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# Effect of Electrical Muscle Stimulation with Voluntary Contraction and Taping on Joint Position Sense in Asymptomatic Scapular Dyskinesic Patients

**Sood Ishita**[1], **Sen Siddhartha**[2*] **and Arfath Umer**[2]

[1]*Department of Musculoskeletal Disorders, Sardar Bhagwan Singh Post Graduate Institute of Biomedical Sciences and Research, Dehradun, India*

[2]*Department of Physiotherapy, Sardar Bhagwan Singh Post Graduate Institute of Biomedical Sciences and Research, Dehradun, India*

[*]**Corresponding author:** Sen Siddhartha, Associate Professor, Department of Physiotherapy, Sardar Bhagwan Singh Post Graduate Institute of Biomedical Sciences and Research, Dehradun, India, Tel: 01352685753; E-mail: siddhartha.pt@gmail.com

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## Abstract

**Background:** Shoulder complex impairments are related to activities and occupations that require prolonged working hours or repetitive overhead activities and show a high prevalence and are rated next to low back pain. The scapular musculature is often subjected to neglect when dealing with evaluation and treatment of shoulder injuries. However, evidence on scapular dyskinesia and serratus anterior is scarce. This study evaluates the effectiveness of two different treatment intervention on neuromuscular control (Joint position sense) in asymptomatic scapular dyskinesis patients. We hypothesized that electrical muscle stimulation with voluntary contraction is a better intervention as compared to taping to correct joint position sense.

**Methodology:** The study was conducted at research laboratory of Sardar Bhagwan Singh Post Graduate Institute of Biomedical Sciences And Research. Twenty female subjects with mean age 22.6 ± 0.96 with a bilateral scapular difference of 1.5 cm and no history of surgery at shoulder or back surgery were included in the study. The subjects were measured for lateral scapular slide test (LSST) at 0°, 45°,90° and joint position sense (JPS) using vernier caliper and digital inclinometer respectively.

**Results:** Mann Whitney's test for between group analysis shows that both taping and EMS with voluntary contraction are significant at 0° and 90° of LSST and non-significant at 45°and JPS.

**Conclusion:** The study demonstrated increase in joint position sense and scapular dyskinesis after electrical muscle stimulation with voluntary contraction and clinically our study leads to enhancement of proprioception by increasing JPS.

**Keywords:** Scapular dyskinesia; Joint position sense; Taping; Electrical muscle stimulation

## Introduction

The extreme complexity of shoulder joint results from the coordinated activity of five different articulations and the supporting soft tissue girdle. It is a mobile joint that relies on muscle control. Any perturbation to it has deleterious biomechanical consequences for the shoulder muscle girdle and will eventually lead to pain and other functional limitations [1-5].

The importance of scapula in maintaining adequate shoulder and upper extremity function has been recognized for many years [4]. The scapula plays several roles in facilitating optimal shoulder function where scapular anatomy and biomechanics interact to produce efficient movement [1]. When the scapula fails to perform its stabilization role, shoulder function is inefficient, which can result not only in decreased neuromuscular performance but may also predispose individual to shoulder injury [6-17]. Recently, increased attention has been given to inadequate or dysfunctional scapular control as a primary cause of shoulder pain and arm weakness not only in throwing or overhead athletes but also in general population using their arm frequently overhead [4]. The scapula plays major role in production of smooth, coordinated movement about the shoulder girdle. The functions are inter-related to maintain the glenohumeral relationship and provide stable base for muscle function [1]. Also, the scapula is a base for muscle attachment that stabilize the scapula attach to the medial border and control its position [1]. The scapular motion is controlled through synergistic co-contractions and force couples, which are paired muscles which control the position of the joint [18].

Muscle weakness is a common finding about the shoulder girdle and decreased support may lead to pathology [1,17]. Weakness of the scapulothoracic muscles potentially leads to abnormal joint positioning of scapula, disturbances in scapulohumeral rhythm and generalized shoulder dysfunction [19]. Most commonly weak muscles are serratus anterior, lower and middle trapezius and rhomboids [1,11]. The scapular musculature is often neglected in the evaluation and treatment of shoulder injuries and dysfunction. Dysfunction in the scapular stabilizers often results in abnormal stress to anterior capsule, increased rotator cuff compression decreased performance and Scapular Dyskinesia.

