EFFICACY OF MYOFASCIAL TRIGGER POINT DRY NEEDLING WITH & WITHOUT PARASPINAL NEEDLING IN PATIENTS WITH ADHESIVE CAPSULITIS. A RANDOMIZED CLINICAL TRIAL

Thesis Submitted for the Award of the Degree of

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DECLARATION

I, hereby declared that the presented work in the thesis entitled "**EFFICACY OF MYOFASCIAL TRIGGER POINT DRY NEEDLING WITH & WITHOUT PARASPINAL NEEDLING IN PATIENTS WITH ADHESIVE CAPSULITIS. A RANDOMIZED CLINICAL TRIAL**" in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision of Dr. Suresh Mani, working as Professor, in the Department of Physiotherapy/Lovely School of Allied Medical Sciences of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph.D. thesis entitled "**EFFICACY OF MYOFASCIAL TRIGGER POINT DRY NEEDLING WITH & WITHOUT PARASPINAL NEEDLING IN PATIENTS WITH ADHESIVE CAPSULITIS. A RANDOMIZED CLINICAL TRIAL**" submitted in fulfillment of the requirement for the reward of degree of **Doctor of Philosophy (Ph.D.)** in the Department of Physiotherapy, Lovely School of Allied Medical Sciences is a research work carried out by Varun Kalia, 41400150, is bonafide record of his original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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ABSTRACT

Background: Adhesive Capsulitis (AC) of the glenohumeral joint is a chronic debilitating musculoskeletal condition that affects between 2 to 5.3 percent of the global population in the world. It causes pain, impaired range of motion (ROM), and diminished myofascial kinetics due to fibrosis of the capsules and ligaments. Myofascial trigger points (MTrPs) in the shoulder girdle muscle may impose a further restriction on the shoulder function in the AC population. Therefore, in subjects with AC, myofascial trigger point dry needling (MTrP-DN) with and without paraspinal dry needling (PSDN) intervention and other conservative therapies would improve clinical outcomes. However, there is insufficient evidence to support the local MTrP-DN with and without PSDN for AC management.

Objective: To evaluate the effectiveness of MTrP-DN with and without PSDN in improving shoulder pain, range of motion, pressure pain threshold (PPT), and physical disability among subjects with AC.

Research Methodology: A total of 210 (98 male &112 female) clinically diagnosed subjects with AC were recruited from a multi-specialty hospital and randomly assigned to three groups. G1: Local MTrP-DN group (n=70) G2: Local MTrP-DN with PSDN group (n=70) G3: Conventional physiotherapy (CPT) group (n=70). The outcome measures included pain intensity (VAS), shoulder ROMs (Goniometer), disability (SPADI), and pressure pain threshold (pressure algometer) were assessed at baseline and 12^{th} day of the intervention.

Results: No significant difference was found between the three groups regarding the sociodemographic and primary outcomes at baseline. All shoulder ROMs (except abduction), pain intensity, SPADI, and PPT improved (statistically) significantly ($p < 0.05$) in "Group 1" and "Group 2" compared to "Group 3," but there was no significant difference among both "G1" and "G2."

Conclusion: Local MTrP-DN is an effective treatment technique when combined with conventional physiotherapy intervention, but PSDN has no additive effect on outcome measures in subjects with AC. Previous studies show the effectiveness of PSDN only in muscles attached to the spinal column but not in distant muscles, but the present study denies the effectiveness of PSDN in muscles around the shoulder joint.

Keywords: Adhesive Capsulitis, Physiotherapy, Pain, Disability, Impairment.

