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Effect of rhythmic stabilization exercises on pain, scapular muscle strength and scapular position in type 1 scapular dyskinesis among elite badminton players: An interventional study

Aditi Pawar and Dr. Chintan Solanki

Abstract
Scapular dyskinesis or SD is defined as alteration in normal scapular kinematics. SD was found to be more common (61%) in overhead athletes than in nonoverhead athletes (31%). Rhythmic stabilization is a form of proprioceptive neuromuscular facilitation (PNF) that involves alternating isometric antagonist muscles contractions against resistance intending to enhance muscle strength and balance, joint stability, and pain relief.
Method: Thirty-six subjects who fulfilled selection criteria included using convenient sampling. Subjects were evaluated for scapular dyskinesis pre and post intervention using NPRS, manual muscle testing and lateral scapular slide test. Subjects were given PNF-Rhythmic stabilization for three days in a week for total four weeks.
Result: Statistical analysis for group was done using by Wilcoxon test. Rhythmic stabilization is having significant effects on LSST, NPRS and MMT in trapezius and serratus anterior muscle in the group. The final analysis proves that it is clinically significant (p value <0.05).
Conclusion: The study concluded that the Rhythmic stabilization exercise are effective for pain, scapular muscle strength and scapular position. They simple and easy to apply in Scapular dyskinesis type 1 subjects. So, it can be implemented clinically as well.

Keywords: LSST, muscle strength, NPRS, pain, rhythmic stabilization exercise, scapular dyskinesis

Introduction

According to anatomy, the scapula is the intervening bony connector between the humerus and the clavicle/axial skeleton and is a component of both the glenohumeral (GH) joint and the acromioclavicular (AC) joint. According to physiology, the muscles' secure bases of origin help to maintain the dynamic GH stability. In terms of mechanics, efficient arm movement requires scapulohumeral rhythm (SHR), which couples the motion of the scapula and humerus in a synchronized manner. Effective shoulder position, motion, stability, muscle performance and motor control are heavily dependent on the scapular performance [2].

Dyskinesis is defined as a deviation from normal scapular kinematics. "Dyskinesia" is a different phrase that is frequently used synonymously. The term dyskinesis, which is more encompassing, is selected since dyskinesia is typically used to describe abnormally vigorous (voluntary) movements that are mediated by neurologically regulated elements. It has been hypothesized to relate to changes in GH angulation, AC joint sprain, subacromial space dimension, shoulder muscle activation and humeral position and motion [2].

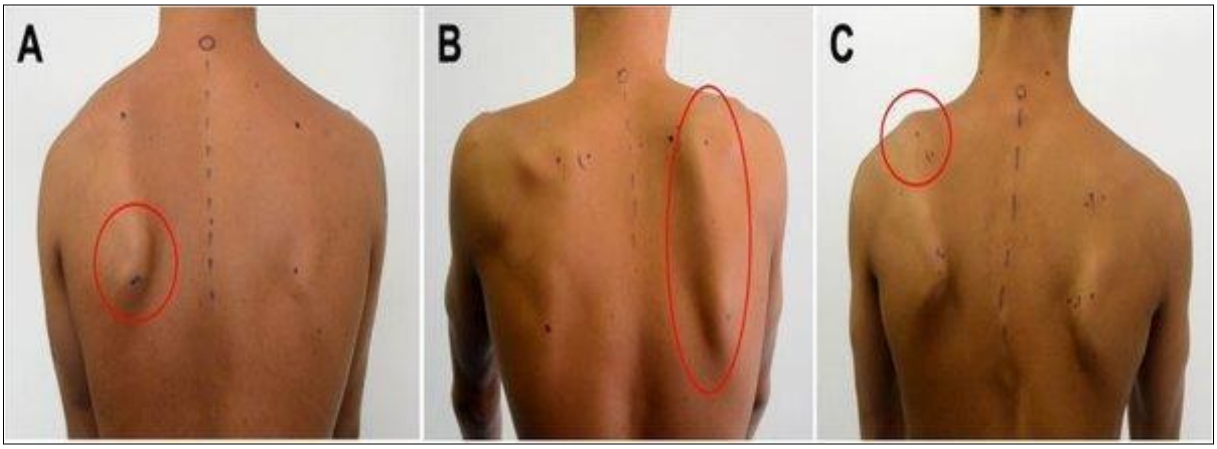
Dyskinesis may result from a variety of causes. It can be bought on by a number of conditions, including those of the bone (such as thoracic kyphosis or clavicle diseases, the nervous system (cervical radiculopathy or nerve palsy), the soft tissues (tightness or stiffness of the pectoralis minor and posterior capsule) and the muscular imbalance (between the upper trapezius and the serratus anterior) [17].

