ISSN No:-2456-2165

Effectiveness of Myofascial Release and Muscle Energy Technique on Pectoralis Minor Length in Subjects with Shoulder Impingement Syndrome: A Comparative Study

Dr. Narayanavarapu Priyanka, Dr. Patchava Apparao, Dr. Rayudu.Geetha Mounika
Department of Physiotherapy, Swatantra Institute of Physiotherapy & Rehabilitation, Rajamundry, India
Corrresponding Author: N. Priyanka

**Abstract*:-* *Background and Objective* - Shoulder Impingement Syndrome (SIS) is a common cause of shoulder pain in adults. People with this condition experience pain related to the shoulder's tendons and soft tissues when lifting the arm overhead. The Pectoralis Minor muscle was found to be significantly more active during elevation in subjects with SIS. Increased activity is indicative of a shortened muscle. When this muscle is in a shortened position however, it can limit scapular upward rotation, which is necessary for shoulder elevation, while causing excessive anterior tilting and internal rotation of the scapula. The increased anterior tilt and internal rotation caused by Pectoralis Minor tightness mechanically reduce the Subacromial space, and has been associated with symptoms commonly seen with SIS. Physiotherapy techniques like Myofascial Release (MFR) and Muscle Energy Technique (MET) have been proposed as an adjunct to Conventional therapy to treat Shoulder Impingement Syndrome. Both the techniques have been proven to be effective on increasing Pectoralis Minor length, reducing Pain, improving Function in Subjects with Shoulder Impingement Syndrome and studies are limited on their Comparison. Hence need of the Study arise.

Methods - Prospective study design. 64 subjects with age groups between 18 and 35 years having a Clinical Diagnosis of Shoulder Impingement Syndrome were randomly allocated in to two groups. In Group A (n=32) subjects were treated with Myofascial Release (MFR) whereas in Group B (n=32) subjects received Muscle Energy Technique, Participants were given intervention thrice a week for 6 weeks. The outcome measures of this intervention were measured in term of VAS for Pain, SPADI for Function and PMI for Pectoralis Minor Length.

Result - Independent‘t’test was used to compare the mean significance difference between continuous variables. Paired‘t’test was used to assess the Statistical significance difference between Pre and Post test scores. Statistical analysis of the data revealed that within the group comparison, both groups showed significant improvement in all parameters. Whereas in between the group’s comparison Muscle Energy Technique showed better improvement when compared to Myofascial Release.

Conclusion - After 6 weeks of intervention, Both Myofascial Release and Muscle energy technique intervention showed significant improvement on Pectoralis minor length, Pain and function. However, Muscle Energy Technique group is found to be more effective when compared to Myofascial Release group. From the findings of the current study, it is recommended that Muscle energy technique protocol may be incorporated in the management of Shoulder Impingement Syndrome.

Keywords:- *Shoulder Impingement Syndrome, Pectoralis Minor Length, Myofascial Release, Muscle Energy Technique*

ISSN No:-2456-2165

I. INTRODUCTION

Shoulder pain is the third most common musculoskeletal complaint in orthopedic practice and Impingement Syndrome is one of the more common underlying cause. The prevalence of shoulder pain in India has been reported to be 7% to 34%, often with 26.4% for Shoulder Impingement Syndrome (SIS) as the underlying etiology with an incidence of 14.7 new cases per 1000 patients per year seen in clinics. Gender wise prevalent cause of shoulder pain with Subacromial Impingement in males 17.24% and in females 11.11% [1].

In 1972 **"Neer"** described it as a painful condition in which the soft tissues of the Subacromial space were entrapped and compressed between the humeral head and the coracoacromial arch, due to narrowing of subacromial space or superior migration of the humeral head caused by weakness or muscle imbalance. Typically occurs in younger individuals with pain located in the anterior or anterolateral aspect of the shoulder. The symptoms are usually activity-specific and involve overhand activities[2].
Neer categorised Impingement in to three stages namely[3] ,

- Stage-I is characterized by edema or bleeding of subacromial bursa and rotator cuff usually in people aged under 25 years;
- Stage-II represents fibrosis or tendinitis of rotator cuff usually occurs in patients aged between 25and 40 years of age with thickening and fibrosis of subacromial soft tissues;
- Stage-III includes tendon tear leading to progressive failure of limb motor function which is common in patients aged over 40 years.

