

Effectiveness of Blackburn exercise on pain, strength of rotator cuff muscles and disability in shoulder impingement syndrome among water polo player: An experimental study

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Abstract

Background: Shoulder impingement syndrome (SIS) is a frequent overuse condition that affects water polo players because of the repetitive overhead throwing, swimming, and defensive actions they perform. This repeated stress on the shoulder can lead to discomfort, weakening of the rotator cuff muscles, and issues with daily functioning, which can harm their performance in sports. Blackburn exercises are a set of exercises designed to stabilize the shoulder blade and strengthen the rotator cuff muscles, with the aim of improving shoulder mechanics. However, there is not much research on how effective these exercises are for water polo players specifically.

Objective: The goal of this study was to assess how effective Blackburn exercises are in reducing pain, improving the strength of the rotator cuff muscles, and enhancing shoulder function in water polo players who have shoulder impingement syndrome.

Methods: This study used a pre-post experimental design and included 47 water polo players aged between 17 and 35 years who had been diagnosed with shoulder impingement syndrome based on positive results from the Neer and Hawkins-Kennedy tests. Participants took part in a supervised Blackburn exercise program that lasted six weeks. Pain levels were measured using the Visual Analogue Scale (VAS), the strength of the rotator cuff muscles was assessed through Individual Muscle Testing (IMT), and shoulder function was evaluated using the Kerlan-Jobe Orthopaedic Clinic (KJOC) Shoulder and Elbow Score. The data was analyzed using SPSS version 23. To check if the data followed a normal distribution, the Shapiro-Wilk test was used, and paired t-tests were used to compare results before and after the intervention. A p-value less than 0.05 was considered statistically significant.

Results: All 47 participants completed the study. After the six-week intervention, there were significant improvements in all the measured outcomes. The average VAS scores dropped from 5.64 ± 0.90 to 1.70 ± 0.70 ($p < 0.0001$). There were also notable gains in the strength of the rotator cuff muscles, with the average IMT scores increasing from 2.44 to 4.48 for the infraspinatus, 2.14 to 4.32 for the supraspinatus, 2.56 to 4.52 for the teres minor, and 2.64 to 4.74 for the subscapularis (all $p < 0.0001$). Functional outcomes also showed significant improvement, with the KJOC scores rising from 71.22 ± 9.00 to 91.01 ± 4.32 ($p < 0.0001$).

Conclusion: A six-week program of Blackburn exercises led to a significant decrease in pain, an improvement in the strength of the rotator cuff muscles, and an enhancement in shoulder function for water polo players with shoulder impingement syndrome.

Keywords: Blackburn exercises, shoulder impingement syndrome, water polo, rotator cuff, shoulder rehabilitation, sports physiotherapy

Introduction

Water polo is a high-intensity aquatic team sport that includes swimming, throwing, rapid directional changes, and physical contact. The sport requires athletes to perform repetitive overhead movements while maintaining body stability through the eggbeater kick, placing considerable biomechanical stress on the shoulder complex. As a result, shoulder pain is the most frequently reported musculoskeletal complaint among competitive water polo players, with reported prevalence ranging from 38% to 80%. The repetitive overhead throwing motion, combined with high training volumes and physical contact, predisposes athletes to overuse injuries, particularly shoulder impingement syndrome (SIS).^[1-4]

Shoulder impingement syndrome is the most common causes of shoulder pain in overhead athletes and is characterized by compression of the rotator cuff tendons,

subacromial bursa, and other soft tissues within the subacromial space during arm elevation. Repetitive overhead activities performed in water polo, especially during the cocking and acceleration phases of throwing, increase superior migration of the humeral head and reduce the available subacromial space. These biomechanical alterations contribute to tendon irritation, inflammation, pain, muscle weakness, and progressive functional limitation if left untreated.^[3, 5]

The pathophysiology of shoulder impingement in water polo players is multifactorial. Repetitive throwing generates high rotational forces across the glenohumeral joint, while prolonged swimming sessions lead to muscular fatigue and altered scapular kinematics. Weakness of the rotator cuff muscles and scapular stabilizers, reduced neuromuscular control, posterior shoulder tightness, and scapular dyskinesis further impair normal shoulder biomechanics,

increasing the risk of subacromial impingement. These impairments not only affect athletic performance by reducing throwing velocity and accuracy but also increase the likelihood of recurrent shoulder injuries and prolonged absence from sport. [2, 4, 6]