Scapular dyskinesis is believed to be more common in overhead or throwing athletes due to their heavy reliance on unilateral upper extremity function [9]. The glenohumeral and scapular joints undergo more stress when throwing because they serve as the "funnel" or "bridge" that transmits force from the lower extremities and boot to the arm [1].

Scapular dyskinesis is challenging to diagnose clinically and is mostly determined through visual examination [9]. The most well-known categorization technique was introduced by Kibler *et al.* although it has been refined to include weighted workouts, videotaping, inclinometry and tape measurements. The scapular dyskinesis clinical evaluation system is divided into 3 patterns [5].

The inferior medial scapular angle is prominent in Type I dyskinesis, which is a loss of scapular control about a horizontal axis parallel to the scapular spine. Type II is characterized by prominence along the entire medial scapular border, which indicates loss of scapular control along a vertical axis parallel to the spine. Type III is characterized by prominence of the superior scapular border, which indicates excessive scapular upward movement and lack of control around a sagittal axis through the scapula. The patterns are typically more prominent when the arm is lowered because the eccentrically stimulated muscles are under higher strain [5].

Type 1 is due to weakness of lower trapezius and serratus anterior. The inferomedial scapular border is prominent. Posterior scapular tipping is responsible for functional narrowing of the subacromial space during an overhead activity, leading to pain in abduction and external rotation. Type 2 presents with the scapular winging pattern where the entire scapular medial border is prominent due to weakness of trapezius and rhomboids. Superomedial scapular border is prominent in type 3 where excessive and early elevation of the scapula is observed during upper extremity elevation [4].



A) Type 1 scapular dyskinesis B) Type 2 scapular dyskinesis C) Type 3 scapular dyskinesis

Compared to nonoverhead athletes, overhead athletes have a higher prevalence of reported scapular dyskinesis. 61% of overhead athletes and 33% of nonoverhead athletes were found to have scapular dyskinesis [1].

The sport of badminton calls for a certain level of physical preparation in terms of coordination of movement and action controls; coordinative elements including reaction time, foot placement, and static or dynamic balances, which are crucial motor demands in this activity. Thus, players of badminton need to have a lot of strength while making quick postural movements around the court, the dynamic balance level [10].

Elite badminton players are individuals who have competed in the sport at a high level with an average shuttle speed of 50 to 75 m/s during the match. These athletes are exceptionally skilled technically and are flexible, strong, and long-lasting. Compared to sub elite players, elite players are more dependent on quick reflexes, visual acuity, and anticipation [8].

Patients experiencing back and shoulder pain had a considerably greater prevalence of scapular dyskinesia. Patients experiencing these discomforts are more likely to experience Type 1 and Type 2 scapular dyskinesis. In both shoulder impingement and shoulder instability, the trapezius and serratus anterior muscles have been linked to the emergence of scapular dyskinesis [6]. Almost 50% of recreational and professional badminton players have or have had shoulder pain, with 20% reporting continuing shoulder pain. Despite reporting an impact on training, competition, and daily routines, the majority of players still choose to play through the pain. For dominant and non-dominant shoulders, distinct shoulder kinematics were observed [4].

Treatment of scapulothoracic dysfunction associated with shoulder injuries includes strengthening exercises of the scapular muscles designed to restore balanced activation of the upper trapezius vs lower trapezius, middle trapezius, and serratus anterior [7].

Rehabilitation of patients with superior glenoid labral lesions and scapular dyskinesis can also include the kinetic chain exercises [13].

The PNF approaches are based on the idea that motor recruitment can be strengthened by properly utilizing reflexes and proprioceptive inputs, which in turn will enhance the patient's postural responses, movement patterns, strength, and muscular endurance. PNF exercises cause irradiation, which activates the weaker muscles by activating the stronger set of muscles, so enhancing their strength. The distribution of muscle fibers and the cross-sectional area of the muscle are altered by PNF training. The PNF causes changes in the distribution of the muscle fiber type, which results in a unidirectional pattern of conversion of fast twitch fibers to slow twitch fibers [19].