Scapular dyskinesia is the alteration in the normal static or dynamic position or motion of the scapula during coupled scapulohumeral movements [11]. There are many proposed mechanisms that can lead to scapular dyskinesis like postural imbalance or anatomical disruption, nervous injury, lack of muscular/capsular flexibility,

muscle imbalance or weakness, proprioceptive dysfunctions [11]. Muscle forces at shoulder play a predominant role in maintaining joint stability during motion [20-21]. Joint stability is important for coordinated performance of functional tasks of daily living as well as for demanding athletic skills [24]. Stability is afforded via factors such as degree of bony congruity, integrity of capsuloligamentous supporting structures and feedback loops involving joint and musculotendinous mechanoreceptors that are integrated by central nervous system [24]. The effect of loops is collectively known as Proprioception, it is the specialized variation of sensory modality of touch and encompasses the sensation of joint motion (kinesthesia) and joint position(joint position sense) [25]. The joint position sense is assessed by measuring the reproduction of passive positioning, maximally stimulating joint receptors, like Ruffini or Golgi type mechanoreceptors. It can be assessed by active positioning which stimulates both joint and muscle receptors and constitute a more functional approach of afferent pathways [5]. Several studies have stated that mechanoreceptors are responsible for proprioceptive feedback causing neuromuscular control and confer that muscle fatigue, sustained anterior dislocations feasibly affect the join propriocetions [25]. Direct physical trauma to ligaments and capsules causes proprioceptive loss [11]. Indirect disruption from effusion and haemarthrosis may provide incorrect positional information due to increased pressure and can deactivate neuromuscular pathways resulting in dyskinesis [11].

## Methodology

The study was performed on 20 female patients with mean age 22.6 ± 0.94 with asymptomatic scapular dyskinesia. It was an experimental study which was performed in the girl's hostel of Sardar Bhagwan Singh Post Graduate Institute of Biomedical Sciences And Research Dehradun. The study was performed in accordance with the ethical considerations of the institute and proper consent was taken prior to the study. Before beginning with the procedure, the subjects were selected on the basis of convenient sampling methods and those selected had to satisfy the inclusion criteria and were given detailed explanation about the procedure. The exclusion criteria was subjects with dorsal scapular nerve involvement, cardiovascular and respiratory disorders, any skin related problem, allergy to tape and non-compliance of the subjects. All the subjects were randomly divided into two groups viz. Group-A where they received electrical muscle stimulation with voluntary muscle contractions and Group-B where they received only taping. Outcome was measured as joint position sense and lateral scapular slide test.

### Measurement of lateral scapular slide test

The subjects were asked to stand comfortably with their feet shoulder length apart. The position of scapula was measured by deriving the difference in side to side measurements of scapular distance in three test positions at the level corresponding to inferior angle.

Position 1 involves placement of shoulder in glenohumeral joint in neutral.

Position 2, the humerus is placed in a position of medial rotation with 45° of shoulder abduction in coronal plane.

Position 3, the upper extremity is placed in maximal medial rotation with 90° of shoulder abduction in coronal plane.

The measurements of scapular position are taken bilaterally from the inferior angle of the scapula to the spinous process of thoracic vertebra in the same horizontal plane in all three positions. A bilateral difference of greater than 1.5 cm suggests scapular asymmetry. The measurements were taken with the help of vernier caliper [28-39].

### Measurement of joint position sense

Joint position sense was measured using the digital inclinometer. The measurements were taken with the subjects in relaxed normal posture. It was measured in accordance with subject's ability to actively recreate a randomly selected target position. To ensure JPS reproduction was affected through mechanoreceptors, subjects were blindfolded. The measures were taken by passively placing the dominant upper extremity to random target angle. The limb was held in the presented angle for 10 seconds and the subject was asked to concentrate on the position, and then the limb was returned passively to the neutral. The subject was instructed to reproduce the target angle. The difference between the presented angle and the angle that was repositioned by the subject was calculated as error of reproduction. The mean of three trials were calculated [21].

