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Short Communication

Effect of motor control retraining exercise along with rotator cuff strengthening exercise on shoulder musculoskeletal pain among female throwball players: a pilot study

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ABSTRACT

Due to the repetitive strain on the shoulder complex, throwball players are more susceptible to rotator cuff damage, altered scapular mechanics, and shoulder musculoskeletal pain. Overhead athletes can improve shoulder stability and function by combining strengthening exercises with motor control retraining. This study included 20 amateur female throwball players, ages 16 to 25, who had shoulder musculoskeletal pain. For 6 weeks, rotator cuff strengthening exercises and motor control retraining were performed four times a week as part of the intervention program. Global rating of change (GRC), shoulder range of motion (ROM), and the shoulder pain and disability index (SPADI) were some of the outcome indicators that were assessed before and after the intervention. Following the intervention, there were noticeable improvements in every outcome measure. GRC scores improved from -4.00±0.73 to 4.35±0.49, whereas SPADI scores decreased from 50.75±2.84 to 21.80±2.17, Furthermore, ROM increased in flexion (136.45° to 166.40°), extension (31.40° to 45.55°), internal rotation (66.60° to 86.10°), and external rotation (56.60° to 76.15°) ($p<0.05$). Combining motor control retraining with rotator cuff strengthening exercises reduced shoulder discomfort and improved function and range of motion in female throwball players.

Keywords: Shoulder pain, Rotator cuff, Motor control, Throwball players, Well-being

INTRODUCTION

One common condition is pain in the neck muscles and shoulder girdle. It has been suggested that the three main characteristics on which physical exposure can be objectively quantified are the degree or quantity of force, repetition, and duration of exposure.[1] Shoulder injuries are prevalent, particularly in competitive sports. Eight to thirteen percent of sports injuries involve the shoulder. Shoulder mobility impairment has a significant impact on carrying out daily life activities.[2,4] The most common cause of shoulder pain, according to most authors, is shoulder impingements. Numerous factors have been associated with impingement syndrome. These include irregular kinematic patterns caused by weak rotator cuff or scapular muscle function, atypical acromial morphology, abnormalities in the capsule, poor posture, and overuse brought on by repeated eccentric loading or extended arm use exceeding 90 degrees of elevation. There is some evidence linking shoulder impingement to scapular dysfunction.[3]

Shoulder impingement syndrome, the most common diagnosis of shoulder dysfunction, is often characterized

by shoulder pain that worsens with overhead activity. One intrinsic factor that may be the source of primary impingement is rotator cuff weakness. Secondary shoulder impingement is a relative reduction in the subacromial space caused by abnormal scapulothoracic kinematics or instability of the glenohumeral joint. Athletes who compete in overhead throwing sports frequently experience secondary impingement, which occurs when the rotator cuff is impinged. This configuration may become pathogenic due to excessive external rotation, anterior capsular instability, scapular muscular imbalances, and/or recurrent stress of the rotator cuff muscles.[7] In general practice, subacromial impingement syndrome (SIS), one of the most common shoulder diseases, is often treated using conservative therapy techniques.[8] Shoulder impingement and tendinopathy, also referred to as rotator cuff disease, are the most common issues. Its etiology is most likely complex. Intrinsic tendon degeneration from eccentric strain and changes in scapular or humeral movement that damage the rotator cuff tissues are two probable explanations.[9] The point prevalence of shoulder pain in the general adult population is thought to be between 6.9% and 26%. Epidemiological studies show that 22% to 68% of people continue to experience persistent shoulder soreness up to a year after it first appears. Physical therapy is a conservative treatment for shoulder impairment that has been shown to improve shoulder function over time by up to 88% and considerably reduce shoulder discomfort.[5,6,10]