Etiology of Shoulder Impingement Syndrome has both primary and secondary forms. Primary impingement is due to structural changes that mechanically narrow the subacromial space these include bony narrowing on the cranial side or an increase in the volume of the subacromial soft tissues due to Subacromial bursitis or calcific tendinitis on the caudal side. Secondary External Impingement related to abnormal Scapulohumeral kinematics, strength balance alteration resulting in functional disturbance in the centering of the humeral head, leading to an abnormal displacement of the center of rotation when the arm is elevated, Generally caused by weakness of the Rotator Cuff Muscles and scapular muscles[4].

Muscle tightness has been implicated in Shoulder Impingement. In particular, during elevation, anterior shoulder girdle muscle tension may affect the tension on the leading edge of the coracoacromial ligament, predisposing it to tightness ultimately leading to structural impingement. Shortening or tightness of Pectoralis Minor muscle is one of the potential biomechanical mechanism associated with scapular protraction by tilting it anteriorly and limits scapular upward rotation, and posterior tilt, thereby reducing subacromial space. The resting length of PM is identified as a potential contributor to detrimental shoulder kinematics; a reliable clinical assessment of resting length will be valuable for planning interventions and assess the effect of those interventions[5].

Measuring PM muscle length using the coracoid process and the fourth rib as origin-insertionlandmarks is considered the "gold standard" method. A tape measure demonstrated good reliability, to measure pectoralis minor muscle length, and is readily available and easily manipulated in clinical practice. The PMI was first proposed by "**Borstad and Ludewig"** to classify relatively short and long PM and evaluate the effect of PM length on scapula kinematics. In addition, a direct measurement is more useful for making clinical decisions about an individual patient [6].A thorough history and physical examination are key to the diagnosis of Shoulder Impingement Syndrome and Special tests are key components of the physical examination. Imaging studies are often performed to confirm the diagnosis and rule out other pathologies[6].

There are various Physiotherapy treatment protocols such as Cryotherapy, Massage, Stretching,, Strengthening, Dry needling, Soft tissue Mobilization, Manual Therapy procedures, Electrotherapy reported better outcomes with evidence on increasing muscle length, reducing Pain, Improving the functional activities of the Subjects with Secondary Shoulder Impingement Syndrome, Among them Myofascial Release and Muscle Energy Technique have drawn much attention in the management of Shoulder Impingement Syndrome. Studies suggested that these techniques are more effective in increasing muscle length, Reducing Pain, Improving Function in Shoulder Impingement Syndrome[7].

Both Myofascial Release and Muscle Energy Technique have been proved to be effective on increasing Muscle length, reducing Pain and improving Function in subjects with Shoulder Impingement Syndrome. However, literature is limited in their comparison. Hence, the need of the study arises.

II. METHODS AND MATERIALS

- *Study design:*

Prospective Study Design

- *Ethical clearance and informed consent:*

The study protocol was approved by the Ethical Committee of GSL Medical College & General Hospital; the investigator explained the purpose of the study and given the patient information sheet. The participants were requested to provide their consent to participation in the study. All the participants signed the informed consent and the rights of the included participants have been secured.

- *Study population:*

Subjects clinically diagnosed as Shoulder Impingement Syndrome by an Orthopedician. **Study setting**: The study was conducted at out Patient Department of Physiotherapy, GSL Medical College and General Hospital, Rajamahendravaram, Andhra Pradesh, India.

➢ *Study duration:*

The study was conducted during the period between July 2020 to June 2021

➢ *Sampling method:*

Systematic Random Sampling.

➢ *Intervention Duration:*

3 sessions a week for 6 weeks.

➢ *Sample size:*

A total of 100 subjects were screened in that 64 subjects were recruited who are willing to participate in the study. Recruited participants were explained the purpose and relevanceof the study. Those who willing to voluntarily be included in the study after obtaining informed consent. All eligible participants were conservatively randomized in to either Myofascial Release Group or Muscle energy technique Group with 32 in each group.

➢ *MATERIALS USED:*

Inch Tape.