The addition of scapular PNF to standard treatment resulted in a substantial decrease in pain intensity, improvement in shoulder range of motion, improvement in scapular dyskinesis, and improvement in functional activities in participants with adhesive capsulitis [20].

The goal of rhythmic stabilization (RS), a type of proprioceptive neuromuscular facilitation (PNF), is to improve muscle strength and balance, joint stability, and pain alleviation by alternating isometric antagonist muscle contractions against resistance. When overhead athletes sustain shoulder injuries, RS is said to enhance proprioception and restore normal kinesthesia of the glenohumeral and scapulothoracic articulations [7].

Materials and Methods
Methodology

Study type: Pre and post intervention study

Study Duration: 6 months

Sample Size: 36

Type of sampling: Convenient Sampling

Study Setting: Private badminton Associations, Sangli district.

Method of collection
The study was conducted on 36 healthy badminton players of age group 18 to 29 years who consented to participate in the study. Subjects with previous shoulder injuries, trunk deformity, any degenerative disease of spine, neurological condition and recreational injuries were excluded.
The intervention was explained to subjects and institutionally approved written consent was taken. Materials used were a measuring tape, a medicine ball, plinth, consent form, pen and data collection sheet. Pre intervention and post intervention evaluation immediately following the rhythmic stabilizations exercise to measure pain, muscle strength and scapular dyskinesis.

Intervention
Rhythmic stabilization exercise given for 3 times a week for 4 consecutive weeks. All exercises include 10 sec hold, 3 sec rest, 10 repetitions and 3 set for 3 times per week for 4 weeks.

First four sessions
Open chain kinetic rhythmic stabilization exercises.
1. **Scapular elevation/ depression:** Place your top hand superiorly and the other hand inferiorly around the scapula to provide manual resistance.
2. **Scapular protraction/retraction:** Place your top hand along the medial border and the other around the coracoid process to provide resistance.
3. **Scapular upward and downward rotation:** Place one hand around the inferior angle and the other hand around the acromion and coracoid process to provide resistance.

Resist the scapular motions of elevation/depression and retraction directly against the scapula; resist protraction by pushing against the elbow.

Fig 1: Rhythmic stabilization exercise for protraction and retraction

Fig 2: Rhythmic stabilization exercises for elevation and depression

The next four sessions
Closed kinetic rhythmic stabilization exercises on stable surfaces.
All exercises are performed by applying alternating resistance against the shoulders or trunk and ask the patient to "hold" against the force. Apply resistance in various directions.
Exercises are as follows:
1. Side lying on the uninvolved side. Both elbow and shoulder of the involved arm flexed to 90 degrees with hand placed on the table and bearing some weight. Resist the scapular motions of elevation/depression and retraction directly against scapula and resist protraction by pushing against elbow.
2. Sitting with forearms placed on thigh or table. Lean forward slightly to place light body weight through the upper extremities. Apply gentle resistance against the shoulders and ask the patient to match the resistance and "hold".
3. Standing with shoulder at 90 degrees flexed on stable surfaces (wall) with bilaterally upper extremity supported.
4. Standing with unilateral upper extremity flexed at 90 degree against the wall.
5. Quadruped position with bilateral upper extremity supported on ground.
6. Then progressed to unilateral upper extremity supported in quadruped position.

Fig 3: RS for unilateral extremity on stable surface

Fig 4: RS in quadruped position on stable surface

Fig 5: RS in quadruped position with unilateral extremity on stable surface

In last four sessions

Closed chain rhythmic stabilization exercises on unstable surfaces (Apply resistance against the shoulders and ask them to hold for 10 secs):

1. Standing with shoulders flexed at 90 degrees on unstable surfaces, such as wobble board or a ball with bilaterally upper extremity supported on the ball.
2. Standing with unilateral upper extremity supported on the swiss ball/ medicine ball against the wall from standing facing the Swiss ball against the wall.
3. Quadruped position with bilateral upper extremity supported on the Swiss ball/ medicine ball against the ground.
4. Quadruped position with unilateral upper extremity supported on swiss ball/ medicine ball against the ground.

Post-intervention assessment is taken by using LSST, NPRS and Manual muscle testing.

