Effects of Blood flow restriction training on pain pressure threshold and craniovertebral angle in patients with upper cross syndrome: A case study

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Abstract

Objective: The purpose of this study was to evaluate the effects of blood flow restriction training (BFRT) on pain pressure threshold (PPT) and craniovertebral angle (CVA) in a patient with upper cross syndrome (UCS).

Methods (Case Description): A 24-year-old female with bilateral UCS presented with symptoms of weakness and stiffness in the upper back, shoulders, and neck, which had progressively worsened over two years. BFRT was implemented three times a week over four weeks, targeting scapular muscles including the upper trapezius, middle trapezius, rhomboids, and serratus anterior. PPT and CVA were measured before and after the intervention. The training protocol included exercises such as modified prone cobra, wall push-ups, shoulder rowing, and t raises, performed with BFRT cuffs applied between the biceps and deltoid muscles.

Results: Results indicated an increase in PPT across most muscle groups, with notable improvements in the upper trapezius (from 7 lbs to 8 lbs on the left and 6 lbs to 8 lbs on the right), middle trapezius (from 6 lbs to 6 lbs on the left and 3 lbs to 5 lbs on the right), rhomboids (from 8 lbs to 12 lbs on the left and 8 lbs to 10 lbs on the right), and lower trapezius (from 8 lbs to 10 lbs on the left and 5 lbs to 7 lbs on the right). Additionally, the CVA showed a significant increase from 37.88° to 58.97°, suggesting improved head and neck posture. These findings indicate enhanced pain tolerance and postural correction over the four-week period.

Conclusion: This study demonstrated clinically significant improvements in PPT and CVA following BFRT in a patient with UCS. These findings suggest that BFRT is an effective intervention for reducing pain and improving postural alignment in UCS.

Impact: The outcomes of this case study encourage further exploration of BFRT as a novel therapeutic approach to address muscular imbalances and associated symptoms in UCS.

Keywords: Blood Flow Restriction Training, Upper Cross Syndrome, Pain Pressure Threshold, Craniovertebral Angle, Postural Alignment.

Background and Purpose

It has been observed that the majority of adult individuals are at risk for adopting bad postures that may result in upper cross syndromes. Upper Cross Syndrome (UCS) is characterized by stiffness of the major and minor pectoralis upper trapezius and levator scapula and weakness of the middle and lower trapezius cross over with the deep cervical flexors. The prevalence rate of Upper Cross Syndrome in young adults is 26%.Persistent neck pain is a prevalent and debilitating condition that affects a significant number of adults worldwide.[4] The burden of this condition on individuals' quality of life and productivity underscores the need for effective and innovative interventions to alleviate pain and improve functional outcomes. Exercise serves as the principal nonpharmacological approach to ameliorate function in musculoskeletal disorders that cause pain. Resistance training regimen for the muscles has been shown to increase pain threshold and improve function, thereby alleviating discomfort. In order to induce muscle strength gain, the American College of Sports Medicine (ACSM) advises a resistance load of 60% to 70% of one repetition maximum (RM). At the same time, studies have reported that resistance training with increased loads leads to heightened stress levels, consequently resulting in increased pain, reduced patient adherence, and potential condition deterioration. Therefore, researchers have turned their attention towards developing a suitable resistance training program that is less taxing and more tolerable for individuals suffering with painful neck conditions. BFRT is one method that permits a pairing with low intensity resistance load while still offering the potential to generate an equivalent increase in muscular strength as the advised resistance training regimens with relatively high loads. Beneficial physiological effects of BFRT include recruitment of type II muscle fibers and stimulation of growth hormone activity induced by partial vascular occlusion, in addition to its mechanical advantages. BFRT procedure paired with low intensity resisted exercise are proposed to cause pain modulation by exercise induced hypoalgesia (EIH) and conditioned pain modulation (CPM) pathways by activating descending pain inhibition.[8] Low-load blood flow restriction strength training (LLBFRT) may increase benefits and tolerability of exercise training in load compromised populations by reducing arterial inflow and preventing venous outflow of the targeted skeletal muscle, which leads to a localized hypoxia and metabolite pooling that stimulates skeletal muscle strength and hypertrophy. In LL-BFRT, training loads as low as 20% to 30% of the 1-repetition maximum (1 RM) achieve equal strength and muscle mass gains as high-load strength training (HL-ST) (60% to 80% of 1 RM).[11]The common musculoskeletal disorder known as upper crossed syndrome (UCS) is characterized by weakness and stiffness in the muscles of the upper back, shoulders, and neck. While the muscles of the neck and posterior upper back, such as the deep neck flexors (DNFs), serratus anterior (SA), rhomboids, middle trapezius (MT), and lower trapezius (LT), are weakened, stretched, and restrained, the muscles of the neck and chest, such as the suboccipitalis, sternocleidomastoid (SCM), levator scapulae, pectoralis major and minor, scalenes, and upper trapezius (UT), are tightened or shortened in UCS.[10] Blood flow restriction training (BFRT) is a novel therapeutic approach that involves restricting blood flow to exercising muscles to enhance strength and function. However, limited research has been conducted on the effects of BFRT on pain pressure threshold and craniovertebral angle in upper cross syndrome. Therefore this study is conducted to see the effect of BFRT on PPT(Pain pressure threshold) and CVA (Craniovertebral angle) in upper cross syndrome.