A. Inclusion Criteria:

Subjects with unilateral Secondary Shoulder impingement syndrome diagnosed by orthopaedician and referred to physiotherapy OPD [8].

1. Both male and female subjects between the age of 18 and 35 years.
2. Pain of more than one month localized [anterior and or anterolateral] to the acromion
3. Pain at rest, aggravating at overhead activity or on lying on the affected shoulder
4. Pain with palpation of rotator cuff tendon.
5. Patients who show positive Neer impingement sign, Hawkins-Kennedy test, Painfularc syndrome, Empty can test.

B. Exclusion Criteria:

Documented US and/or MRI evidence of Stage III Impingement andclinical inability to lift the arm (drop arm sign) [9].

1. Primary Shoulder Impingement Syndrome
2. Recent history of Trauma, Contusion, fall, or Sudden Jarring. Dislocation of the Glenohumeral joints on the affected side.
3. Clinical findings of Shoulder Injury, Adhesive Capsulities,
4. Excluded if they had Ligament laxity based on Positive Sulcus Test, had Apprehension during Apprehension Test.
5. Known or suspected Polyarthritis, Rheumatoid Arthritis or diagnosed of fibromyalgia.

C. Outcome Measures

➢ *VISUAL ANALOGUE SCALE (VAS) [10]:*

is a numerical scale which measures the pain of the individual. It is a 10 cm line with one end marked as Zero indicates no pain and other end with Ten indicates intolerable pain or worst type of pain. Studies show that VAS has high amount of reliability and validity and can be used as a measurement tool. VAS was used to measure Pain at baseline and at the end of 6 weeks [13].

➢ *THE SHOULDER DISABILITY INDEX (SPADI) [11]:*

The shoulder pain and disability index is a self-report questionnaire developed to measure the pain and disability associated with shoulder pathology. The SPADI consists of 13 items in two subscales: pain "5 items" and disability "8 items". Validity was established by correlating SPADI total and subscale scores with shoulder range of motion. SPADI was used to measure Shoulder disability at baseline and at the end of 6weeks.

➢ *PECTORALIS MINOR LENGTH (PMI) [12]:*

A standard tape technique is used to obtain the linear measurement of pectoralis minor muscle length. Participants stood upright and distance from the inferomedial aspect of 4th rib to the coracoids process of scapula was measured in centimetres, this distance was measured by participants in height in centimeters, 3 trails were performed and averaged for analysis. This measurement has been shown to have high intra-rater reliability over a 7 day period. PMI was used to measure Pectoralis minor muscle length at baseline and at the end of 6 weeks.

Pectoralis Minor Index =Pm Length (Cm)/Subject Height (Cm) X100

D. Intervention

➢ *PROCEDURE FOR PML MEASUREMEN[13]:*

Participants were positioned in supine; A pillow placed under their head, without impacting upon the shoulder position. Both arms relaxed by their sides, elbows were extended with the palm of the hand against their thighs. The medial border of the anterior aspect of the coracoid process was palpated and then the fourth rib. The measurement was taken with a tape measure between these points. The tape measure was removed before two further measurements were then repeated and the average was taken

➢ *GROUP A MYOFASCIAL RELEASE TECHNIQUE[14]:*

Subject's position was supine lying with shoulder flexed to 90 to 120 degrees. The investigator was standing by the side of the patient at the angle of 45 degree from midline of the patient, investigator's thumbs slide underneath the pectoralis minor and the hands grasped the muscle firmly between the thumbs and fingers, is gently lifted or bent away from the thorax. With one hand maintaining the same position as described above, the thumbs moved posteriorly until in contactwith the pectoralis minor. The muscle is difficult to palpate, but if the ribs are palpable, the muscle is being palpated. The thumbs pressed onto the pectoralis minor, and a gentle "cross-friction type" technique performed.

➢ *GROUP B MUSCLE ENERGY TECHNIQUE[15]:*

The subject is in a side-lying position for application of the method for shoulder flexion, abduction and the supine position for shoulder internal and external rotation. The

therapist stands by the sideof the subject. The therapist performs the movement when the first physiological barrier is reached, the subject is asked to oppose the movement utilizing no more than 20% ofavailable strength, building up force slowly. This effort is firmly resisted, and after 7-10 seconds the subject is instructed to cease the effort simultaneously with the therapist gradually.