Fig 6: RS for unilateral extremity on unstable surface in standing

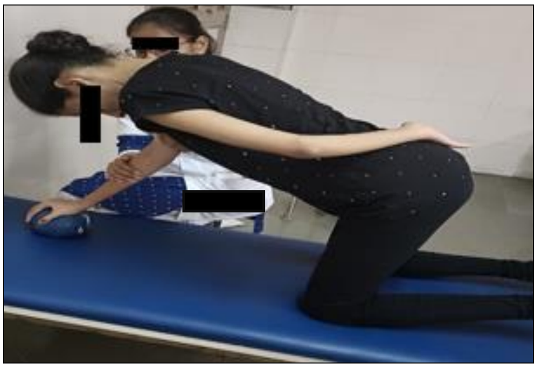


Fig 7: RS in quadruped position on unstable surface (arm at 90 degrees flexion)

Fig 8: RS in quadruped position on unstable Surface (arm at 180 flexion)

Outcome Measures

All outcome measure were evaluated pre and post intervention. Following outcomes were used:

1. NPRS (Numerical pain rating scale)
2. Manual muscle testing

MMT performed for scapular muscles

1. Trapezius (Lower)

Fig 9: Trapezius (Lower)

2. Serratus anterior

Fig 10: Serratus anterior

3. Lateral Scapular Slide Test (LSST)

Technique

The test involves measuring the distance from scapula to the nearest vertebral spinous process using a tape in three positions: shoulder in neutral, shoulder at 40-45 degrees of coronal plane abduction with hand resting on hips and the shoulder at 90 degrees abduction with arms full internal rotation. The injured or deficient would exhibit a greater scapular distance than uninjured or normal side. The bilateral difference of 1.5cm should be taken as positive test.

Position 1

Involves placing the shoulder in neutral position, with the arms relaxed at the sides.

Fig 11: Involves placing the shoulder in neutral position, with the arms relaxed at the sides.

Position 2

The humerus is placed in medial rotation and 45 degrees abduction, by positioning the patient's hands around the waist.

Fig 12: The humerus is placed in medial rotation and 45 degrees abduction, by positioning the patient's hands around the waist

Position 3

The humerus is placed in 90 degrees abduction.

Fig 13: The humerus is placed in 90 degrees abduction.

Results and discussion

Table 1: Normality test using Shapiro-Wilk

Variable	Time frame	z-value	p-value
LSST(in cm)	Pre	0.913	0.008
	Post	0.914	0.009
MMT (trapezius)	Pre	0.540	0.000
	Post	0.540	0.000
MMT (Serratus ant.)	Pre	0.638	0.000
	Post	0.638	0.000
NPRS	Pre	0.893	0.002
	Post	0.802	0.000

Data set is not normally distributed as all variables have indicated significant outcome in the observation. The researcher shall use non-parametric test for data analysis purpose in the following sections.