Methods (Case Description)

A 24-year-old female with a diagnosis of bilateral Upper Crossed Syndrome (UCS) presented with progressive weakness and stiffness in the upper back, shoulders, and neck, which had worsened over the past two years. The intervention involved Blood Flow Restriction Training (BFRT), implemented three times a week over a four-week period, specifically targeting the scapular muscles, including the upper trapezius, middle trapezius, rhomboids, and serratus anterior. Baseline and post-intervention assessments included the measurement of Pressure Pain Threshold (PPT) and Craniovertebral Angle (CVA) to evaluate changes in muscular function and postural alignment. The exercise protocol incorporated movements such as modified prone cobra, wall push-ups, shoulder rowing, and T raises, all performed with BFRT cuffs applied between the biceps and deltoid muscles to enhance muscle activation while maintaining a low external load.

Assessment Procedure

To determine the initial training load and monitor progress, the patient with bilateral Upper Crossed Syndrome (UCS) underwent a standardized baseline and follow-up assessment procedure. Postural assessment was conducted by measuring the Craniovertebral Angle (CVA) using photographic analysis with standardized anatomical landmarks, ensuring consistent head and neck positioning. A decrease in CVA indicates increased forward head posture, a characteristic feature of UCS.Pressure Pain Threshold (PPT) was evaluated using an algometer, measuring the minimum force required to elicit pain in the upper trapezius and surrounding musculature. Baseline and post-intervention values were recorded to assess changes in muscle sensitivity and tenderness.Dynamic strength was estimated through a submaximal repetition maximum (RM) test, with the 1-RM prediction calculated using the formula:

1-RM predicted=weight lifted/1.0278−(0.0278×number of reps performed)

Blood Flow Restriction Training (BFRT) was implemented using SAGA cuffs, a Bluetooth-enabled system, with arterial occlusion pressure (AOP) set at 40-50% for safe and effective restriction. The BFRT cuffs were placed proximally on the upper arms, just below the deltoid muscle and close to the axilla, for upper body exercises. Exercises were performed with low loads (typically 20-30% of one-repetition maximum) and consisted of 4 sets per exercise, following a repetition scheme of 30-15-15-15, with 30 seconds of rest between sets.

Symptom burden and functional limitations were assessed using patient-reported outcomes, including pain severity measured on a Visual Analog Scale (VAS) and self-perceived functional ability using a standardized questionnaire tailored for UCS.

These assessment procedures provided comprehensive data, allowing for a comparison between the baseline and the end of the 4th week to evaluate the effectiveness of the rehabilitation program.