Exercise-based rehabilitation remains the cornerstone of conservative management for shoulder impingement syndrome. Current rehabilitation programmes focus on restoring pain-free range of motion, improving rotator cuff strength, enhancing scapular stability, correcting movement dysfunction, and facilitating a gradual return to sport. Among the various rehabilitation approaches, exercises targeting the coordinated activation of the scapulothoracic and glenohumeral musculature have demonstrated promising outcomes in reducing pain and improving shoulder function in overhead athletes. [7, 8]

Blackburn exercises are a progressive series of prone shoulder exercises specifically designed to strengthen the rotator cuff and scapular stabilizing muscles, including the trapezius, rhomboids, serratus anterior, and posterior shoulder musculature. The six-position exercise programme promotes balanced activation of the scapulothoracic muscles while improving neuromuscular control, muscular endurance, and dynamic glenohumeral stability. By enhancing scapular upward rotation, posterior tilt, and external rotation during arm elevation, Blackburn exercises may reduce excessive superior translation of the humeral head, thereby decreasing mechanical compression within the subacromial space and alleviating symptoms of impingement syndrome. [8–10]

Previous studies have demonstrated the effectiveness of Blackburn exercises in reducing pain and improving shoulder function among individuals with subacromial impingement syndrome, scapular dyskinesis, rotator cuff dysfunction and other overhead athletic populations. However, most available evidence has been conducted among construction workers, school teachers, badminton players, and recreational athletes. Despite the high prevalence of shoulder injuries in water polo, there is a lack of research specifically checking the effectiveness of Blackburn exercises in competitive water polo players. Consequently, evidence supporting the application of this rehabilitation programme in this unique sporting population remains limited. [9–12]

Considering the substantial physical demands of water polo and the limited sport-specific evidence available, evaluating targeted rehabilitation interventions is clinically important. Effective rehabilitation strategies that reduce pain, restore rotator cuff muscle strength, and improve functional performance may facilitate an earlier and safer return to sport while reducing the risk of recurrent injury. Therefore, the present study aimed to investigate the effectiveness of a six-week Blackburn exercise programme on pain intensity, rotator cuff muscle strength, and functional disability among water polo players diagnosed with shoulder impingement syndrome.

Materials and Methods Study Design

An experimental pre–post intervention study was conducted over a period of six months to evaluate the effectiveness of Blackburn exercises on pain, rotator cuff muscle strength, and functional disability in water polo players with shoulder impingement syndrome.

Study Setting

The study was conducted among competitive water polo players recruited from sports clubs and training centres in and around Pune, Maharashtra, India.

Participants

A total of 47 water polo players aged 17–35 years were recruited using convenience sampling. Participants were screened clinically, and those meeting the eligibility criteria were enrolled after providing written informed consent.

Inclusion Criteria

- Male and female water polo players aged 17–35 years.
- Positive Neer Impingement Test and Hawkins–Kennedy Test.
- Shoulder pain interfering with training for at least one week.
- Minimum of three years of competitive water polo experience.
- Regular training at least three sessions per week.

Exclusion Criteria

- History of shoulder surgery.
- Previous shoulder fracture or dislocation.
- Cervical spine pathology.
- Visual Analogue Scale (VAS) score greater than 7.
- Physiotherapy treatment received within the previous three months.
- Participation in other overhead sports.

Outcome Measures

Assessments were performed before and after the six-week intervention using the following validated outcome measures:

- **Pain:** Visual Analogue Scale (VAS)
- **Rotator cuff muscle strength:** Individual Muscle Testing (IMT) for the supraspinatus, infraspinatus, teres minor, and subscapularis muscles.
- **Functional disability:** Kerlan–Jobe Orthopaedic Clinic (KJOC) Shoulder and Elbow Score.

Intervention

Participants underwent a supervised Blackburn exercise programme for six weeks. The intervention was performed three sessions per week and consisted of a standardized warm-up (5 minutes), Blackburn exercises (20 minutes), and cool-down stretching (5–7 minutes).

The Blackburn exercise programme comprised six prone exercises targeting the scapular stabilizers and rotator cuff musculature:

1. Prone horizontal abduction (neutral rotation)
2. Prone horizontal abduction (full external rotation)
3. Prone horizontal scaption (neutral rotation)
4. Prone horizontal scaption (full external rotation)
5. Prone horizontal external rotation
6. Prone horizontal extension

Each exercise was performed for three sets of ten repetitions with progressive isometric hold durations over the six-week period (5 seconds during weeks 1–2, 10 seconds during weeks 3–4, and 15 seconds during weeks 5–6).