Table 2: Shows gender, frequency and percent

Gender	Frequency	Percent
Male	20	56
Female	16	44
Total	36	100

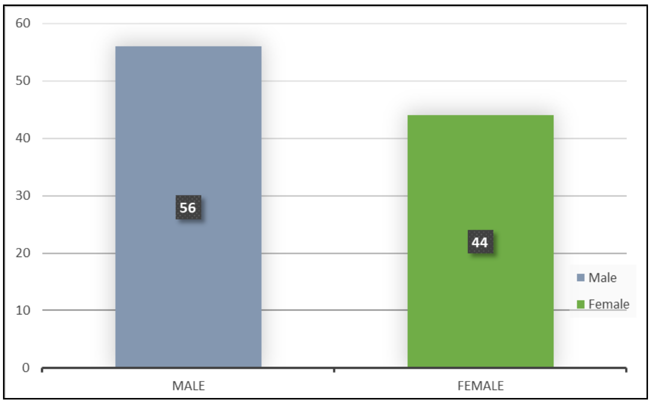


Fig 14: Gender

Table 3: Shows dominance, frequency and percent

Dominance	Frequency	Percent
Left	9	25
Right	27	75
Total	36	100

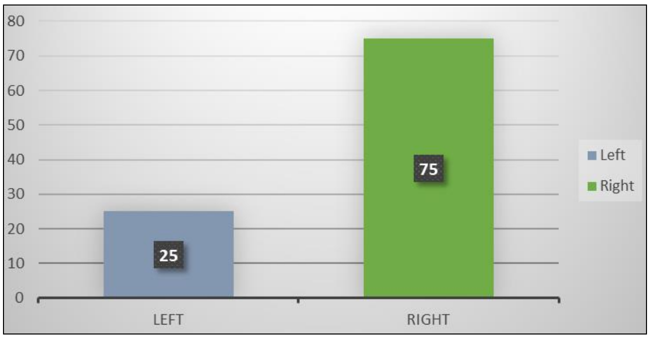


Fig 15: Dominance

Descriptive Statistics

Table 4: Descriptive statistics

Particular	Minimum	Maximum	Mean	SD
Age	18.00	28.00	21.86	2.79
BMI	16.00	25.00	20.50	2.21

Within group Pre and post test

Comparison of pre-test and post-test LSS scores by Wilcoxon test

Table 5: Shows Pre and post test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	Z-value	p-value
Pre-test	2.15	0.28	0.64	0.15	4.24	5.262	0.001*
Post-test	1.51	0.19					

The LSS mean value indicated changes post treatment and lower values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 4.24 value which is assumed to be very high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

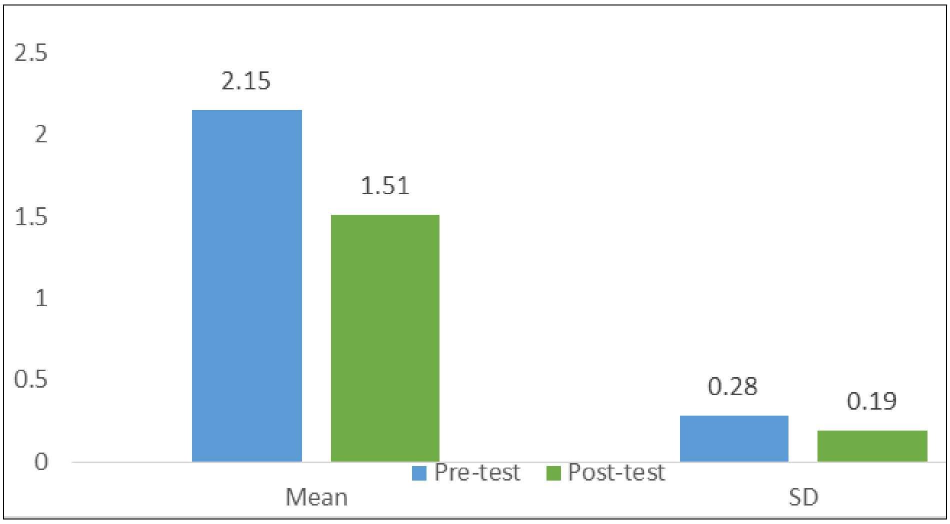


Fig 16: Comparison of pre-test and post-test LSS scores

Table 6: Comparison of pre-test and post-test MMT (trapezius) scores by Wilcoxon test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	Z-value	p-value
Pre-test	4.25	0.44	0.75	0.44	1.71	5.196	0.001*
Post-test	5.00	0.01					

The MMT (trapezius) mean value indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 1.71 value which is assumed to be very high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

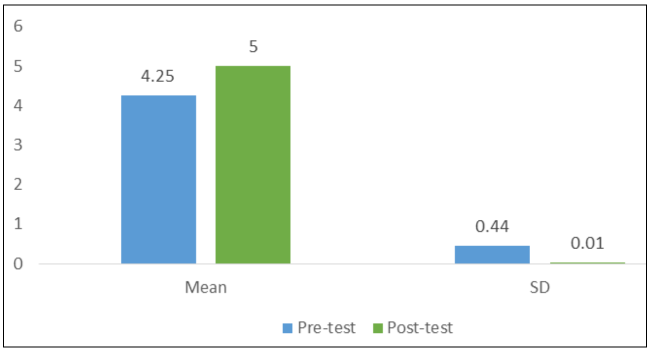


Fig 17: Comparison of pre-test and post-test MMT (trapezius) scores

Table 7: Comparison of pre-test and post-test MMT (Serratus ant.) scores by Wilcoxon test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	Z-value	p-value
Pre-test	4.50	0.51	0.50	0.51	0.99	4.243	0.001*
Post-test	5.00	0.01					