When evaluating the pain, impairment, and rehabilitation of individuals with shoulder dysfunction, accurate outcome measures are crucial.[11] Shoulder issues rank third among musculoskeletal conditions that appear in general practice, with a point frequency of 7-26%. Forty to fifty percent of patients report persistent and recurrent symptoms after six to twelve months. It has been shown that shoulder impingement is the most common cause of shoulder pain. Impingement syndrome can result in functional disability and a reduction in quality of life. Among other biomechanical and physiological characteristics, patients with shoulder impingement have been observed to exhibit abnormal scapular movements and muscle activation. Physiotherapy is often the first line of treatment for shoulder impingement. Strengthening and motor control exercises can help persons with shoulder impingement function better, according to recent research. Movement retraining can change motor control by utilizing the principles of motor learning.[12] Shoulder joint pain is the second most prevalent sign of this instability. The underlying pathologic process is self-perpetuating aggravation, which is brought on by repeated mechanical compression of the rotator cuff muscle. Abnormal movement can quickly change its shape since it depends on muscular activation for stability. The scapular plane stability exercise does not overwork the shoulder joints. It can be used to stabilize the entire shoulder girdle in addition to correcting improper movement function and scapular positioning caused by inadequate dynamic adjustment.[13] Removing the active and passive restrictions of the rotator cuff may cause instability in the shoulder.[14] Subacromial and internal impingement are two distinct pathophysiological conditions linked to shoulder impingement. Overhead athletes frequently suffer from internal impingement when the arm is abducted and externally rotated. Persistent irritation can lead to microtears and partial-thickness rotator cuff damage.[15] The term "scapular dyskinesis" describes alterations in the scapula's position and movement. Therapeutic exercises that focus on scapular control may be able to lessen pain and improve function.[16]

Rotator cuff disease is associated with functional limitations, shoulder pain, and a reduced quality of life.[17] The distinct anatomical structure of the human shoulder complex allows for a broad range of motion at various speeds and force levels. Degenerative illnesses and other traumas can affect shoulder structures, particularly the rotator cuff tendons. Rotator cuff tendon tears are common in the general population and can cause shoulder pain, a worse quality of life, and restricted functional skills.[18] One of the most frequent overhead motions is throwing, and injuries can result from repetitive motion as well as environmental and personal factors. These injuries are caused by collapse of the kinetic chain and functional issues with the lower limbs, chest, pelvic girdle, or shoulder girdle. Due to the repetitious nature of the action, athletes who throw overhead endure physiological strain on their shoulders. The tendon may experience recurrent microtrauma as a result of these pressures and torques.[19] Because overhead athletes routinely do shoulder motions with great velocity and extreme range of motion, they are more likely to develop shoulder issues.[20] In order to achieve stability of the scapula for improved shoulder kinematics, scapular stabilization exercises seek to restore scapular posture, muscle motor control, and movement pattern.[21,22] Understanding the biomechanical changes specific to a certain sport may help design effective conditioning and rehabilitation programs for athletes.[23] Despite the increasing amount of evidence supporting rotator cuff strengthening exercises and motor control retraining, few studies have been done, especially on female throwball players. Therefore, the aim of this study was to examine the effects of a motor control-based retraining combined with rotator cuff strengthening exercise on shoulder musculoskeletal pain among female throwball players.

METHODS

This was a preliminary single group pre- test post- test study conducted at outpatient department of private hospitals among amateur female throwball players with shoulder musculoskeletal pain. The intervention lasted for a total of six weeks. A total of 20 amateur female throwball players were recruited for the study based on the inclusion and exclusion criteria. Participants were recruited by convenience sampling. Participants aged 16-25 years with decreased rotator cuff function, shoulder pain for the last one month, SPADI score between 21-60 points, shoulder

flexion less than 150°, shoulder internal rotation less than 90°, shoulder external rotation less than 70°, and shoulder extension less than 40° were included in the study. Subjects with chronic shoulder pain, rotator cuff tear, recent shoulder surgery, adhesive capsulitis, recent shoulder fracture and dislocation, and experienced throwball players were excluded from the study.

The outcome measures used in the study were SPADI, ROM, and GRC. Range of motion was assessed using a universal goniometer. The intervention protocol consisted of motor control retraining exercises combined with rotator cuff strengthening exercises. The exercise program was conducted for 6 weeks with 4 sessions per week. The initial phase of the intervention focused on scapular position correction, scapular kinematics with feedback, assisted active scapular elevation, isometric internal and external rotation exercises, external rotation in side-lying position, and wand elevation exercises. The progression phase included rhythmic stabilization exercises, serratus punches, diagonal elevation with scapular control, TheraBand internal and external rotation exercises, prone external rotation exercises, prone horizontal abduction exercises, and wall closed-chain weight shift exercises. The advanced phase of the intervention included proprioceptive neuromuscular facilitation (PNF) scapular patterns, dynamic scapular stability exercises, quadruped closed-chain arm lifts, standing rhythmic stabilization exercises, functional reach exercises with scapular control, push-up plus exercises, and diagonal elevation exercises using TheraBand resistance. Detailed exercise progression and dosage are presented in Tables 1-6.