After complete relaxation, the shoulder is moved to the next restriction barrier

Fig: 1 Pectoralis Minor Muscle Length

Fig: 2 Therapist Performing Myofascial Release

Fig: 3 Therapist Performing Muscle Energy Technique

Fig: 4 Subject Performing Seated Rows

Fig: 5 Therapist Performing Lateral Pull Downs

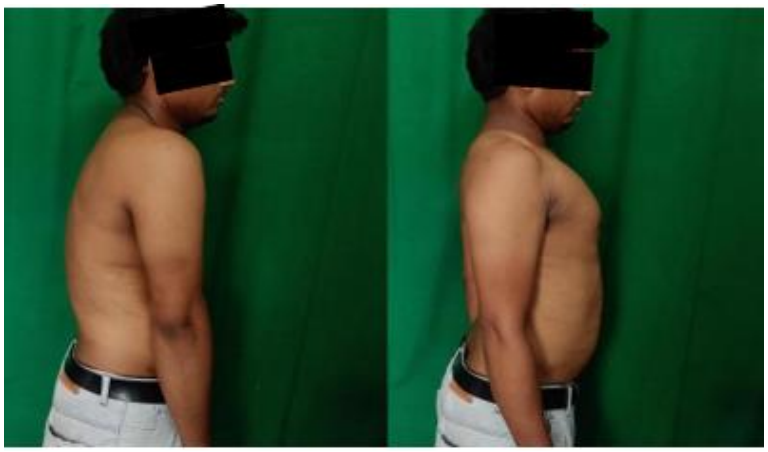

Fig: 6 Scapular Protraction and Retraction Exercises

Fig: 7 Subject performing, Depression Elevation, Internal and External Rotation

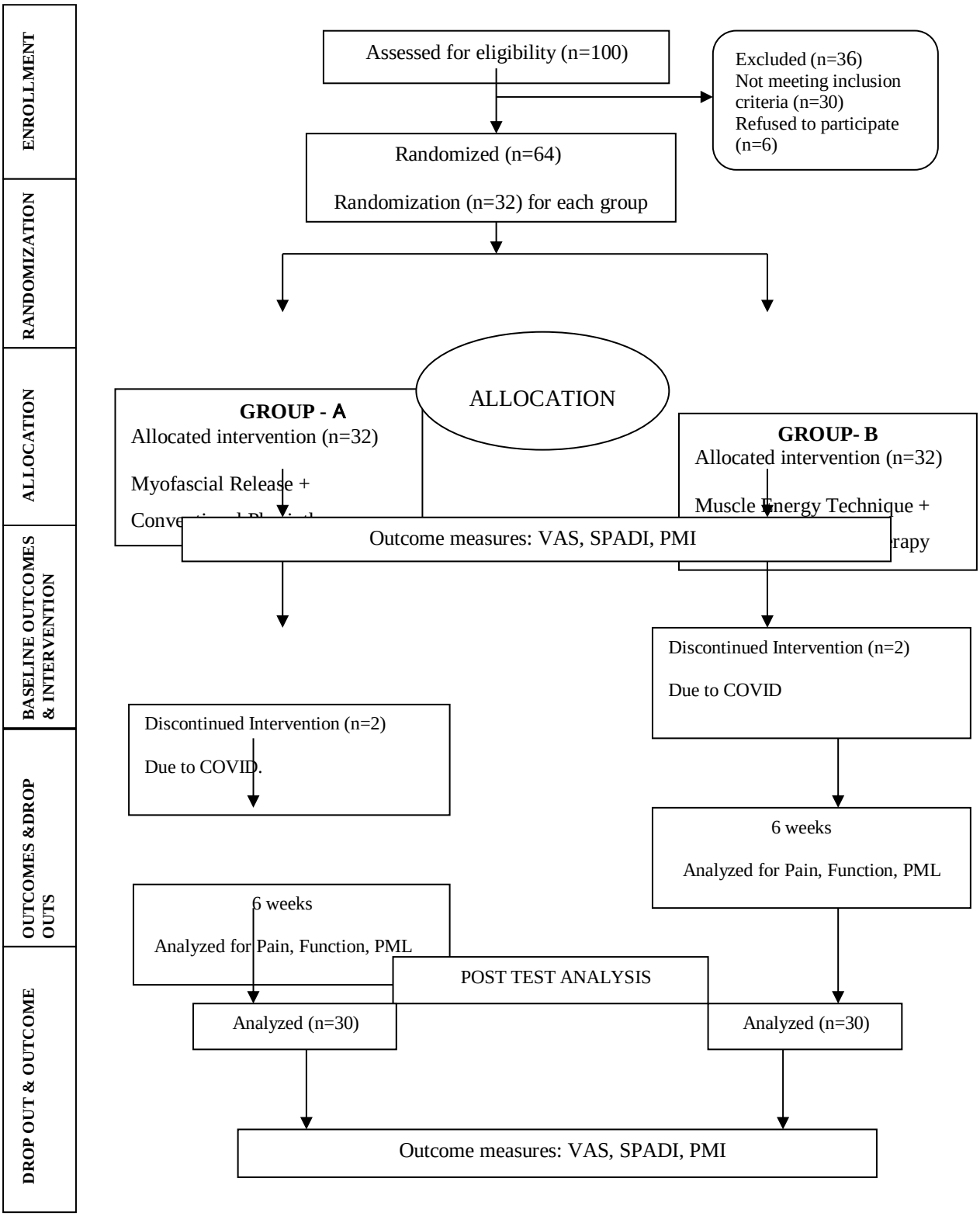

Fig: 8 FLOW CHART

➢ *CONVENTIONAL PHYSIOTHERAPY: STRENGTHENING:*

The strengthening program was standardized in terms of the exercise, but the number of repetitions and order of exercises was varied on a case-by- case basis across 18 sessions over 6 weeks[16].

Group	Outcome	Pre (Mean ± SD)	Post (Mean ± SD)	p-value
GROUP A	VAS	7.76 ± 0.817	5.1±0.758	0.0004
	SPADI	70.97 ± 6.767	59.08±5.272	0.000
	PMI	10.77±1.978	10.98±2.019	0.0001
GROUP B	VAS	7.8±0.805	59.08±5.272	0.000
	SPADI	72.97±6.767	69.65±5.655	0.002
	PMI	11.02±0.483	11.96±0.550	0.0002

Table 1

- Scapular stabilizers with lateral pull-downs
- Rowing
- Shoulder shrugs and scapular protraction/retraction exercises in the supine position
- Rotator cuff muscles with resistance bands during internal and external rotations, the coordination of muscles with compound movements.

III. RESULTS

The results of the study were analysed in terms of Reduction of Pain on Visual Analogue Scale and decrease in Shoulder Disability on SPADI, Increase in Pectoralis Minor length on PMI.

The consort flow chart of the study organization in terms of Subjects screening, Random allocation and analysis following the intervention.