Study Procedure

Baseline assessments of pain, rotator cuff muscle strength, and shoulder function were performed before commencement of the intervention. Participants subsequently completed the supervised Blackburn exercise

programme for six weeks. Post-intervention assessments were conducted using the same outcome measures by the same assessor under standardized conditions.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 23. Normality of data distribution was assessed using the Shapiro–Wilk test.

Continuous variables were expressed as mean $\pm$ standard deviation. Pre- and post-intervention comparisons were performed using paired *t*-tests. Statistical significance was set at $p < 0.05$.

Results

Participant Characteristics

Table 1: Baseline demographic characteristics of participants

Variable	Category	n (%)
Gender	Male	30 [63, 0]
	Female	17 [37, 0]
Age (years)	11–20	11 [22, 0]
	21–30	38 [76, 0]
	31–40	1 [2, 0]
Playing experience (years)	3–4	32 [64, 0]
	5–6	13 [26, 0]
	7–8	4 [8, 0]
	9–10	1 [2, 0]

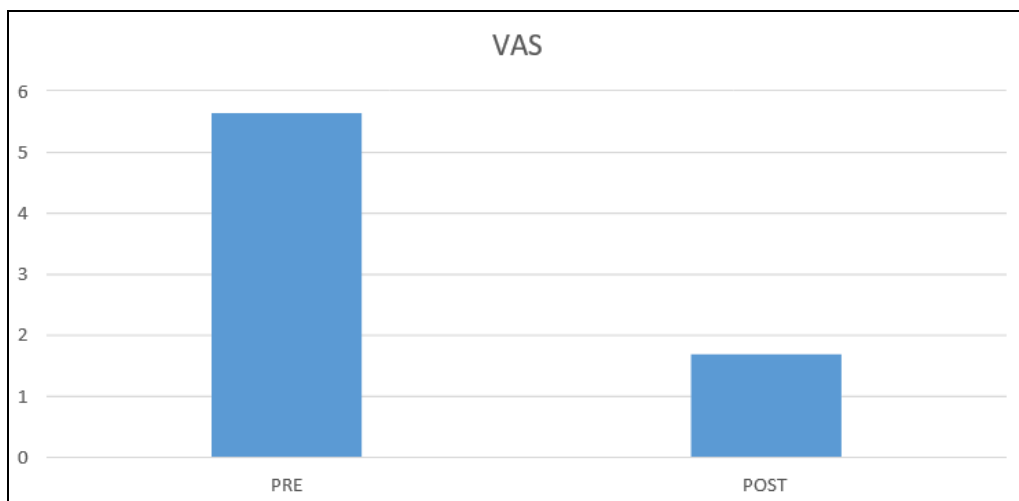
Interpretation

Most participants (76%) belonged to the 21–30-year age group. Male athletes constituted 63% of the study population, while the majority (63%) had 3–4 years of competitive water polo experience.

Pain Outcome

Table & Graph 2: Comparison of pain (VAS) before and after Blackburn exercise programme

Outcome	Pre-intervention Mean $\pm$ SD	Post-intervention Mean $\pm$ SD	Mean Difference	p-value
VAS	5.64 $\pm$ 0.90	1.70 $\pm$ 0.70	3.94	<0.0001*