The MMT (Serratus ant.) mean value indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 0.99 value which is assumed to be very high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

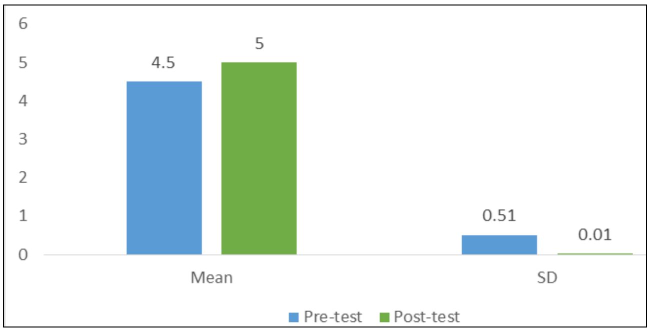


Fig 18: Comparison of pre-test and post-test MMT (Serratus ant.) scores

Table 8: Comparison of pre-test and post-test NPRS scores by Wilcoxon test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	Z-value	p-value
Pre-test	4.75	1.52	3.94	0.95	4.13	5.292	0.001*
Post-test	0.81	0.89					

The NPRS mean value indicated changes post treatment and lower values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 4.13 value which is assumed to be very high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.

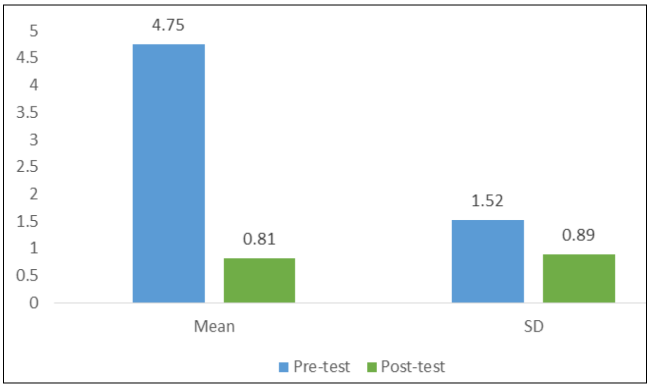


Fig 19: Comparison of pre-test and post-test NPRS scores

Table 9: Comparison of pre-test and post-test NPRS scores

Variable	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	Z-value	p-value
LSST	Pre-test	2.15	0.28	0.64	0.15	4.24	5.262	0.001*
	Post-test	1.51	0.19					
MMT (trapezius)	Pre-test	4.25	0.44	0.75	0.44	1.71	5.196	0.001*
	Post-test	5.00	0.01					
MMT (Serratus ant.)	Pre-test	4.50	0.51	0.50	0.51	0.99	4.243	0.001*
	Post-test	5.00	0.01					
NPRS	Pre-test	4.75	1.52	3.94	0.95	4.13	5.292	0.001*
	Post-test	0.81	0.89					