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Date:

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LIST OF ABBREVIATIONS

Abbreviations	Full Form
AC	Adhesive Capsulitis
AChE	Acetylcholinesterase
AChR	Acetylcholine receptor
APTA	American Physical Therapy Association
AROM	Active range of motion
ASES	American Shoulder and Elbow Surgeons Score
CSI	Corticosteroid injection
DASH	Disabilities of the Arm, Shoulder and Hand Questionnaire
DN	Dry Needling
EPA	Electrophysical agents
ESWT	Extracorporeal Shockwave Therapy
GH	Glenohumeral
IC	Ischemic compression
IFT	Interferential Therapy
LLLT	Low-Level Laser Therapy
MT	Mirror therapy
MTrP-DN	Myofascial trigger point dry needling
MTrPs	Myofascial trigger points
MUA	Manipulation under anesthesia
MWD	Microwave Diathermy
OC	Oral corticosteroids
PPT	Pressure pain threshold
PROM	Passive range of motion

PSDN	Paraspinal dry needling
PSS	Penn Shoulder Score
PTI	Physical therapy interventions
RCT	Randomized clinical trial
ROM	Range of motion
S&S	Spray and Stretch
SC	Sternoclavicular
SPADI	Shoulder pain and disability index
SSNB	Suprascapular nerve block
SWD	Short wave diathermy
TENS	Transcutaneous Electrical Nerve Stimulation
TPCR	Trigger point compression release
TrPs	Trigger points
UST	Therapeutic Ultrasound
VAS	Visual analog scale

OPERATIONAL DEFINITIONS

Term	Definition
Shoulder Pain and Disability Index (SPADI) (Breckenridge & Mcauley, 2011)	SPADI is internationally accepted for self-reporting pain and disability by using 13 items which includes a 5-item subscale to measure pain and an 8-item subscale that measures disability.
Pressure Pain Threshold (PPT) (Maquet et al., 2004)	PPT is defined as the minimum force applied which induces pain in the trigger point region in muscle.
Visual Analog Scale (Delgado et al., 2018)	The visual analog scale (VAS) is a validated, subjective measure for acute and chronic pain. Scores are registered by creating a handwritten mark on a 10-cm line that represents a scale between “no pain” and “worst pain.”
Range of motion (Gajdosik & Bohannon, 1987)	Range of motion is the extent of movement of a joint, measured in degrees of a circle.

CHAPTER - I

INTRODUCTION

1.1 BACKGROUND

Adhesive Capsulitis (AC) is a disabling chronic musculoskeletal pathology of the glenohumeral joint that affects 2 to 5.3 percent of the global population (Elnady et al., 2020; Lundberg, 1969; Manske & Prohaska, 2008). The beginning of shoulder pain accompanied by a diminished range of motion (ROM) is predominantly expressed by subjects with AC. The AC may either be primary (idiopathic) or secondary. There is no definite etiology or underlying pathology associated with primary AC, and it occurs spontaneously, and they are the least understood but the most common type of AC. On the other hand, secondary AC mainly results from trauma (Le et al., 2017; Walker, Gabard, Bietsch, Masek-VanArsdale & Robinson, 1997), but over 3.8 & 4.3 percent were linked to thyroid disease and diabetes mellitus respectively (Bridgman, 1972; Chiaramonte et al., 2020; Lundberg, 1969). In addition, women are more affected by AC (approximately 70%) than men, but there is more risk for a more extended recovery period and more significant disability in men (Le et al., 2017).

While AC can impose a significant disability on individuals, it would also put a substantial burden on healthcare expenditure. Literature reported that the yearly health care and non–health care expenses of AC per episode are approximated to be $7,000 and $8,000, respectively, with the societal cost estimated to be $55 per session (Cohen & Ejnisman, 2015; Hout et al., 2005). $53 per hour was the cost of home nursing care after hospitalization for the treatment of AC with manipulation under anesthesia and acromioplasty. Home care services also cost $30 per hour (Berg et al., 2005), So the evaluated significant burden on the subject and the community suggested to achieve speed up healing, effective early management of AC is warranted (Hout et al., 2005).