To measure the target angle (30° of scapular upward rotation) the lateral arm of the inclinometer was placed over the posterior-lateral acromion and the medial arm was placed over the root of scapular spine [15]. The hold button was pressed to record the measurement.

### Electrical stimulation with voluntary contractions

The subjects were positioned supine and were asked to raise their arm above their heads. The leads from the intellect 340 combo, Chattanooga group were positioned on the lateral side of the scapula, in the axilla providing stimulation to the serratus anterior directly. EMS was conducted at 70 Hz with a pulse width of 300 μseconds. The stimulation was prescribed to be 30 second on and 30 second off for 15 mins twice daily [3]. Along with stimulation, subjects were asked to position their arm at 90°, reaching towards the ceiling, elbow straight and were asked to reach towards the ceiling bringing their shoulder blade off the surface whomsoevers' they feel the contraction and rest when it is gone.

### Taping procedure

The subjects were asked to sit comfortably with their arm in 100-110° of abduction. The taping started from 2 cm medial to the scapular border following the line of ribs down to the mid axillary line. Four one third overlapping strips are applied with the origin and insertion pulled together and bunching the skin. Prior to the application of adhesive tape, skin preparation was done which included the use of protective barrier wipe beneath the tape to assist in maintaining the skin integrity. Initial tape comprised of 1 inch hypo-allergic non-woven bandage over which laid the zinc oxide adhesive tape.

## Results

Freidman's test was performed for sessions at week 0, 1 and 2. The results show significant difference ($p<0.001$) for LSST and JPS for group A pre and post intervention (Table 1, Figures 1-6).

Freidman's test has been performed for session at week 0, 1 and 2. The result shows significant difference ($p<0.001$) for JPS within group

B. The mean difference values for week 0, 1 and 2 were 1.43, 0.5, 1.76, 1.2 for group A and B respectively (Table 2 and Figure 5).

Mann's Whitney test has been performed between group A and B. The result shows significant difference ($p<0.05$) for weeks 1 and 2 at 0 and 90 degrees with values 0.001, 0.000, 0.007, 0.002 respectively whereas non-significant difference was found at 45 degrees with values of 0.755, 0.727 and 0.787 at week 0, 1 and 2 respectively (Tables 3 and 4).

Mann's Whitney test has been performed between group A and B. The result shows significant difference ($p<0.05$) with values 0.033 at 0 week and non-significant difference with values 0.493, 0.135 at 1 and 2 week respectively (Table 3).

| | Mean ± Standard Deviation | | | $\chi^2$ | P |
|---|---|---|---|---|---|
| | Week 0 | Week 1 | Week 2 | | |
| 0° | 1.73 ± 0.09 | 1.66 ± 0.12 | 1.42 ± 0.13 | 18.66 | 0.0001 |
| 45° | 1.86 ± 0.15 | 1.58 ± 0.26 | 1.26 ± 0.30 | 19.53 | 0.0001 |
| 90° | 2.04 ± 0.18 | 1.80 ± 0.23 | 1.49 ± 0.21 | 20.00 | 0.0001 |

**Table 1:** Within group analysis of lateral scapular slide test for Group-A

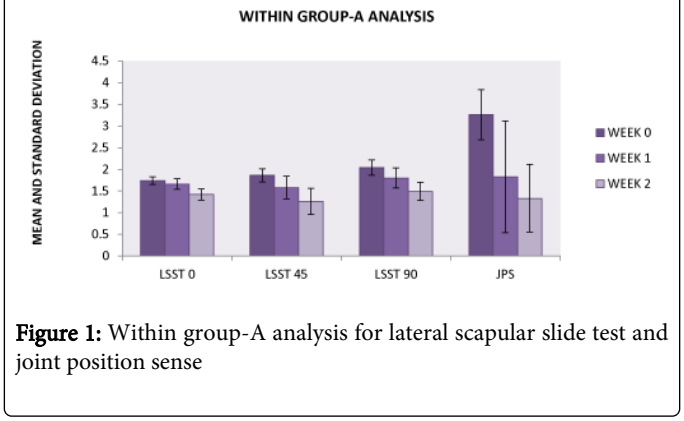


**Figure 1:** Within group-A analysis for lateral scapular slide test and joint position sense

| | Mean ± Standard Deviation | | | $\chi^2$ | P |
|---|---|---|---|---|---|
| | Week 0 | Week 1 | Week 2 | | |
| 00 | 1.74 ± 0.10 | 1.44 ± 0.09 | 1.09 ± 0.11 | 20.00 | 0.0001 |
| 450 | 1.87 ± 0.13 | 1.57 ± 0.10 | 1.17 ± 0.12 | 20.00 | 0.0001 |
| 900 | 1.97 ± 0.18 | 1.53 ± 0.20 | 1.12 ± 0.19 | 20.00 | 0.0001 |