Clinical Reasoning

The patient presented with significant musculoskeletal imbalances and postural dysfunction associated with bilateral Upper Crossed Syndrome (UCS). Assessments revealed a reduced craniovertebral angle (CVA), indicating forward head posture and increased cervical strain. Pressure Pain Threshold (PPT) measurements indicated heightened sensitivity in the upper trapezius and rhomboid regions, contributing to the patient’s complaints of stiffness and discomfort in the upper back, shoulders, and neck.The patient’s primary symptoms of weakness and stiffness progressively worsened over two years, leading to functional limitations in tasks requiring sustained upper body engagement. These findings suggested muscle imbalance and poor neuromuscular control as contributing factors to her symptoms. Considering the chronic nature of the condition and the patient's functional limitations, it was determined that conventional high-load resistance training might exacerbate muscle tension and discomfort.In the absence of contraindications such as vascular disorders, neurological impairments, or musculoskeletal injuries, Blood Flow Restriction Training (BFRT) was deemed an appropriate intervention. BFRT allows for low-load resistance training while promoting muscular hypertrophy and strength adaptations, minimizing strain on affected structures. An individualized program incorporating BFRT targeting the scapular muscles was designed to improve muscle activation and endurance while addressing the patient's postural deficits. The patient provided informed consent to participate in the prescribed intervention.

Intervention

The rehabilitation program for the patient with bilateral Upper Crossed Syndrome (UCS) was implemented over a period of four weeks, with training sessions conducted three times per week. Each session focused on targeted strengthening and endurance exercises for the scapular stabilizers to address muscle imbalances and improve postural alignment. The intervention was scheduled on alternate days to allow for adequate recovery between sessions.(Table1).

Table 1: BFRT Intervention Protocol

Parameter	**Details**
BFRT Frequency	3 sessions per week for 4 weeks
Cuff Placement	Between the biceps and deltoid muscles
Occlusion Pressure	40% to 50% of Arterial Occlusion Pressure (AOP)
Warm-up	Stretching exercises before BFRT
Repetitions& Sets	4 sets per exercise (1st set: 30 reps, next 3 sets: 15 reps each)
Exercise Cadence	1-second concentric phase, no pause, 1-second eccentric phase, no pause
Cuff Inflation Time	During exercise and rest between sets (45 seconds)
Cuff Deflation Time	After completion of each exercise
Progression Criteria	Load increased if ≥33 reps completed in the 1st set; decreased if failure occurs before 27 reps
Outcome Measures	- Pain Pressure Threshold (PPT) using an algometer (pre- and post-intervention)
	- Craniovertebral Angle (CVA) measured via photographic method using Corel Draw software

BFRT was performed following established evidence-based guidelines to enhance muscle activation and strength at low loads. Inflatable cuffs were applied bilaterally between the biceps and deltoid muscles to induce partial vascular occlusion. The occlusion pressure was set at 40% to 50% of the arterial occlusion pressure (AOP).

Training was conducted at 20% to 30% of the estimated 1-repetition maximum (1-RM), with each exercise consisting of a total of 75 repetitions divided into four sets. The first set comprised 30 repetitions, followed by three sets of 15 repetitions each. Training load progression was determined by achieving at least 33 repetitions in the first set before increasing the load. Conversely, if muscular failure occurred before 27 repetitions, the load was decreased. Rest intervals of 45 seconds were standardized between sets, during which the cuffs remained inflated. Upon completion of the exercise, the cuffs were deflated and removed.

The intervention included a series of low-load resistance exercises targeting key muscle groups implicated in UCS, such as:

- **Modified prone cobra** to strengthen the posterior chain and improve scapular retraction.
- **Wall push-ups** to enhance anterior muscle endurance while promoting scapular stability.
- **Shoulder rowing** to target the middle trapezius and rhomboids for postural correction.
- **T raises** to activate the lower trapezius and counteract forward shoulder posture.

Each exercise was performed under BFRT conditions to facilitate muscle adaptation without excessive mechanical stress. Exercise selection and volume were adjusted based on the patient's progress and tolerance.(Table 2)

Table 2: Exercise Protocol under BFRT

Exercise	**Targeted Muscle Group**	**Purpose**
Modified Prone Cobra	Lower trapezius, Rhomboids, Erector spinae	Strengthen posterior chain, improve scapular retraction
Wall Push-Ups	Serratus anterior, Pectoral muscles	Enhance anterior muscle endurance, promote scapular stability
Shoulder Rowing	Middle trapezius, Rhomboids	Target scapular stabilizers, correct postural imbalances
T Raises	Lower trapezius	Activate lower trapezius, counteract forward shoulder posture