While chronic inflammation-induced fibrosis of shoulder capsules and coraco-humeral ligaments (Akbar et al., 2019; Neviaser, 1945) could have reasoned restricted shoulder ROM, the recent evidence elucidates impaired myofascial kinetics, shoulder girdle muscle tightness, and myofascial trigger points (MTrPs) which could additionally limit shoulder ROMs (Page & Labbe, 2010; Ughreja et al., 2019). In regular clinical practice, AC with restricted ROM has been managed with a variety of treatment approaches. However, the most successful treatment for this chronic disability condition remains under debate, and no specific treatment protocol has yet been developed (Jason et al., 2015). Furthermore, the literature reported several treatment options such as electrotherapy modalities, joint mobilization exercise, dynamic splinting, stretching, and total end range time (Jason et al., 2015), though complete recovery was not attained with existing treatment protocols. Several studies have shown that the subject experiences long-term pain, stiffness, and disability despite regular conservative treatment (Hand et al., 2008; Koh, 2016). It was reported that 15 percent of AC subjects still reported long-term disability, 7 to 15 percent permanent functional loss, and persistent symptoms in 40 percent following conservative interventions (Koh, 2016). Therefore, there is a need for effective early treatment strategies that can help in the early recovery of subjects with AC.

MTrPs in the shoulder girdle muscles could be a possible non-articular cause of pain and restricted ROM in AC (Sukumar & Lawrence, 2014). The MTrPs are focal, hyperirritable areas of increased tension within a muscle. Recently, there has been growing evidence to support the clinical efficacy of myofascial trigger point dry needling (MTrP-DN) for the effective treatment of various musculoskeletal pain conditions (Puentedura et al., 2017). In the process of dry needling (DN), “a solid monofilament needle is inserted into the muscle area with motor anomalies (i.e., taut bands) to decrease discomfort and promote expected muscle functions” (Dommerholt, 2011; Pavkovich, 2015). Page and Labbe (2010) reported that MTrPs in the muscle of the subscapularis induced restricted flexion and external shoulder joint rotations (Page & Labbe, 2010). In another study, Clewley et al. (2014) concluded in a case series that combining MTrP-DN intervention with conservative therapies improved the prognosis of subjects with AC (Clewley et al.,

2014). Besides, Hyuk et al. (2007) have endorsed MTrP-DN along with paraspinal dry needling (PSDN), which improves pain, depression, and cervical ROM in elderly subjects with upper trapezius MTrPs (Hyuk et al., 2007). However, there is a scarcity of literature to aid the clinical efficacy of local MTrP-DN in conjunction with PSDN for the management of subjects with AC. Therefore, the purpose of this study is to check the effectiveness of MTrP-DN with and without PSDN in subjects with AC.

AC is a chronic progressive disease that affects the large general population and causes disability due to shoulder pain and restricted ROMs, which puts a substantial burden on healthcare expenditure. Previously clinicians thought that joint capsular tightness was the cause behind the formation of AC, and they used many different management techniques, but still, subjects reported disability even after the management. Presently clinicians came to know that not only tight joint capsule is responsible for AC, but impaired myofascial kinetics, shoulder girdle muscle tightness, and MTrPs around the shoulder joint could further restrict shoulder movements. Therefore, the present study evaluated the efficacy of MTrP-DN with and without PSDN in AC subjects.

1.2 RESEARCH PROBLEM

AC is a condition that is linked with pain & restricted ROM of the glenohumeral joint. This loss of mobility can impose substantial disability on many subjects. The cause of AC is poorly understood (Donatelli, 2012; Page et al., 2019). However, most of the authors believed that pathology lies within the joint capsule, i.e., inflammation & fibrosis of the joint capsule & coracohumeral ligament (Fields et al., 2019; Lundberg, 1969; Neviaser & Neviaser, 2011; Neviaser, 1945; Simmonds, 1949), but one recent study said that shoulder joint restriction is not just because of capsular & ligamentous tightness, but also a fascial restriction, muscular tightness & MTrPs are responsible for it (Page & Labbe, 2010). In previous years, most clinicians believed only in the theory of within joint pathology, so they treated the joint capsule only by using conventional physiotherapy (CPT) includes Short Wave Diathermy (SWD), Ultrasound Therapy (UST), Transcutaneous Electrical Nerve Stimulation (TENS) and joint mobilization (Griggs et al., 2000; Piumia et al., 2021). Various research have shown chronic pain, shoulder tightness, and disability following conventional management. Long-term disability was already reported in 15 percent, irreversible loss of function in 7-15 percent, & chronic clinical manifestation in 40 percent of AC subjects (Hand et al., 2008; Koh, 2016). Recently in 2014, two studies were published. One was the case report which reported that "MTrP-DN could be used as an adjunct treatment for a subject with AC of the shoulder" (Clewley et al., 2014), and the second, was a single-blinded randomized control trial, and they reported that intramuscular manual therapy was more effective than CPT and it can be used as a primary intervention tool in treating AC (Sukumar & Lawrence, 2014), and one more study reported the beneficial effect of PSDN in shoulder disability in an elderly population (Hyuk et al., 2007). But these studies were conducted with smaller sample size, and only shoulder abduction ROM was measured. So there is a need for a randomized clinical trial that will measure all shoulder ROMs, pain, pressure pain threshold (PPT), and disability to confirm the efficacy of DN with and without PSDN in AC.