The data analysis was done using SPSS version 21.0. Descriptive data were expressed as mean±SD. Ethical approval for the study was obtained from the institutional ethics committee. Written informed consent was taken from each participant included in the study.

Table 1: Exercise protocol for week 1.

Exercises	Duration	Reps	Hold/relax	Sets	Procedure
Pendulum exercises	3 min	-	-	-	Patient stands with trunk slightly bent forward and the affected arm relaxed. The arm is allowed to hang freely and is gently swung in small circles, forward-backward, and side-to-side. Movement is produced by body sway, not shoulder muscles.
Scapular position correction	1 min	-	30 secs hold	3	Patient sits or stands upright and gently draws the shoulder blades down and back while maintaining a neutral spine. The position is held for 30 seconds, avoiding upper trapezius shrug.
Scapular kinematics with feedback (side-lying)	1 min	12	-	2	Patient lies on the non-affected side. Therapist guides the scapula through elevation, depression, protraction, and retraction with tactile or visual feedback while patient follows actively.
Scapular correction in scapular plane	1 min	12	-	2	Patient stands and elevates the arm 30° anterior to the frontal plane while maintaining scapular upward rotation and controlled motion.
Assisted active scapular elevation	1 min	10	-	2	Therapist assists upward rotation of the scapula while the patient actively elevates the shoulder in a smooth controlled manner.
Isometric internal rotation	1 min	-	10 secs hold	3	With elbow flexed to 90° and arm at side, patient presses the palm inward against a wall or fixed surface, holds for 10 seconds, then relaxes.
Isometric external rotation	1 min	-	10 secs hold	3	With elbow at 90° and arm at side, patient presses the forearm outward against resistance, holding for 10 seconds while avoiding trunk movement.
External rotation (side-lying)	2 min	12	-	2	Patient lies on non-affected side, elbow flexed to 90°. The forearm is rotated upward and lowered slowly while keeping elbow against the trunk.
Wand elevation (45-90°)	2 min	10	-	2	Patient holds a wand with both hands and uses the non-affected arm to assist elevation of the affected arm within 45-90° pain-free range.

Table 2: Exercise protocol for week 2.

Exercises	Duration	Reps	Hold/ relax	Sets	Procedure
Pendulum warm-up	3 min	-	-	-	Patient stands with trunk slightly flexed forward and the affected arm relaxed. The arm is allowed to hang freely and gently swung in circular, front-back, and side-to-side motions using body sway.
Scapular kinematics (all planes)	2 min	12	-	2	Patient sits or stands and actively moves the scapula through elevation, depression, protraction, and retraction in a slow controlled manner while maintaining relaxed shoulder muscles.
Rhythmic stabilization (side-lying)	2 min	-	20 secs hold	3	Patient lies on the non-affected side with the affected arm supported. Therapist applies gentle multidirectional perturbations while the patient resists and maintains arm position for 20 seconds.
Serratus punches	2 min	12	-	2	Patient lies supine with shoulder flexed to 90° and elbow straight. Arm is pushed toward the ceiling by protracting scapula, then slowly returned.
Diagonal elevation (scapular control)	2 min	8	-	2	Patient stands and lifts the arm in a diagonal pattern across the body while maintaining controlled scapular upward rotation and smooth movement.
External rotation (Full ROM)	3 min	12	-	3	With elbow flexed to 90° and arm close to the body, patient rotates the forearm outward through full pain-free range and returns slowly to starting position.
Wand elevation to 120°	2 min	10	-	2	Patient holds a wand with both hands and uses the non-affected arm to assist elevation of the affected arm up to 120° in a controlled pain-free range.
TheraBand internal rotation (initial)	2 min	12	-	2	Standing with elbow flexed to 90°, patient pulls the TheraBand inward across the body while keeping the elbow at the side and trunk stable.
TheraBand external rotation (initial)	2 min	12	-	2	Standing with elbow at 90° and arm at side, patient pulls the TheraBand outward away from the body, then returns slowly without trunk compensation.

Table 3: Exercise protocol for week 3.