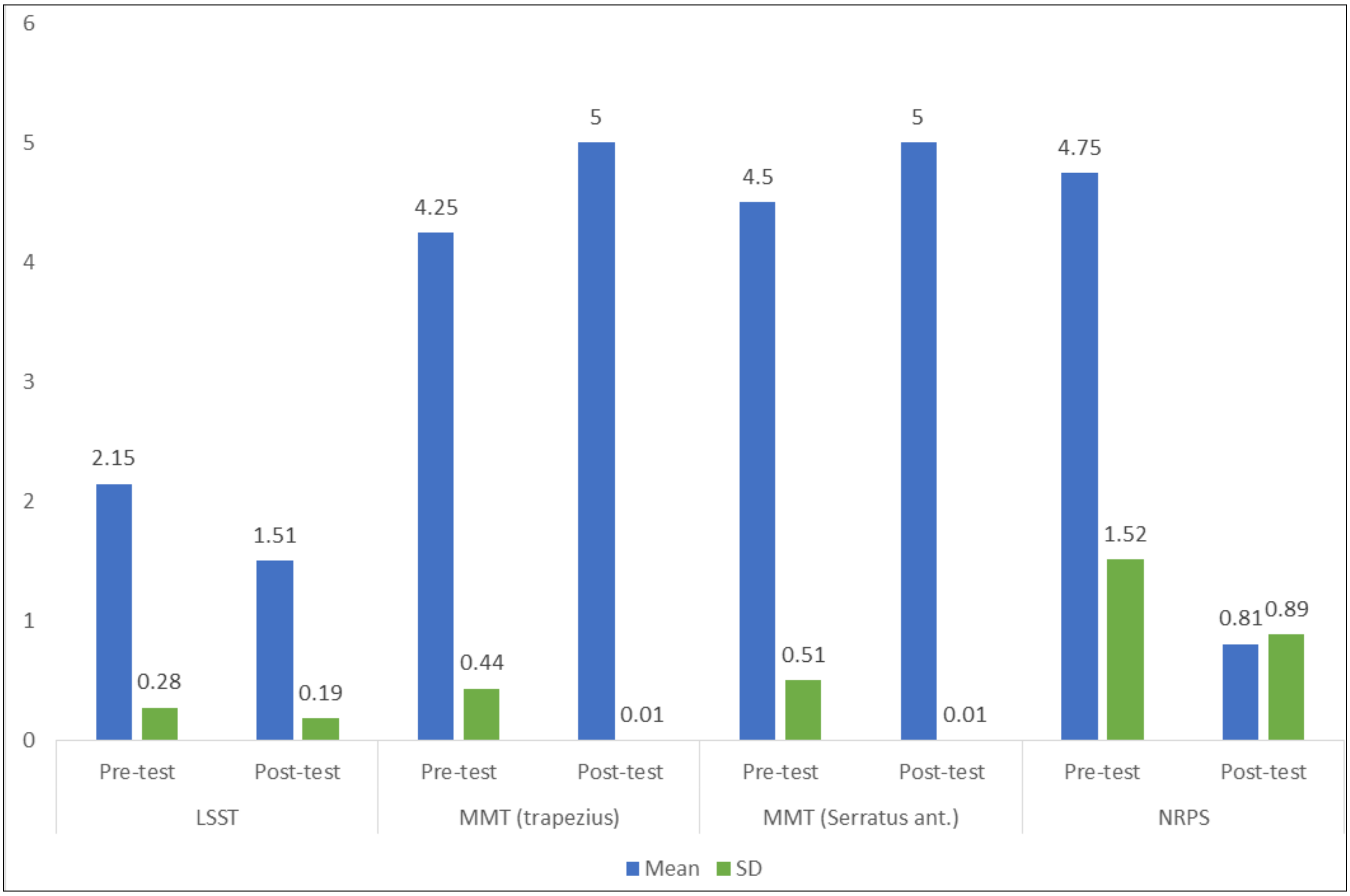


Fig 20: Chart Title

Discussion

Wed statistically significant improvement in muscle (Matthew B. Burn *et al.* 2016, Anjana Mahale *et al.* [1, 3] Scapular dyskinesis is often observed in overhead athletes as compared to non-overhead athletes especially in unilateral overhead sport playing athletes with shoulder pain and reduced strength of muscle.

Ajit Surendra Dabholkar *et al.* explained that scapulohumeral rhythm is maintained by the stabilizing scapular muscles' cooperative coordination of the balance of motion between the shoulder joints. When the muscles are weak or fatigued, scapulohumeral rhythm is compromised, and shoulder dysfunction results. This dysfunction can cause micro trauma in the shoulder muscles, capsule, and ligamentous tissue and lead to impingement. As per these articles, the purpose of this study was to investigate the effect of rhythmic stabilization exercise on pain and muscle strength in type 1 scapular dyskinesis among elite badminton players.

In this study total 36 subjects were selected. Out of total, subjects within age group of 18-29 years, both male and female were selected according to inclusion criteria. Subjects were evaluated shoulder and upper back pain and muscle strength using NPRS and MMT. Lateral scapular slide test was used to assess type 1 scapular dyskinesis. The subjects were given rhythmic stabilization exercise for four weeks.

The present study demonstrates that the intensity of shoulder and upper back pain improved significantly, and also significant improvement was seen in muscle strength after four weeks of rhythmic stabilization exercises. In this study mean age and mean BMI is 21.86 and 20.50 respectively.