1.3 RATIONALE

AC is a musculoskeletal condition that has a disabling capability (Elnady et al., 2020; Manske & Prohaska, 2008). Around 2 to 5.3 percent of the general population are affected by AC globally (Aydeniz et al., 2008; Bridgman, 1972; Elnady et al., 2020; Lundberg, 1969; Pal et al., 1986). Hout et al. (2005) found that AC laid a burden of $5556 per subject per year (Hout et al., 2005), Which is significant to the economy of the country that's why it should be one's priority to find cost-effective treatment for AC subjects. For the last many decades, researchers thought that AC was primarily a disorder affecting the joint capsule, so they were treating the subjects with the help of CPT methods, but various research has illustrated chronic pain, glenohumeral joint tightness, and disability following CPT. Long-term disability was already reported in 15 percent, irreversible loss of function in 7-15 percent, & chronic clinical manifestation in 40 percent of AC subjects (Hand et al., 2008; Koh, 2016). Additionally, literature reported that the MTrPs in the muscles present around the shoulder girdle may be a source of pain and mobility restriction (Clewley et al., 2014; Sukumar & Lawrence, 2014). However, DN resolves the MTrPs effectively in a large number of conditions of myofascial dysfunctions (Fernández-de-las-peñas et al., 2019). Furthermore, the literature claimed that PSDN produces a more beneficial effect in distant MTrPs when combined with local MTrP-DN (Hyuk et al., 2007; Shanmugam & Mathias, 2017). Consequently, the present study evaluates the effectiveness of MTrP-DN with & without PSDN in subjects with AC.

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1.4 RESEARCH SIGNIFICANCE

- This study provides new insights into the benefits of MTrP-DN in subjects with AC.
- Through this research, the clinician community will further realize promoting the use of MTrP-DN in the treatment of AC.
- People and medical institutions (hospitals) may also consider the MTrP-DN as a treatment option for AC.
- This study provides information regarding whether MTrP-DN with and without PSDN is having an additional effect than CPT in AC.
- This study provides information regarding whether local MTrP-DN with and without PSDN helps in the reduction of shoulder pain, and disability, and increases ROMs, and PPT of MTrP, or not in AC subjects.
- Moreover, the analysis that is presented in this study will convey valuable information for future research that will explore the various benefits of MTrP-DN in AC and other diseases.

1.5 RESEARCH QUESTION

- What are the effects of local MTrP-DN in improving shoulder pain, ROM, PPT, and disability in subjects with AC?
- Is PSDN improve the outcomes of local MTrP-DN in subjects with AC?

1.6 RESEARCH OBJECTIVES

1.6.1 General Objectives

- To evaluate the clinical effectiveness of MTrP-DN with and without PSDN in improving shoulder pain, ROMs, PPT, and physical disability among subjects with AC.

1.6.2 Specific Objectives

- To evaluate the clinical efficacy of local MTrP-DN in improving pain, ROM, PPT, and shoulder disability in subjects with AC.
- To evaluate that paraspinal dry needling (PSDN) improves the outcomes of local myofascial dry needling in subjects with AC.

1.7 RESEARCH HYPOTHESIS

- **Null Hypothesis:** The PSDN along with local MTrP-DN does not improve the shoulder pain, ROM, PPT, and disability in the subjects with AC.
- **Alternate Hypothesis:** The PSDN along with local MTrP-DN improves the shoulder pain, ROM, PPT, and disability in the subjects with AC.