Table 2: Within group analysis for lateral scapular slide test of Group-B

| | Mean ± S.D | | | χ2 | p |
|---|---|---|---|---|---|
| | Week 0 | Week 1 | Week 2 | | |
| GROUP A | 3.26 ± 0.58 | 1.83 ± 1.29 | 1.33 ± 0.78 | 13.28 | 0.0001 |
| GROUP B | 3.86 ± 0.47 | 2.10 ± 0.58 | 0.90 ± 0.56 | 20 | 0.0001 |

**Table 3:** Within Group A and B analysis for joint position sense

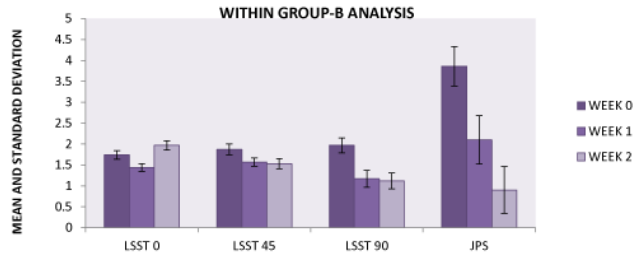


**Figure 2:** Within group-B analysis for lateral scapular slide test and joint position sense

| Variable/week | Week 0 | Week 1 | Week 2 |
|---|---|---|---|
| LSST 0 | 0.874 | 0.001* | 0.000* |
| LSST 45 | 0.755 | 0.727 | 0.787 |
| LSST 90 | 0.259 | 0.007* | 0.002* |
| JPS | 0.033 | 0.493 | 0.135 |

**Table 4:** Between Group A and B analysis

*Significance at 0.05 level

## Discussion

On the basis of mean difference and of LSST and JPS, we try to find out an intervention and propose that electrical muscle stimulation can be considered as a better remedy for correcting the Joint position sense in scapular dyskinesia.

In the study, the advantages of electrical muscle stimulation was observed on improving Joint position sense and LSST, suggesting that electrical muscle stimulation with voluntary contraction is more effective in improving scapular dyskinesia. Scapular dyskinesia is related with many problems and impairments resulting in substantial effect on daily living activities and directly affecting the joint position sense due to disruption of normal neuromuscular reflex joint stabilization contributing to excessive strain in capsule and ligaments and thus increasing the potential for shoulder injury. With regards to our results, we try to document an intervention that would improve patient's disability and enable them to return to normal activity and we propose that electrical muscle stimulation with voluntary contraction serves the purpose.

In group B, the study revealed a significant effect of electrical muscle stimulation with voluntary contraction on scapulothoracic JPS. The above can be explained as when muscle contracts as a result of Electrical stimulation, the changes taking place in muscle are similar to those associated with voluntary contraction. The changes may have arisen from the facilitation of spinal motoneuron pools via the stimulation of afferent pathways, increased sensitivity of neural synapses and better synchronization of motor unit firing pattern. The selective recruitment of large twitch type II fibers over slow twitch type