A total of 100 subjects were screened for eligibility, Amongst 64 subjects were included in the study trail. All the 64 subjects who met inclusion criteria have undergone baseline assessment and included.Subjects were randomized into two equal groups consisting 32 subjects each. In this study 30participants completed training in Group A and 30 participants completed training in Group B with dropouts of 2 in each group.

Comparison is done within the group as well as in between the two groups. So as to evaluate the intra group and inter group effectiveness of Myofascial Release and Muscle Energy Technique on Pectoralis Minor Length which are under considerations in the Present study.

A. Analysis Within the Group

Outcome	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
VAS	6.2±0.924	5.1±0.758	0.0005
SPADI	69.65±5.655	59.08±5.292	0.0004
PMI	10.98±2.019	11.96±0.550	0.0003

Table 2

B. Statistical Analysis

All statistical analysis was done by using SPSS software version 21.0 and Microsoft excel-2007. Descriptive data was presented in the form of mean ± standard deviation and mean difference Percentages were Calculated and Presented.

➢ *Within the groups:*

Paired Student "t" test was performed to assess the statistical difference within the groups for Pain, Shoulder Function, and PMI from Pre-test and Post-test values.

➢ *Between the groups:*

Independent student "t" test was performed to assess the statistically significant difference in mean value between the groups Visual Analogue Scale for Pain, Shoulder Pain Disability Index for Function and Pectoralis Minor index for Pectoralis Minor length.