CHAPTER - II

LITERATURE REVIEW

CHAPTER OVERVIEW

This chapter provides a review of the published evidence literature & identifies the research gap in the literature about AC and its management.

2.1 ADHESIVE CAPSULITIS

2.1.1 History

AC or Frozen Shoulder is a common chronic painful progressive musculoskeletal condition caused by inflammation, fibrosis, and contracture of the glenohumeral joint capsule resulting in pain, movement restriction, and functional disability (Elnady et al., 2020; Hsu et al., 2011; Neviaser & Hannafin, 2010). Historically, Dr. Rigenshuran coined the term “50s Shoulder” in 1797, which was described as pain in the arm and joints that often occurs at around the age of 50 but improves after some time without medical management (Nobuhara, 2003). Furthermore, Duplay (1872) also reported that the 50s Shoulder was identical to periarthritis of the shoulder and termed “periarthrite scapulohumeral” (Duplay, 1872; Hsu et al., 2011). In 1882, Putnam used the term “Painful periarthritis of the shoulder” for the same condition (Putnam, 1882). Besides, Codman (1934) was the first who coined the term "frozen shoulder" to describe a tendinitis disorder of supraspinatus tendon with secondary involvement of the subacromial bursa with a significant decrease in external rotation of the shoulder joint further, Codman defined a gradual onset of painful shoulders associated with stiffness and sleeping disturbance (Codman, 1934). However, Neviaser (1945) identified the pathological fibrotic lesion, inflammation, and capsular contracture responsible for idiopathic frozen shoulder and coined a new term “adhesive capsulitis” as a more suitable pathoanatomy descriptor for AC (Neviaser, 1945).

2.1.2 Epidemiology of Adhesive Capsulitis

AC affects 3 to 5 percent of the general elderly population globally and 18% population in India, whereas people with diabetes get affected at a younger age, usually less painful, intractable to treatment, and lasts longer (Elnady et al., 2020; Ray et al., 2011; Redler & Dennis, 2019; Smith et al., 2003). Diabetic people have an incidence rate of 11 to 30 percent, while non-diabetics have a prevalence of 2 to 10 percent (Arkkila et al., 1996; Kidwai et al., 2013; Maini et al., 2019; Manske & Prohaska, 2008; Qidwai & Ashfaq, 2010). Furthermore, Bridgman (1972) analyzed the medical reports of 800 diabetic subjects and found evidence of AC in 10.8 percent compared to 2.3 percent of 600 non-diabetics (Bridgman, 1972; Doria et al., 2017). However, Pal et al. (1986) found AC in 49 percent of subjects with insulin dependence and 31 percent with non-insulin dependence, and 20 percent of normal subjects (Pal et al., 1986). In addition, females are more prone in their 5^{th} to 7^{th} decade of life to AC development (Binder et al., 1984; Nagy et al., 2013; Redler & Dennis, 2019; Reeves, 1975). The prevalence of AC for females was enhanced by 8 percent for each 10-year rise in the age group. Whereas, for men born more recently, there is no increase in the prevalence of AC, and the general trend was not correlated with AC prevalence for each 10-year rise in the age group (White et al., 2011). Generally, there is no preference for handedness in AC, and it rarely occurs concurrently bilaterally (Binder et al., 1984; Reeves, 1975). However, others have reported that it can occur bilaterally in up to 40 to 50 percent of subjects sequentially (Greene, 2001).

Correspondingly, subjects with hyperthyroidism are 1.22 times more likely than the general population to experience AC (Huang et al., 2014). Subjects with Hypothyroidism (27.2%), Parkinson's disease (12.7%), Cardiac disease (37.8%), Coronary bypass surgery (29.0%), 1-month post Stroke (15.0%), 1-3 months post Stroke (75.0%), 3-6 months post Stroke (10.0%), shoulder subluxation with 1-month post Stroke (84.2%), shoulder subluxation with 1-3 months post Stroke (15.8%), post Mastectomy (7.3%) have more prevalence of AC compared to the normal population (Ali et al., 2018; Chokkalingam et al., 2017; Riley et al., 1989; Schiefer et al., 2017; Zhu et al., 2013). Likewise, 15.6% of the

population from Asia, 25% from British, and 60.1% of black/ African Americans have AC (Kingston et al., 2018; Malavolta et al., 2018; Wang et al., 2013).