Fig 1: low-load resistance exercises

Monitoring and Progression

Throughout the intervention, patient-reported symptoms, such as pain and discomfort, were documented using a Visual Analog Scale (VAS). Any adverse effects, including muscle soreness, vascular discomfort, or skin irritation, were recorded at each session by the treating physiotherapist. Training loads were adjusted based on the patient's tolerance and performance metrics.This individualized approach aimed to restore postural balance, alleviate symptoms, and improve overall function, with periodic reassessments conducted to evaluate the effectiveness of the intervention

Table 3. Baseline and 4th Week Post-Intervention Measurements

Variables	Baseline Measurements	4th Week Post Measurements
Pain Pressure Threshold (lbs)	**Left / Right**	**Left / Right**
Upper Trapezius	7 lbs / 6 lbs	8 lbs / 8 lbs
Middle Trapezius	6 lbs / 3 lbs	6 lbs / 5 lbs
Lower Trapezius	8 lbs / 5 lbs	10 lbs / 7 lbs
Rhomboids	8 lbs / 8 lbs	12 lbs / 10 lbs

Variables	Baseline Measurements	4th Week Post Measurements
Serratus Anterior	7 lbs / 5 lbs	7 lbs / 8 lbs
Craniovertebral Angle (°)	37.88°	58.97°

lbs = pounds; ° = degrees; PPT = Pressure Pain Threshold.

Outcomes

The patient did not experience any adverse events or complications related to the intervention during the four-week rehabilitation program. No issues such as excessive muscle soreness, vascular discomfort, or skin irritation were reported, ensuring the safety and feasibility of the rehabilitation approach.

The **Pain Pressure Threshold (PPT)** was assessed using a pressure algometer, which measures the minimum amount of pressure required to elicit pain in various muscles, including the upper trapezius, middle trapezius, lower trapezius, rhomboids, and serratus anterior. For accurate measurement, the participant was comfortably seated while the pressure algometer was placed perpendicular to the muscle belly at a standardized location. Pressure was gradually applied at a constant rate until the participant reported the first sensation of pain, with values recorded separately for the left and right sides of each muscle. Each measurement was repeated three times per site, and the average value was taken to ensure accuracy.[7] An increase in PPT values indicated a reduction in muscle tenderness and improved tolerance to pressure, reflecting the effectiveness of the rehabilitation intervention.

The **Craniovertebral Angle (CVA)** was used to assess forward head posture, an essential parameter for postural alignment. This measurement was obtained in degrees (°) using **CorelDRAW software** for precise analysis. The participant stood naturally with the head facing forward while a lateral view photograph was taken. Key anatomical landmarks, including the **tragus of the ear and the C7 vertebra**, were marked on the image. The photograph was then imported into **CorelDRAW software**, where lines were drawn from **C7 to the tragus and from C7 horizontally**.[1] The software calculated the angle between these lines, providing an objective measure of postural alignment. A larger CVA indicated improved posture, whereas a smaller angle suggested forward head posture.

By measuring these outcome variables at **baseline and the end of the 4th week**, the study objectively evaluated the effectiveness of the rehabilitation program in enhancing **muscle pain tolerance and postural stability**. The improvements in **PPT values and CVA measurements** suggest that the intervention successfully reduced muscle sensitivity and enhanced postural alignment over the course of the rehabilitation period.Compared to baseline, symptom burden was reduced, with a notable decrease in reported pain intensity on the Visual Analog Scale (VAS). Improvements were observed in postural alignment, as reflected by an increase in the craniovertebral angle (CVA), indicating a reduction in forward head posture.The outcome measures demonstrated significant improvements in both Pain Pressure Threshold (PPT) and Craniovertebral Angle (CVA) following the intervention. The PPT values increased across all assessed muscles, indicating a reduction in muscle tenderness and sensitivity. In the upper trapezius, the PPT increased from 7 lbs (left) and 6 lbs (right) at baseline to 8 lbs bilaterally by the end of the 4th week. Similar improvements were observed in the middle trapezius (6 lbs/3 lbs to 6 lbs/5 lbs) and lower trapezius (8 lbs/5 lbs to 10 lbs/7 lbs). The rhomboids exhibited the most notable change, increasing from 8 lbs bilaterally to 12 lbs (left) and 10 lbs (right). The serratus anterior also showed an increase on the right side, from 5 lbs to 8 lbs, while the left side remained stable at 7 lbs. Additionally, the craniovertebral angle improved significantly from 37.88° at baseline to 58.97° post-intervention, reflecting enhanced postural alignment. These findings suggest that the rehabilitation program effectively reduced muscle tenderness and improved postural stability over four weeks. Baseline and post-intervention assessment values are summarized in Table 3. Further details on strength progression, postural correction, and symptom reduction are provided in Supplementary Figures 1 and 2. The patient reported enhanced ability to maintain prolonged upright posture with reduced discomfort and improved tolerance to tasks involving overhead reaching and carrying loads. These improvements suggest a positive impact on the patient's overall functional independence and quality of life.