For all statistical analysis, $P< 0.05$ was considered as statistically significant

IV. DISCUSSION

The aim of the study was to evaluate the Effectiveness of Myofascial Release (Group-A) andMuscle energy Technique (Group-B) on Pectoralis Minor length in subjects with Shoulder Impingement Syndrome. In this study subjects were assessed for Pain, using VAS, and for function, SPADI and PMI for Pectoralis Minor length.

In this study (Group-A) Myofascial Release group showed statistically significant difference within the groups from pre-test to post-test values on increasing the length of

Pectoralis Minor muscle, reducing Pain, Improving function in subjects with shoulder impingement.

In this study (Group-B) Muscle Energy Technique group showed statistically significant difference within the groups from pre-test to post-test values on increasing the length of Pectoralis Minor muscle, reducing Pain, Improving function in subjects with Shoulder Impingement.

In MFR, the gentle forces applied to the facial restrictions will elicit vasomotor response and increase blood flow to the affected area, thereby enhancing lymphatic drainage of toxic metabolic wastes. It also realigns the facial planes, and most importantly resets the soft tissue proprioceptive sensory mechanism. This latter factor reprograms the centralnervous system, enabling a normal functional range of motion without eliciting the old pain pattern. "Paul J et al", explained that MFR improves the vertical alignment and lengthens the body providing more space for proper functioning of osseous structures, nerves, muscles, blood vessels and organs which improves the function[17,18].

"Barnes MF" claimed that as a result of MFR, there is change in the viscosity of the ground substance of the muscle and fascia which can restore proper alignment of the muscle fiber and increase the joint mobility. He explained that MFR made the fascia elongated, softened and more pliable thereby, helping to restore the normal length of the fascia. Thus, it can be helpful to increase the flexibility and joint ROM. The resultant muscle relaxation may encourage a copious return of blood and oxygen, which dramatically elevates pain threshold and encourage healthy, compliant tissue. This promotes healing, reduces pain and pressure in the fibrous band of connective tissue or fascia by breaking up the adhesions[19].

According to **"Kidd,"** MFR is inherently not evidence-based medicine. Kidd argued that because the application of MFR relies on clinician-patient interaction, it cannot be a neutral treatment; therefore, the subjectivity of the interaction cannot be removed when we try to determine its outcome[22]. Our results are supported by Kidd indicated that much of the effect of MFR relies on the skill of the clinician and his or her ability to sense the changes in the tissue. In addition, biological effects of touch can change the effectiveness of the treatment, depending on the state of either the clinician or the patient[20].

According to **"Greenman"** Muscle energy technique is an active method of voluntary contraction of muscle against the counterforce of the movement. Mechanism of the MET's on pain reduction and activity improvement are clearly unknown, but various hypothesis suggests that muscle and joint mechanoreceptors which involve centrally mediated pathways including periaqueductal gray matter in midbrain and noradrenergic plays a major role in descending inhibitory pathways. MET increases range of motion since the muscle extensibility is increased in around shoulder pain and there is a reflex relaxation and viscoelastic changes which could cause change in the stretch tolerance. The reduction in pain in MET is as a result of painful inhibition, through both the ascending and descending neurological passageway, after the activation of muscle and joint mechano-receptors over the course of the isometric contractions[21].

A shortened Pectoralis Minor restricts flexion of the shoulder joint by limiting scapular rotationand preventing glenoid cavity from attaining the cranial orientation necessary for complete flexion of the joint. When by applying the Myofascial Release and Muscle-Energy Technique individually on Pectoralis minor muscle MET have shown highly significant improvement in length with P value ($P<0.05$) Our results are supported by[22,23]. **Kluemper et al** that MET assist in lengthening the pectoralis minor, but this increased resting length was sustained for at least 48hours after the final application. Muscle length change greater than 1 cm is needed to identify a real change in pectoralis minor length at baseline and at the 6^{th} week[24]. The change in resting PML index showed a clinical significance in group B. Thus, MET should be considered when increased muscle length is desired for an extended period of time. Furthermore, because tightness of the pectoralis minor has been associated with the development of shoulder pain, this technique may assist in decreasing the prevalence of shoulder pain among subjects with overhead activities. However, further research is necessary to confirm this hypothesis[25].