2.1.3 Burden of Adhesive Capsulitis

The annual health care and non-healthcare expenses ranged from $7,000 to $8,000 per episode for the management of ACs (Buchbinder et al., 2007; Hout et al., 2005). A burden of illness study reported that estimated costs to society were $42 per session (Hout et al., 2005) for AC management. In addition, the societal expenses, including the subject's time and travel costs, were estimated at $12 per 1 hour (Berg et al., 2005). In addition, hospitalizations for AC treatment which incorporated manipulation under anesthesia (MUA) and acromioplasty that necessitated home nursing care, were charged $41 per hour. The prescribed drug was priced plus $8 for each purchase other than over-the-counter drugs and other prices, which include in-house assistance and informal treatment expenditure of $24 and $12 per seven days, respectively (Berg et al., 2005). While AC is thought to be a self-limiting condition with symptoms that disappear after two or three years, the predicted high burden on both the person and the community necessitates an effective early therapy to hasten recovery. (Hout et al., 2005).

2.1.4 Classification of Adhesive Capsulitis

The lack of standardized AC nomenclature creates uncertainty in the literature. Lundberg proposed the first classification system in 1969, which classified primary AC as idiopathic and secondary AC as post-traumatic (Lundberg, 1969). Nash and Hazelman (1989) extended the classification system further by adding medical conditions under secondary AC such as “diabetes mellitus,” “myocardial infarction,” or several neurological conditions (Nash & Hazleman, 1989). The secondary AC has been divided into three sub-categories; (a) Systemic secondary AC is more common due to the underlying processes of systemic connective tissue disorders; (b) Extrinsic secondary AC refers to instances where the shoulder joint is not directly involved with pathology. And; (c) Intrinsic secondary AC describes the pathology of soft tissues or structures in the glenohumeral joint (Arslan & Çeliker, 2001; Bruckner & Nye, 1981; Parker et al., 1989). In 1994, Zuckerman et al.

reported a classification in which the primary and idiopathic AC that is deemed similar and are not associated with a clinical disease or injury (Zuckerman et al., 1994).

In 2009, one additional classification was established depending on the extent of irritation of the individuals (low, moderate, and high), which helps make treatment decisions about physiotherapy intervention. Irritability is decided by pain, reduced ROM, and degree of impairment. Subjects having mild irritability experience slight discomfort and also have capsular end feel without pain; thus, active and passive ROM is equal to minor disability. Typically, the most common complaint of these subjects is stiffness rather than pain. On the other hand, subjects with moderate irritability have moderate pain at the end of ROM, and subjects with high irritability have severe pain leading to reduced passive movement and greater impairment. Usually, these subjects report pain instead of stiffness as a key complaint (Table 2.1) (Kelley et al., 2009).

Table 2. 1 Classification of AC depending on irritability (Kelley et al., 2009).

High irritability	**Moderate irritability**	**Low irritability**
High pain (≥ 7/10). Consistent night or resting pain. High disability on DASH, ASES, PSS. Pain before the end ROM. AROM is less than PROM, secondary to pain.	Moderate pain (4-6/10). Intermittent night or resting pain. Moderate disability on DASH, ASES, PSS. Pain at the end ROM. AROM is similar to PROM.	Low pain (≤ 3/10). No resting or night pain. Low disability on DASH, ASES, PSS. Minimal pain at the end ROM with overpressure. AROM is the same as PROM.

Abbreviations: AROM- Active range of motion; ASES- American Shoulder and Elbow Surgeons Score; DASH- Disabilities of the Arm, Shoulder and Hand Questionnaire; PROM- Passive range of motion; PSS- Penn Shoulder Score; ROM- Range of motion.