The first objective of this study was to study the effect of rhythmic stabilization exercise on pain using NPRS. The second objective of this study was to study the effect of rhythmic stabilization exercise on scapular muscle strength using manual muscle testing Nick Kofotolis *et al.* did a study to understand the effect of PNF exercises for four weeks on trunk muscle endurance, flexibility and functional performance in subjects with pain. According to this study PNF exercise programme can considerably improve range of motion and endurance in persons with CLBP. The nature of PNF exercises which are created particularly to maximize flexibility improvements may be responsible for beneficial benefits of the current training programmes. These exercises help to increase muscle relaxation by taking use of the body’s inhibitory responses. PNF exercises are effective reducing pain, and the gains in functional capacity could be considered as a direct outcome of flexibility and endurance improvements.

Roopa Rajendra Desai *et al.* conducted a study on Proprioceptive Neuromuscular Facilitation (PNF) techniques versus Closed Kinematic Chain (CKC) exercises on pain, scapula position and upper extremity work related musculoskeletal disorders in housekeeping staff with scapular dyskinesia and concluded that PNF exercises shoed greater effects than CKC in improving the strength of scapular muscles. This happens as a result of the neuronal adaptation that follows four weeks of strength exercise. PNF exercises result in a reduction in CNS inhibition, a decrease in the golgi tendon organ's sensitivity, and modifications at the myoneural junction of the motor unit. These elements boost the recruitment, firing rate, and synchronicity of the motor units, which enhances motor coordination and learning. PNF exercises showed a substantial decrease in upper extremity work-related musculoskeletal problems and a significant improvement in pain intensity during rest and activity, as well as an increase in scapular muscle strength that helped with scapula position.

The third objective of this study was to study the effects of rhythmic stabilization exercises on scapular position by lateral scapular slide test. Myeungsik Hwang *et al.* stated that the scapula's ability to stabilise is significantly reduced by an asymmetrical position. When the scapula is positioned asymmetrically, the arm movements cause functional disorder and injury to the upper extremity, transferring proximal energy to the distal regions. The PNF exercise was distinct from the other exercises as it involved manual contact from a physiotherapist. By sending information to the skin receptors, this contact enabled the participants to move in the appropriate direction. Furthermore, this resulted in the coordination muscles contracting and becoming irritated, which enhanced the movements, encouraged axis stabilization, and raised the tension exerted on the muscles during contraction. The position, movement, pain, and abilities of the scapula all significantly improved after PNF exercise. The more effective results compared to those in the other groups are therefore thought to be related to these effects.

Gonca SAĞLAM *et al.* conducted study to evaluated the prevalence of SD in patients with neck, back and shoulder pain. In the thoracic area, the scapula is a part of the shoulder kinematic chain. The development of abnormal scapular mechanics is mostly influenced by the muscles that surround the scapula and the rotator cuff muscle. They stated that both shoulder impingement and shoulder instability have been associated with the trapezius and serratus anterior muscle has been linked with emergence of SD. There is evidence that shoulder pain, along with neck and back pain, is related to scapular dyskinesia, which is defined by impairment of scapula resting position and functions. They observed in their research that patients who has neck, shoulder or back pain are more likely to have type 1 or type 2 scapular dyskinesis.

The results of the current study agreed with Mona Faggal *et al.* results who conducted study to compare effect of scapular muscle training and PNF’s technique rhythmic stabilization exercises. They reported that study shows both techniques are equally effective interventions to specifically activate the scapular posterior tilting muscles, reduce shoulder pain, functional disability, scapular protraction and external/internal rotation ratio. Rhythmic stabilization was more effective intervention to improve trapezius/serratus anterior ratio and the scapular upward rotation in this study. They suggested that by activating the middle and lower trapezius parts before the glenohumeral prime mover (posterior deltoid) and the upper trapezius, these precise exercises effectively improve intermuscular as well as intramuscular timing of stabilizing portions of the trapezius muscle.

In this study rhythmic stabilizations exercises sho strength of lower trapezius and serratus anterior and type 1 SD by gradually improving scapula dynamic stability and reducing shoulder and upper back pain.

Conclusion

The present study concludes that rhythmic stabilization is effective in reducing pain and improving muscle strength of lower trapezius and serratus anterior and scapular position. Rhythmic stabilization is statistically effective in improving pain, muscle strength and scapular dyskinesis.

Appendix

Ethical clearance

Consent Form

Acknowledgement

I, take this wonderful opportunity to thank all the "Hands" which have joined together to make this project a Success.

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