II fibers can be implicated. The improvement in the muscle strength may have been achieved through increase in the muscle bulk as a result of repetitive contraction. In a study conducted by Michael V Hurley on sensory-motor changes suggests that articular mechanoreceptors may also evoke abnormal sensory information which decreases voluntary activation in patients. Afferent fibers from articular mechanoreceptors projects on alpha motoneuron and activate the extra fusal muscle fibers. It has been stated in a study conducted by that articular mechanoreceptors afferent fibers project on gamma motoneurons in spinal cord. The gamma motor neurons activate the intrafusal muscle fibers and govern the muscle spindle sensitivity. Any changes in the articular mechanoreceptors would evoke sensory inputs that decrease muscle spindle sensitivity and thus decreasing proprioception acuity. The role of proprioceptive mechanism in the maintenance of shoulder joint stability is very important. It has been postulated that gamma motoneurons innervating the intrafusal fibres are activated simultaneously with alpha motoneurons which innervate the extrafusal muscle fibers. This co-activation maintains the sensitivity of the muscle spindle afferents. The physiological effects of muscle stimulation can be explained as direct muscle stimulation produces muscle contraction by transcutaneous peripheral nerve stimulation. The contraction can be produced directly through depolarization of motoneurons or indirectly through depolarization of sensory afferents. Stimulation recruits motor units in specific way which is different from physiological muscle recruitment during voluntary contraction and thus is responsible for strength gain. Muscle stimulation increases the metabolic demand compared to voluntary contraction with higher rates of phosphates and higher cell oxygen level. Studies have shown that neuromuscular electrical stimulation with or without voluntary contraction/exercises causes greater strength improvement than voluntary exercise alone and thus indirectly help in improving the joint position sense.

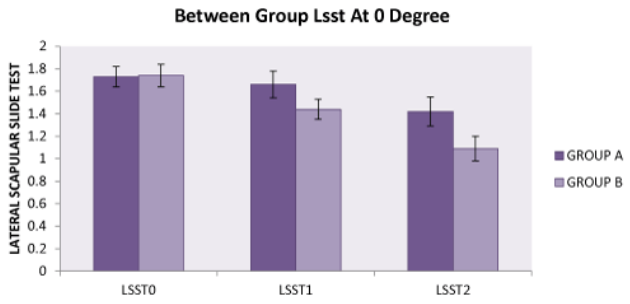


**Figure 3:** Between group analysis of lateral scapular slide test at 0 degrees

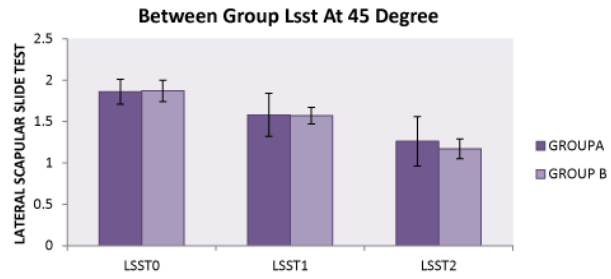


**Figure 4:** Between group analysis of lateral scapular slide test at 45 degrees

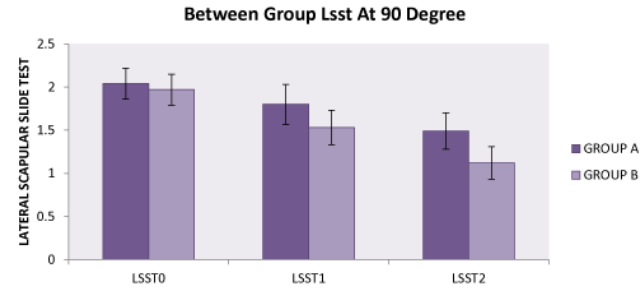


**Figure 5:** Between group analysis of lateral scapular slide test at 90 degrees

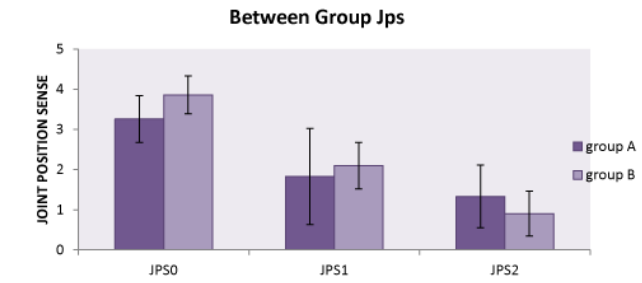


**Figure 6:** Between group analyses of joint position sense

In group A, there was significant improvement in JPS after taping. This can be supported on the basis of the theory that traction on the skin or pressure of the tape provides cutaneous sensory cues, thus providing proprioceptive inputs. The two most frequently proposed mechanisms are the proprioceptive and the mechanical. Tape stimulates the neuromuscular pathways via increased afferent feedback from cutaneous receptors. The mechanical effects are to relocate the joint n such a way so as to stabilize the joint and alter the muscle tension relationship [31]. Also, tape helps by providing cutaneous feedback to maintain correct posture via increased skin tension and improve resting alignment of related joints and length tension properties of shared muscles between scapula and regions of upper quadrant (Kessler) In a study conducted by Hall, Heigton and Payton, it was stated that repeated application of scapular taping may reduce

the negative feedback of participants or even allow adaptation of neural pathways by consistent correct proprioceptive feedback [3].