2.1.5 Stages of Adhesive Capsulitis

The literature reports that AC progresses through three overlapping clinical phases (Reeves, 1975):

1. **An early, painful stage**: This stage lasts from 10 to 36 weeks. Pain is always very severe at this stage, causing sleep disruption and pain-restricted shoulder ROM. Arthrography showed a steady decrease in the total volume of the capsule, as well as obliteration of the subscapular bursa and, in some cases, the tendon sheath of the bicipital groove. The painful phase steadily diminishes, and at the end of this period, the shoulder capsule is very tight that reducing the shoulder joint volume.
2. **An intermediate, stiff (frozen) stage**: This stage is primarily characterized by restricted movement, which lasts 4 to 12 months. Chronic pain with a significant reduction in active and passive shoulder ROMs is present in this stage, and an arthrography study revealed pedunculated synovitis.
3. **A recovery (thawing) stage**: This stage lasts from 5 to 24 months or more. In this stage, gradual recovery takes place to some extent.

According to Bowling et al. (1986) AC is divided into three stages:

1. **Acute stage of capsulitis**: There may be no end-feel or muscle-guarding end-feel present at this stage. Subjects with resisted movement can feel pain before reaching the end range.

2. **The intermediate stage of capsulitis**: As the limb is moved through its ROM, the end feel is characterized by muscle guarding.

3. **Late-stage of capsulitis**: Late capsulitis has a mechanical end limit known as "capsular"; when the glenohumeral joint is stretched by the therapist toward its end of ROMs in flexion or abduction, the sensation is identical to "stretching a piece of leather." (Table 2.2) (Bowling et al., 1986).

Table 2. 2 Stages of Adhesive Capsulitis (Bowling et al., 1986)

	Acute Stage	Intermediate Stage	Late Stage
The capsular pattern of limitation in ROM	Yes	Yes	Yes
End feel	Muscle Guarding	Muscle Guarding	Capsular
Pain and resisted movement	Pain with resistance; before end feel	Pain with resistance; throughout range	Pain after resisted movement

Based on the clinical and arthroscopic presentation, Neviaser and Neviaser (1987) categorized the AC natural development into four phases (Neviaser & Neviaser, 1987):

1. **Stage I:** In this stage, subjects reported a major complaint of shoulder pain, particularly at night, though they have maintained movement. Synovitis may be seen arthroscopically, but there are no adhesions or contractures.
2. **Stage II:** The subject's shoulder begins to stiffen at this point, with synovitis and partial loss of the axillary fold seen arthroscopically, indicating early adhesion development and capsular contracture.
3. **Stage III:** This stage is distinguished by the significant global loss of ROM and discomfort at the joints' end ROMs. Synovitis resolves at this stage, commonly known as the maturation stage, but the axillary fold is obliterated due to severe adhesions.
4. **Stage IV:** As the synovitis has healed, there is significant stiffness but minimal pain. Subjects' shoulder mobility improves gradually as their pain is reduced. Arthroscopically, advanced adhesions and glenohumeral joint space limitations are visible.

Neviaser's four major AC stages are often reclassified as the "painful phase," "stiff phase," and "thawing phase." (Le et al., 2017).

Neviaser and Neviaser (2011) gave three stages of AC based on histology (Neviaser & Neviaser, 2011):

1. **Stage I:** Inflammatory cell infiltration of the synovium characterizes this stage.
2. **Stage II:** Synovial proliferation characterizes this stage.
3. **Stage III:** Dense collagenous tissue within the capsule characterizes this stage.

2.1.6 Capsular Pattern of Adhesive Capsulitis

The capsule of the shoulder joint has unique motion restrictions when it undergoes a pathological process, known as a capsular pattern, and it corresponds to a specific sequence of passive motion limitations (Hammer, 2007). The concept of the capsular pattern was first reported by Cyriax in 1978. He created capsular patterns to separate capsular etiologies of motion loss from other probable skeletal or muscular ones, with external rotation (ER) being the most restricted, followed by abduction (ABD) and internal rotation (IR) (Cyriax, 1978; Wadsworth, 1986). Hence, the capsular pattern has proven to be extremely useful in determining probable arthritis and capsular involvement and guide to choosing appropriate therapy (Hammer, 2007).