Exercises	Duration	Reps	Hold/ relax	Sets	Procedure
Warm-up pendulums	3 min	-	-	-	Patient stands with trunk slightly flexed forward, allowing the affected arm to hang freely. The arm is gently swung in circular, front-back, and side-to-side motions using body sway.
Alternating isometric scapular stabilization	2 min	-	10 secs hold	3	Patient sits or stands while therapist applies alternating resistance to the scapula in different directions. Patient holds the scapula in neutral for 10 seconds against each resistance.
Scapular kinematics full rom	2 min	12	-	2	Patient actively moves the scapula through full elevation, depression, protraction, and retraction with controlled, pain-free motion.
PNF scapular ae/pd pattern	2 min	6	-	2	Therapist guides the scapula through diagonal anterior elevation and posterior depression patterns while the patient assists the movement.
Wall closed-chain weight shift	2 min	-	20 secs hold	2	Patient stands facing the wall with hands on the wall and shifts body weight side-to-side while maintaining scapular stability.
TheraBand internal rotation (medium)	3 min	12	-	3	Standing with elbow flexed to 90°, patient pulls the TheraBand inward across the body, keeping the elbow close to the trunk.
TheraBand external rotation (medium)	3 min	12	-	3	Standing with elbow at 90°, patient pulls TheraBand outward away from body and returns slowly.
Prone external rotation	2 min	10	-	2	Patient lies prone with the arm supported off the table and rotates the forearm upward while keeping the shoulder stable.
Prone horizontal abduction	2 min	10	-	2	Patient lies prone and lifts the arm sideways with the thumb pointing upward, then lowers slowly with control.

Table 4: Exercise protocol for week 4.

Exercise	Duration	Reps	Hold/ relax	Sets	Procedure
Warm-up pendulums	3 min	-	-	-	Patient stands with trunk slightly flexed forward and the affected arm relaxed, gently swinging the arm in circular, front-back, and side-to-side motions using body sway.
PNF rhythmic stabilization at 90°	3 min	-	20 secs hold	3	Patient holds the shoulder abducted to 90° while the therapist applies multidirectional resistance. Patient maintains position for 20 seconds against each perturbation.
PNF trunk + scapular integration	2 min	6	-	2	Therapist guides diagonal trunk and scapular movement patterns while the patient actively follows, emphasizing coordinated core and shoulder control.
Dynamic scapular control (diagonal)	2 min	8	-	2	Patient performs diagonal arm movements while maintaining controlled scapular upward rotation and trunk stability.
Alternating isometrics (mid-range)	2 min	-	10 secs hold	3	Therapist applies alternating resistance in different directions while the patient holds the shoulder in mid-range and resists for 10 seconds.
TheraBand IR (high level)	3 min	12	-	3	Standing with elbow flexed to 90°, patient pulls high-resistance TheraBand inward across the body with controlled motion.
TheraBand ER (high level)	3 min	12	-	3	Standing with elbow at 90°, patient pulls high-resistance TheraBand outward away from the body and returns slowly.
TheraBand shoulder elevation	2 min	10	-	2	Patient stands on the band and elevates the arm upward against resistance while maintaining scapular control.
Quadruped closed-chain arm lifts	2 min	10	-	2	Patient assumes quadruped position and lifts one arm at a time while maintaining scapular and trunk stability.

Table 5: Exercise protocol for week 5.

Exercises	Duration	Reps	Hold/ relax	Sets	Procedure
Warm-up pendulums	3 min	-	-	-	Patient stands with trunk slightly flexed forward, allowing the affected arm to hang freely and gently swinging in circular, front-back, and side-to-side motions.
PNF with TheraBand (Scapular + shoulder)	2 min	8	-	2	Patient performs diagonal PNF patterns against TheraBand resistance while maintaining coordinated scapular and shoulder control.
Dynamic scapular stability (weight-bearing)	2 min	-	20 secs hold	2	Patient assumes a weight-bearing position on the hands and holds scapular stability while maintaining proper alignment for 20 seconds.
Standing rhythmic stabilization	3 min	-	20 secs hold	3	Patient holds the arm in functional position while therapist applies unpredictable multidirectional resistance; patient resists to maintain position.
TheraBand IR at 90°	3 min	10	-	3	Patient stands with shoulder abducted to 90° and elbow flexed, pulling the TheraBand inward with controlled movement.
TheraBand ER at 90°	3 min	10	-	3	Patient stands with shoulder abducted to 90° and elbow flexed, pulling the TheraBand outward against resistance.
Prone external rotation (90° abducted)	2 min	10	-	2	Patient lies prone with shoulder abducted to 90° and rotates the forearm upward while keeping the scapula stable.
Advanced TheraBand rows	3 min	12	-	3	Patient pulls TheraBand backward with elbows close to the body, squeezing the shoulder blades together in a controlled manner.
Closed-chain shoulder taps	2 min	10	-	2	Patient holds plank or wall position and alternately taps each shoulder while maintaining trunk and scapular stability.