In another research conducted by F. Conteiro, M Bullutoro, revealed that tape aims to influence the resting muscle tone by acting on the connections within the connective tissue, precisely between the skin, superficial fascia and the deep fascia. These linkages allow to influence the tension of deep fascia in which proprioceptive receptors and neuromuscular spindles are present and any changes to the structure leads to motoneuronal excitation and increasing proprioception.

Also, exteroceptive afferent signals from skin are mixed and are integrated by brain cortex with those coming from proprioceptive receptors and pathways and thus increase the proprioception. Cutaneous receptors are more sensitive to pressure and pain sensation, muscle spindle receptors are sensory gamma – motoneurons present n muscle belly and are sensitive to change in position and velocity and these are innervated by onset of stimulus thereby affecting the proprioception (Schmidt and Lee). In a research conducted by Simmoneau. It is said that taping, applying pressure, stretching can stimulate the mechanoreceptors present in muscle spindles. Taping and bracing provide increased cutaneous stimuli as well as external support to the joint that they surround. The increased stimulation is provided through direct or indirect contact between the skin and the brace/tape which enhances proprioception and prevents injury or impairment (GuyGSummoriau).

There are contradictory findings reporting taping improves proprioception while sitting not in standing. Kinesiology tape on ankle joint found no difference between no tape and tape on conditions on proprioception as cutaneous ankle mechanoreceptors may rapidly accommodate and may not provide useful feedback during repeated movements [26]. Cools et al. in their study report that scapular taping technique does not affect the muscle function in normal pain free shoulders but possibly affect the neuromuscular control like muscle reaction time [34]. Both back pain and neck pain are major occupational health problems. In the workplace we tend to attain poor posture which leads to low performance levels and other associated musculoskeletal disorders. The cumulative trauma disorder causes loss of function and decreased work performance leading poor posture. Prolonged sitting and standing leads to forward head posture, myofascial disorder and slow rate repair of musculoskeletal system. Prior to the treatment, the subjects informed us about the unconscious attainment of bad posture viz. forward head and drooping or round shoulders, also pain in the upper back areas due to prolonged working hours leading to problems in the activities of daily living and easy fatigue during their work. Our treatment session served their complaints and at the end of the intervention they observed better posture and longevity in their workstation. This can be explained on the basis of strength gain through stimulation and proprioceptive feedback through taping.

## Limitation of the Study

The study was conducted on smaller sample size as there was less time to submit thesis for degree. It assessed proprioception with one methodological approach (active movement reproduction task) as opposed to other methods using passive movement reproduction. Different methods can be used including electrogoniometers, EMG analysis, Electrodiagnostic analysis.

## Clinical Significance

In our study, the effect of electrical stimulation with voluntary contraction and taping is seen on shoulder girdle and decreased support of shoulder due to weakness can lead to pathology leading to abnormal scapular positioning and disturbances in scapular humeral rhythm. These alteration cause generalized shoulder dysfunction, which can interfere with normal coordination and joint stability resulting in functional impairments around the shoulder girdle.

Also, any trauma to tissues disrupts neuromuscular pathways resulting in proprioceptive deficits and causing functional instability. In order to offset this progressive decline in function mechanoreceptors must be retrained so that an individual/athlete regain normal function and dynamic joint stability contributing to coordinated performance of functional tasks of daily living and meeting higher athletic demands. Thus, clinically our study leads to enhancement of proprioception by increasing joint position sense which makes joint more stable for coordinated movements and assure early return to the activity.

## Conclusion

The study demonstrated increase in joint position sense and scapular dyskinesis after electrical muscle stimulation with voluntary contraction and clinically our study leads to enhancement of proprioception by increasing JPS.

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