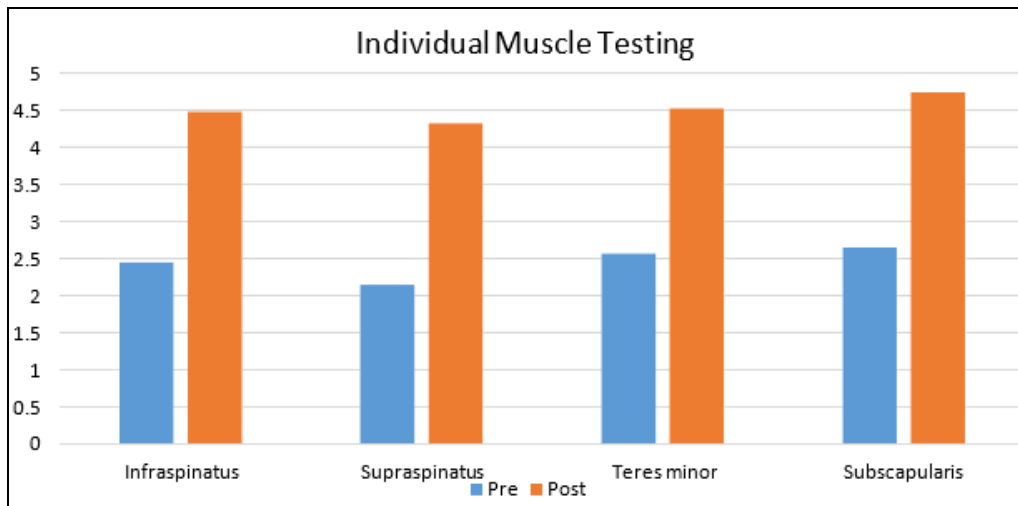
Interpretation

Pain significantly decreased following the six-week Blackburn exercise programme ($p < 0.0001$).

Rotator Cuff Muscle Strength

Table & Graph 3: Comparison of Individual Muscle Testing scores

Muscle	Pre-Mean $\pm$ SD	Post Mean $\pm$ SD	Mean Difference	p-value
Infraspinatus	2.44 $\pm$ 0.50	4.48 $\pm$ 0.50	2.04	<0.0001*
Supraspinatus	2.14 $\pm$ 0.70	4.32 $\pm$ 0.50	2.18	<0.0001*
Teres Minor	2.56 $\pm$ 0.50	4.52 $\pm$ 0.60	1.96	<0.0001*
Subscapularis	2.64 $\pm$ 0.40	4.74 $\pm$ 0.40	2.10	<0.0001*



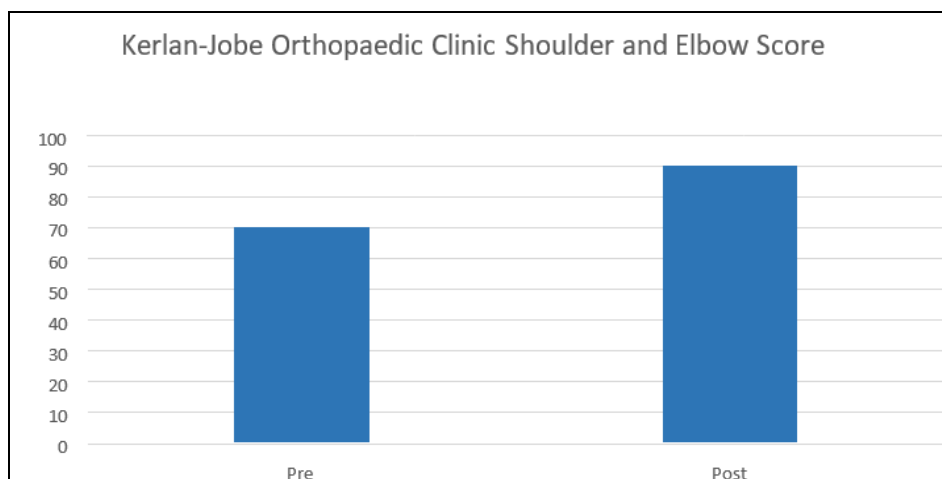
Interpretation

Significant improvements were observed in the strength of all rotator cuff muscles following the intervention ($p < 0.0001$).

Functional Disability

Table and graph 4: Comparison of KJOC scores before and after intervention

Outcome	Pre Mean $\pm$ SD	Post Mean $\pm$ SD	Mean Difference	p-value
KJOC Score	71.22 $\pm$ 9.00	91.01 $\pm$ 4.32	19.79	<0.0001*



Interpretation

The KJOC score demonstrated a statistically significant improvement following the intervention, indicating enhanced shoulder function and sports-specific performance.

Discussion

Water polo is a contact sport which consists of swimming to move about the pool, passing the ball and throw at the same time. It is an intensely aggressive sport in which there is considerable pushing, pulling and at times punching during the course of play which shows direct impact on shoulder leads to shoulder impingement. ^[1] Hence the prevalence of shoulder impingement in water polo players is 38-80%. ^[2] Shoulder impingement syndrome is the commonest shoulder disorder, resulting in functional loss and disability in the patients that it affects the structures passing through the suprahumeral space, which are rotator cuff tendons and the subacromial bursa. ^[9]

Blackburn exercises are the type of exercise which increases strength and functional ability of rotator cuff muscles and helps to improve symptoms of shoulder impingement syndrome. ^[10] These exercises are done in 6 steps in which there is change in position of the arm while doing this exercise in each of the step.