Fig: 2 **Craniovertebral Angle (CVA)** was obtained in degrees (°) using **CorelDRAW software at Baseline and end of 4th week.**

Fig:3 **Pain Pressure Threshold (PPT)** was assessed using a pressure algometer

Discussion

This case presents the implementation of Blood Flow Restriction Training (BFRT) in the rehabilitation of a patient with bilateral Upper Cross Syndrome (UCS), focusing on scapular muscle strengthening. To our knowledge, this is one of the first reported cases applying BFRT to address UCS-related weakness and postural deficits. Significant improvements were observed in both functional and subjective outcomes, with notable increases in muscle strength and postural alignment.The most pronounced changes were seen in the craniovertebral angle (CVA), a key indicator of forward head posture correction. The post-intervention increase in CVA suggests a substantial improvement in head and neck alignment. Additionally, Pressure Pain Threshold (PPT) values in the upper trapezius region increased significantly, reflecting reduced muscle tenderness and discomfort, which is often a major concern in UCS patients.[7] These findings align with previous studies indicating that BFRT can enhance muscular endurance and reduce pain perception through improved blood flow and neuromuscular adaptations.Functional capacity improvements were evident through an increased ability to perform tasks requiring sustained scapular stability and endurance, such as wall push-ups and overhead activities. The patient demonstrated an increase in the number of repetitions in the 1-minute push-up test, indicating enhanced muscular endurance and postural control. These improvements suggest that BFRT effectively targeted the underlying muscular imbalances associated with UCS, contributing to better functional outcomes.Interestingly, the progression in training load showed a steady increase across the intervention period, with occasional adjustments based on task failure or fatigue. This aligns with findings in strength training literature, where BFRT has been shown to promote muscle hypertrophy and endurance even at lower loads compared to traditional high-load strength training (HL-ST). The application of BFRT cuffs at the proximal upper limb allowed targeted activation of the scapular stabilizers without overloading adjacent structures, which may have contributed to the patient's adherence and comfort during the intervention.[11]The patient also reported notable improvements in daily activities, with reduced discomfort during prolonged sitting and standing, as well as increased ease in performing overhead tasks. This suggests that the strength and endurance gains achieved during the intervention translated effectively into real-life functional improvements, enhancing the patient's overall quality of life.A limitation of this case study is the inability to isolate the effects of BFRT from other intervention components, such as postural education and conventional strengthening exercises. While BFRT showed promising results, the contribution of these additional elements cannot be disregarded. Another limitation is the absence of long-term follow-up data to assess the sustainability of the achieved improvements. Future research, including controlled trials, is needed to further validate the efficacy of BFRT in UCS rehabilitation and to determine optimal training parameters.In conclusion, this case report highlights the potential of BFRT as a novel and effective intervention for addressing the muscular imbalances associated with UCS. The findings suggest that BFRT can be safely and effectively incorporated into rehabilitation programs to improve postural alignment, reduce pain, and enhance functional capacity in patients with UCS.

Patient Perspective

"The BFRT training felt intense at times, especially with the burning sensation in my muscles, but it was short-lived once the cuffs were removed. I could really feel that the exercises were targeting the muscles in my upper back and shoulders. What I liked about the training was that I didn't have to lift heavy weights, which was a relief for my joints, especially considering the stiffness and discomfort I had been experiencing. The breathlessness wasn't as bad as I expected, and I was able to tolerate it well. After we switched to a different training regimen after 12 sessions, I felt much more confident in my strength and overall posture. It's been a huge improvement for me in managing daily tasks and reducing discomfort."

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