Sturyf et al reported that a 6-week program involving Scapular focused strengthening of the Rotator cuff muscles will improve scapular dynamics. Due to the association between scapular orientation and shoulder pain, the MET technique we used may also assist in decreasing the risk of shoulder injury[26]. **Die drichsen et al** suggested that Strengthening Exercises should be a part of conventional physiotherapy for SIS and are efficient in improving the muscular imbalance, correcting scapular alignment in subjects with shoulder impingement[27,28]. Insufficient scapular positioning can lead to decreased glenohumeral rotation strength, altered neuromuscular-activation patterns, an increased risk of developing subacromial and internal impingement syndrome. Such that Strengthening of weakened muscles leads to biomechanical movement and obtaining appropriate direction of abnormal parts. Stretching the shortened muscle mutually with strengthening the weaken muscles has considerable influence on improving the abnormal scapular kinematic[29,30].

The study shows that Shortening of Pectoralis Minor length is one of the potential contributer for abnormal scapulohumeral dynamics in shoulder impingement syndrome. In the present study, both MFR and MET are individually proven to be effective in pre-test to post-test comparison on increasing Pectoralis Minor length, reducing pain and improving function in subjects with Shoulder impingement syndrome. But in between the group comparison MET with conventional physiotherapy have proven to be highly significant in improving pain and function, increasing the length of Pectoralis Minor.

This study proved that MET along with Conventional Physiotherapy were effective in increasing the Pectoralis. Minor length, reducing pain and in improving the function in subjects with shoulder impingement syndrome than MFR along with Conventional physiotherapy

Hence, we can conclude that subjects with Shoulder Impingement Syndrome can achievesignificant results using MET along with Conventional physiotherapy.

V. CONCLUSION

The present study concluded that six weeks of Interventions of Myofascial Release along with Conventional Physiotherapy and Muscle Energy Technique along with Conventional Physiotherapy were shown statistically significant difference in increasing muscle length reducing Pain and improving Function. However more percentage of improvement was found in subjects received Muscle Energy Technique along with Conventional Physiotherapy when compared to Myofascial Release along with Conventional Physiotherapy.

From the findings of the current study, it is recommended the Muscle Energy Technique along with Conventional Physiotherapy protocol may be opted as a treatment of choice for increasing muscle length, reduction of Pain and improvement in function.