Table 6: Exercise protocol for week 6.

Exercise	Duration	Reps	Hold/ relax	Sets	Procedure
Warm-up pendulums	3 min	-	-	-	Patient stands with trunk slightly flexed forward, allowing the affected arm to hang freely and gently swinging in circular, front–back, and side–to–side motions using body sway.
Advanced PNF diagonal patterns	2 min	8	-	2	Patient performs advanced diagonal PNF movement patterns against resistance, emphasizing coordinated trunk, scapular, and shoulder motion.
Standing rhythmic stabilization at 90°	3 min	-	20 secs hold	3	Patient holds shoulder abducted to 90° while therapist applies multidirectional resistance; patient maintains position for 20 seconds.
Functional reach with scapular control	2 min	12	-	2	Patient reaches forward and overhead while maintaining proper scapular alignment and trunk control, then returns slowly.
TheraBand IR (high resistance)	3 min	12	-	3	Standing with elbow flexed to 90°, patient pulls high-resistance TheraBand inward across the body with controlled motion.
TheraBand ER (high resistance)	3 min	12	-	3	Standing with elbow flexed to 90°, patient pulls high-resistance TheraBand outward away from the body and returns slowly.
Prone er + extension (advanced)	2 min	12	-	2	Patient lies prone and performs external rotation combined with shoulder extension while maintaining scapular stability.
Closed-chain push-up plus (wall/table)	2 min	10	-	2	Patient performs wall or table push-ups followed by scapular protraction at the top of the movement.
Diagonal elevation with TheraBand	2 min	10	-	2	Patient performs diagonal arm elevation against TheraBand resistance while maintaining scapular control and trunk stability.

RESULTS

The present study included 20 female throwball players with a mean age of 20.30±2.20 years, following the intervention, the GRC score improved from -4.00±0.73 to 4.35±0.49. The SPADI scores decreased from 50.75±2.84% prior to the intervention to 21.80±2.17% following it. Similarly, ROM also improved following the intervention. Mean shoulder flexion increased from 136.45±5.13° to 166.40±5.17°, while extension improved from 31.40±2.87° to 45.55±2.82°. Internal rotation showed an increase from 66.60±3.65° to 86.60±3.65°. Internal rotation increased from 66.60±3.65° to 86.10±3.70°, while external rotation improved from 56.60±3.65° to 76.60±3.65°. The pre- and post-test comparison of outcome measures Table 7 and Figure 1.

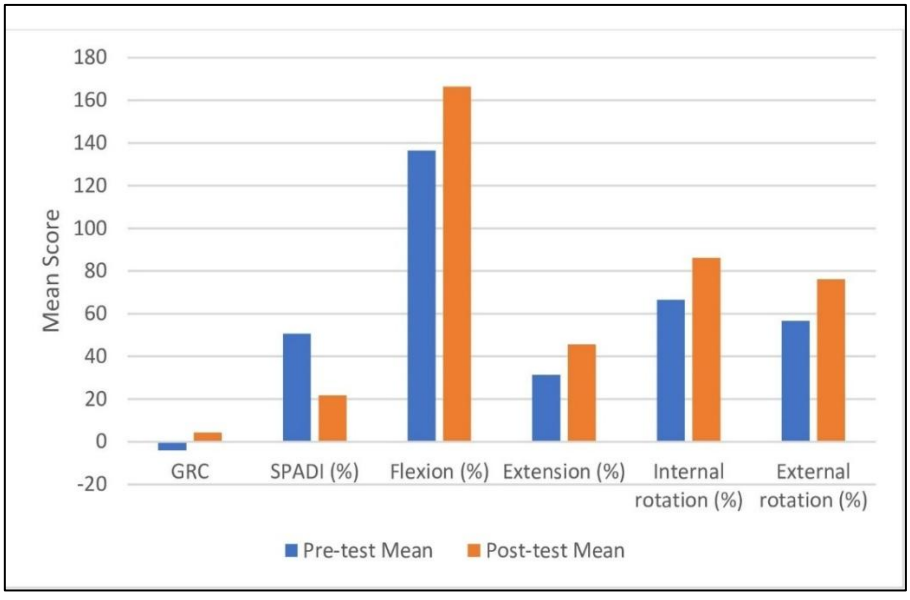

Figure 1: Pre- and post-test comparison of outcome measures.

Table 7: Pre- and post-test comparison of outcome measures.

