to weight room routine with assistance of strength and conditioning coach ▪ Increased ITP to 3x/week
Weeks 13-14	▪ Continue all BFR exercises ▪ Incorporated weighted baseballs into ITP ▪ Began pitching on flat ground
Weeks 15-18	▪ 1st bullpen session ▪ Continue ITP with bullpen sessions ▪ Athlete discharged home with offseason strength and throwing program

Outcome Assessments

Of note, the baseball season had concluded during the athlete's rehabilitation process. Prior to being sent home with an offseason strength and throwing program, the athlete's strength and range of motion were tested. The athlete's internal and external shoulder rotation strength were tested isometrically at 90 degrees of shoulder abduction. A Kiio force sensor, which has been shown to have better validity and reliability than an isokinetic dynamometer, was used to measure strength [5]. The athlete's shoulder internal rotation strength was 101.3% compared to the unaffected limb and shoulder external rotation strength was 96.3% compared to the unaffected limb. Grip strength was equal bilaterally. Range of motion in the right shoulder was measured at 49 degrees of internal rotation and 100 degrees of external rotation. This was equivalent when compared to the contralateral side. The athlete had performed successful upper extremity plyometric exercises and participated in six bullpen sessions with no complaints or increase in symptoms.

Discussion

While the positive effects of BFR training are understood, the mechanism behind its effectiveness is still unclear. There are multiple proposed theories, with large amounts of literature that attempt to explain each. The most accepted is called the metabolite theory, which credits the tourniquet pressure with limiting the oxygen supply to the muscle cells. This is thought to cause a shift from aerobic to anaerobic metabolism, imitating high load training, and thus resulting in the recruitment of more fast-twitch muscle fibers. The production of lactate is an indicator of this transition to anaerobic metabolism and evidence supports that lactate levels rise with BFR training [14,19]. In fact, the lactate

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levels with BFR training rise to the same extent as they do with high intensity training. Increased lactate has been shown to inhibit surrounding contracting fibers, forcing the recruitment of additional motor units in order to maintain force production [13,19,21]. Increased lactate levels also cause the pituitary gland to release large amounts of growth hormone, resulting in production of insulin like growth factor. There is evidence that hypertrophy has been linked to increased release of insulin like growth factor [4,12]. The use of BFR therapy has shown immediate increased hemodynamic measures of growth hormone and insulin like growth factor [18,19]. One study demonstrated a similar decrease in myostatin, thus increased myogenesis, after an 8 week BFR training protocol, as seen in high intensity resistance training [7]. Research has also indicated that protein synthesis increases 46% three hours after BFR training as compared to work-matched controls [3]. While the exact mechanisms are not known, each of these factors may contribute to the benefits of BFR training, consistent with improvements demonstrated in this case study.

In order to ensure the dose of BFR training was optimal, a 1RM should have been obtained before the first treatment session. Using the 1RM, the exercise load could have been monitored and adjusted to be in the optimal 15-30% of 1RM range that has been shown to provide maximum benefit. However, 1RM testing was not feasible for this case due to the potential of further injury and pain. While normal rehabilitation progression and clinical judgement were used to select the dose of BFR training in this case, more accurate methods could have been implemented to ensure the BFR training dose was in the 15-30% of 1RM range. The Rating of Perceived Exertion scale has been proven to be correlated with maximum volitional contraction [11]. This method could have been applied to improve accuracy in determining if the exercise intensity prescription was optimal.

This athlete underwent physical therapy rehabilitation 7 days per week, for approximately 2 hours each day. Therefore, 3 days included BFR training with standard rehabilitation and 4 days included standard rehabilitation without BFR training. The BFR training is extremely intense and is occasionally associated with extreme exhaustion. The athlete often reported BFR training as difficult and intense. While the exercises are performed with low loads, the athlete’s subjective responses were similar to that of high intensity resistance training. The athlete did report occasional soreness on days following BFR training. The highly-trained nature of this athlete and the intense rehabilitation protocol must be considered when examining this athlete’s outcomes.

This case report provides an example of the successful utilization of BFR therapy in the rehabilitation of a professional baseball pitcher who suffered a subscapularis strain. The athlete obtained full range of motion and very close to full strength at the completion of rehabilitation. As a case report, we cannot determine if the athlete would have progressed the same without the addition of BFR therapy. However, the positive outcomes in this athlete, without any adverse responses, suggest BFR therapy may be beneficial to use in conjunction with traditional physical therapy in this patient population and setting. Some individuals may not qualify due to cardiovascular conditions or some may not tolerate the intensity of BFR therapy. However, the low loads associated with BFR training may be adequate to induce hypertrophic and strength gains, yet minimize mechanical stress to injured tissues. While we cannot generalize the results of this case, and it is not reasonable to assume the outcomes seen in this athlete would be seen in all patients of this type, it may be appropriate to consider BFR in other highly athletic populations. In conclusion, this case study suggests that BFR therapy may be beneficial in a young, healthy population to induce hypertrophy in the early phases of rehabilitation following injury.

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