REFERENCES

[1]. Garving C, Jakob S, Bauer I, Nadjar R, Brunner UH. Impingement syndrome of the shoulder. Deutsches Ärzteblatt International. 2017 Nov;114(45):765.
[2]. Singh B, Bakti N, Gulihar A. Current concepts in the diagnosis and treatment of shoulder impingement. Indian journal of orthopaedics. 2017 Oct;51(5):516-23.
[3]. Singh S, Gill S, Mohammad F, Kumar S, Kumar D, Kumar S. Prevalence of shoulder disorders in tertiary care centre. Int J Res Med Sci. 2015 Mar;3(4):917-20.
[4]. Creech JA, Silver S. Shoulder impingement syndrome. StatPearls [Internet]. 2020 May
[5]. Umer M, Qadir I, Azam M. Subacromial impingement syndrome. Orthopedic reviews. 2012 May 9;4(2).
[6]. Garving C, Jakob S, Bauer I, Nadjar R, Brunner UH. Impingement syndrome of the shoulder. Deutsches Ärzteblatt International. 2017 Nov;114(45):765.
[7]. Creech JA, Silver S. Shoulder impingement syndrome. StatPearls [Internet]. 2020 May 7.
[8]. Morais N, Cruz J. The pectoralis minor muscle and shoulder movement-related impairments and pain: Rationale, assessment and management. Physical Therapy in Sport. 2016 Jan 1;17:1-3.
[9]. Richards, Erika Jaci. Relationship between Pectoralis Minor Length, Subacromial Space, and Pain in Swimmers and Overhead Athletes. Brigham Young University, 2017.
[10]. Morais, Nuno, and Joana Cruz. "The pectoralis minor muscle and shoulder movement-related impairments and pain: Rationale, assessment and management." Physical Therapy in Sport 17 (2016): 1-13.
[11]. Gurudut, Peeyoosha, Aarti Welling, and Gayatri Kudchadkar. "Combined Effect of Gross and Focused Myofascial Release Technique on Trigger Points and Mobility in Subjects with Frozen Shoulder-A Pilot Study.
[12]. Başkurt, Zeliha, et al. "The effectiveness of scapular stabilization exercise in the patients with subacromial impingement syndrome." Journal of back and musculoskeletal rehabilitation 24.3 (2011): 173-179.
[13]. Kaur, Paramdeep, and G. Jayaraman. "To Compare the Effectiveness of Myofascial Release (MFR) with Strengthening and Stretching with Strengthening to Improve the Rounded Shoulder Posture." Indian Journal of Physiotherapy & Occupational Therapy 13.2 (2019).
[14]. Bohunicky, Sarah. "Myofascial release of the pectoral fascia: Effect on shoulder posture, pectoral length, muscle activity, and movement performance." (2021).
[15]. Borstad JD.Measurement of pectoralis minor muscle length: validation and clinical application journal of orthopaedic and sports physical therapy.2008 Apr;38(4):169-74.
[16]. Erika jaci Richards, Relationship between pectoralis minor length, subacromial space, and pain in swimmers and overhead athlets. Department of exercise science, Brigham young university.2017
[17]. Morais and Cruz, The pectoralis minor muscle and shoulder movement related impairment and pain: Rationale, Assesment and management.oct 2015.
[18]. Alex Urfer Physical therapy management of an elite rock climbers with subacromial impingement syndrome. Idaho state university, Department of physical and occupational therapy.29- Apr -2018.
[19]. Dayana P.Rosa, john D. Borstad & Paula R. Camargo, UNIMEP, Brazil. Reliability of measuring pectoralis minor muscle length in subjects with and without signs of shoulder impingement, 2015 Oct 1.
[20]. Green, Sally, Rachelle Buchbinder, and Sarah E. Hetrick. "Physiotherapy interventions for shoulder pain." Cochrane database of systematic reviews 2 (2003).
[21]. Turgut, Elif, Irem Duzgun, and Gul Baltaci. "Effects of scapular stabilization exercise training on scapular kinematics, disability, and pain in subacromial impingement: a randomized controlled trial." Archives of physical medicine and rehabilitation 98.10 (2017): 1915-1923.
[22]. Wang, Che-Hsiang, et al. "Stretching and strengthening exercises: their effect on three-dimensional scapular kinematics." Archives of physical medicine and rehabilitation 80.8 (1999): 923-929.
[23]. Van de Velde, Annemie, et al. "Scapular-muscle performance: two training programs in adolescent swimmers." Journal of athletic training 46.2 (2011): 160-167.
[24]. Morais and Cruz, The pectoralis minor muscle and shoulder movement related impairment and pain: Rationale, Assesment and management.oct 2015.

[25]. Alex Urfer Physical therapy management of an elite rock climbers with subacromial impingement syndrome. Idaho state university, Department of physical and occupational therapy.29- Apr -2018.
[26]. Dayana P.Rosa, john D. Borstad & Paula R. Camargo, UNIMEP, Brazil. Reliability of measuring pectoralis minor muscle length in subjects with and without signs of shoulder impingement, 2015 Oct 1.
[27]. Green, Sally, Rachelle Buchbinder, and Sarah E. Hetrick. "Physiotherapy interventions for shoulder pain." Cochrane database of systematic reviews 2 (2003).
[28]. Turgut, Elif, Irem Duzgun, and Gul Baltaci. "Effects of scapular stabilization exercise training on scapular kinematics, disability, and pain in subacromial impingement: a randomized controlled trial." Archives of physical medicine and rehabilitation 98.10 (2017): 1915-1923.
[29]. Wang, Che-Hsiang, et al. "Stretching and strengthening exercises: their effect on three-dimensional scapular kinematics." Archives of physical medicine and rehabilitation 80.8 (1999): 923-929.
[30]. Van de Velde, Annemie, et al. "Scapular-muscle performance: two training programs in adolescent swimmers." Journal of athletic training 46.2 (2011): 160-167.