Outcome measure	Pre-test, mean±SDa	Post-test, mean±SDa	T value	P value*
GRCb	-4.00±0.73	4.35±0.49	40.01	<0.001
SPADIc	50.75±2.84	21.80±2.17	-88.19	<0.001
Flexion (°)d	136.45±5.13	166.40±5.17	195.15	<0.001
Extension (°)d	31.40±2.87	45.55±2.82	84.92	<0.001
Internal rotation (°)d	66.60±3.65	86.10±3.70	39.00	<0.001
External rotation (°)d	56.60±3.65	76.15±3.76	43.44	<0.001

*a-Values are expressed as mean±SD, b-GRC-Global rating of change scale, c-SPADI-Shoulder pain and disability index, d-Flexion, extension, internal rotation and external rotation are measured in degrees (°), *p<0.001 indicates statistically significance difference.

DISCUSSION

The present study investigated the effects of motor control retraining and rotator cuff strengthening exercises on shoulder pain, disability, perceived recovery, and shoulder range of motion in female throwball players with shoulder musculoskeletal discomfort. After the six-week intervention, improvements were observed in GRC, SPADI, shoulder flexion, extension, internal rotation, and external rotation. These findings suggest that strengthening exercises and motor control retraining may improve shoulder performance and reduce pain in female throwball players. A study by Panagiotopoulos et al reported that scapular dyskinesis is one of the main causes of shoulder pain and dysfunction, which emphasizes the significance of focused physical therapy rehabilitation in improving shoulder function.[24] These findings support the present study, which demonstrate that the combination of motor control retraining and rotator cuff strengthening exercises reduced shoulder discomfort, disability, perceived recovery, and range of motion in female throwball players.

A systematic review by Zhong et al reported that scapular stability exercises were reported to improve shoulder function and decrease discomfort in individuals with subacromial pain syndrome.[25] Similar improvements were observed in the present study, where combination of motor control retraining and rotator cuff strengthening exercises enhanced the SPADI scores, perceived recovery, and shoulder range of motion of female throwball players. A study by Niering et al reported that multimodal exercise regimens that incorporated stretching, eccentric and isometric movements, balance training, and progressive training greatly improved athletes' physical performance and injury-related outcomes.[26] This aligns with the findings of the present study, which showed improvements in shoulder range of motion, perceived recovery, and shoulder pain in female throwball players.

A study by Da Silva Barros et al highlighted that people with rotator cuff tendinopathy may benefit from strengthening exercises for shoulder pain, function, muscle strength, and scapular muscle activity.[27] This study demonstrated similar outcomes when motor control retraining and rotator cuff strengthening exercises were combined to increase shoulder range of motion, perceived recovery, and shoulder pain in female throwball players. Study by Intelangelo et al reported that one of the primary risk factors for shoulder injuries in overhead athletes was an imbalance in muscular strength. The authors also emphasized the significance of scapular control and shoulder muscle function for athletic success.[28] These results are in line with the current study, which discovered that when rotator cuff strengthening exercises were combined with motor control retraining, female throwball players' shoulder range of motion, perceived recovery, and shoulder pain all improved. Study by Promsri et al highlighted significance of movement control and stability in enhancing athletic performance. Study showed that specific training techniques can affect dynamic stability during movement activities.[29] These results are supported by current study, which found that motor control retraining combined with rotator cuff strengthening exercises improved shoulder function, perceived recovery, and shoulder range of motion in female throwball players. Study by Moradi et al reported that motor control retraining exercises improved proprioception, pain, strength, and shoulder function in patients with scapular dyskinesis and shoulder impingement syndrome.[30] Results of current study are in line with these findings, where shoulder discomfort, recovery, and range of motion were all improved by motor control retraining. There are some limitations to the current study. Small sample size and data collection from a single setting may have an impact on the study's external validity and generalizability. Subjects with rotator cuff tears, chronic shoulder conditions, and seasoned throwball players were excluded from trial, and longer follow-up evaluations were not conducted to determine intervention's long-term effects. A larger sample size and a longer intervention period can be used in future studies. Regular long-term monitoring may provide further information on effectiveness of treatment. Future studies could employ a variety of outcome measures to more fully evaluate shoulder function and performance.

CONCLUSION

Rotator cuff strengthening exercises combined with motor control retraining improved shoulder range of motion and reduced discomfort and impairment in female throwball players. These findings encourage the use of sport-specific rehabilitation programs for overhead athletes with shoulder musculoskeletal problems.

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