In the study 47 samples were taken according to inclusion and exclusion criteria. The test procedure was then explained to the all participants. They were explained with the aim and objectives of the study and the consent forms were filled by the participants. The data was collected and statistical analysis was done. The outcome measures taken were VAS, IMT 36 and KJOC. The group was evaluated pre and post intervention with the outcome measures.

The study included water polo players experiencing pain from repeated overhead activities, such as throwing, catching and defending the ball. The significant difference ($p\text{-value} < 0.0001$) in pre and post-intervention VAS and KJOC scores indicates a reduction in pain at the end of the 6 weeks.

According to Annika Taulaniemi *et al.*, exercise is widely recognized as the most effective treatment for managing and preventing pain. Regardless of the type of physical activity, exercise activates natural pain inhibitory pathways and reduces sensitivity to unpleasant stimuli. Blackburn exercises similarly demonstrate these pain-relieving effects. [11]

The IMT (Individual muscle testing) was used as an outcome measure before and after the intervention to assess rotator cuff muscle strength. A significant difference (p -value < 0.0001) was observed in the pre and post intervention scores for rotator cuff muscle strength, including supraspinatus, infraspinatus, teres minor, and subscapularis. This indicates that Blackburn exercises effectively enhance rotator cuff muscle strength by the end of the 6 week period.

As highlighted by Ujwalla Garad and Dr. Unika Purohit *et al.*, maximizing the effectiveness of Blackburn exercises involves focusing on tightly squeezing the shoulder blades. This isometric exercise targets muscle endurance and strength by stimulating the Golgi tendon organ, which is located 37 at the tendon-muscle fiber junction and increases muscle tension in response to contraction. [12]

The pre intervention mean KJOC score is 71.22 ± 9 which shows moderate dysfunction [8, 13] and the post intervention score is 91.01 ± 4.32 which indicates that player is functional, no or minimal symptoms, athlete fit for full competition [14, 16]. A significant difference (p -value < 0.0001) was observed in the pre and post-intervention scores.

The study's findings provide valuable insights into the efficacy of Blackburn exercises as an intervention strategy for alleviating pain and improving muscle strength among water polo players. The statistically significant improvements observed in VAS, IMT and KJOC scores underscore the program's potential to enhance individuals' overall condition.

Blackburn exercise helps to improve the strength of scapulothoracic and rotator cuff musculature and also help to decrease the muscle imbalance. It will reduce the excessive superior translation of humeral head in glenoid fossa during elevation and increases upward rotation of scapula and posterior tipping on thorax which in turns prevents the impingement of structures in subacromial space. This suggests that Blackburn exercise will deal with the root cause of the shoulder impingement. [9]

According to LambaDheeraj and Upadhyay Ritambhara K *et.al* Isometric exercises increase the mass of the tendon because of the enhanced deposition of type I collagen. The stimulation of type I collagen production may be of particular benefit because fibroblast from areas of rotator cuff tear synthesize 38 a greater proportion of mechanically inferior type III collagen than their healthy counterparts. [17] Thus, the study shows that after 6 week protocol there is a significant effect of Blackburn exercise on pain, strength of rotator cuff muscles and disability in shoulder impingement syndrome among water polo player.

Conclusion

The findings of this study demonstrate that a six-week Blackburn exercise programme significantly reduced pain, improved rotator cuff muscle strength, and enhanced shoulder function in competitive water polo players with shoulder impingement syndrome. These results suggest that

Blackburn exercises are an effective conservative rehabilitation strategy and may be incorporated into physiotherapy programmes for overhead athletes to improve functional outcomes and facilitate return to sport.

Limitations

- The study employed a single-group experimental design without a control group.
- Muscle strength was assessed using Individual Muscle Testing rather than objective dynamometry.
- The intervention was evaluated only over a six-week period; long-term outcomes were not assessed.

Future Scope

- Conduct randomized controlled trials with larger, multicentre samples to strengthen the evidence.
- Compare Blackburn exercises with other evidence-based rehabilitation programmes for shoulder impingement syndrome.
- Investigate the long-term effects of Blackburn exercises on injury recurrence, return-to-sport outcomes, and athletic performance in overhead athletes.

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