On the other hand, according to Dutton (2004), capsular patterns are focused on clinical observations rather than research; perhaps that's why the capsular patterns may be different or inconsistent (Dutton, 2004). Rundquist and Ludewig (2004) denied Cyriax's proposed glenohumeral capsular pattern (Rundquist & Ludewig, 2004). Neviaser and Neviaser (1987) describe shoulder limitation in AC as restricted motion, both actively and passively, primarily in three planes: ABD or elevation, IR, and ER (Neviaser & Neviaser, 1987).

2.1.7 Pathomechanics of Adhesive Capsulitis

AC is a pathological condition in which the articular capsule (ligaments) that encircles the shoulder joint becomes fibrosis and narrow (Page & Labbe, 2010). But these changes took place in the later stage. In stage I, the subjects have a gradual worsening of pain in the region of "deltoid muscle," and it is generally worse at bedtime, as well as arthroscopic

evidence of synovitis but no adhesions. A biopsy of the joint capsule reveals atypical inflammatory cells, hypervascular, hypertrophic inflammation of the synovial membrane, and normal capsular tissue. (Yuan et al., 2017).

Subjects begin developing stiffness in stage II due to the presence of MTrPs in the muscles around the shoulder joint, and recent studies stated that MTrPs are the primary cause of pain and movement dysfunction in the shoulder joint (Sukumar & Lawrence, 2014). The development of MTrPs in combination with synovitis causes axillary fold loss, early adhesion formation, and capsular contracture. However, moving the joint forward or away from the body, as well as rotating it, is now challenging for the subjects. The tissues are affected by hypertrophic, hypervascular synovitis with perivascular and subsynovial scar formation (Yuan et al., 2017).

Stage III, often known as the maturation stage, is marked by a considerable decrease in shoulder ROM and an increase in pain at the limits of motion. Synovitis has resolved at this point, but substantial adhesions have obliterated the axillary fold. The swelling and adhering connective tissues no longer offer the joint to work properly, as demonstrated by the capsular biopsy of the thick hypercellular collagenous tissue, notably toward the anterior of the joint capsule (Yuan et al., 2017).

Lastly, stage IV shows stiffness with minimal pain and resolved synovitis (Le et al., 2017). Arthroscopy reveals that scar tissue and adhesions have matured to the point that they conceal the structure of the joint (Yuan et al., 2017). With pain relief, subjects may see a gradual improvement in shoulder mobility, although this can take months or years. According to the literature, 15 percent of AC patients experience long-term disability, 7 to 15 percent experience permanent functional loss, and 40 percent experience persistent symptoms (Hand et al., 2008; Koh, 2016).

2.1.8 Evaluation of Adhesive Capsulitis

The evaluation of AC starts with a thorough shoulder history. Inciting events such as mild trauma are often given concerning shoulder pain. This may be something very trivial, and,

may not be related to the process, but the subject may recall something that is attributed to starting the process. In addition, AC often involves the non-dominant extremity. This is because it is easier to protect and not use the extremity because it is painful and the dominant extremity can do the work. When the extremity is held close to the body, often to "protect it", the process can then proceed unchecked. This becomes even more apparent when passive ROM is accompanied by an unusual amount of pain and guarding. Codman (1934) discussed this entity describing a slow onset of pain, felt near the insertion of the deltoid, inability to sleep on the affected side, and restriction in both active and passive elevation as well as external rotation, yet with normal radiologic appearance. Without degenerative joint disease on radiographs, this clinical picture suggests the diagnosis of AC (Codman, 1934).

The physical examination is marked by the loss of both passive and active ROMs. This motion may also be painful as the capsule reaches its stretching point. Examination tests for other shoulder abnormalities can also be positive. Testing for impingement may be positive with a Hawkins or Neer sign; however, the pain is likely from the intrinsic process of impingement or capsular stretch rather than from AC. Furthermore, the presence of MTrPs in the muscles which are present around the shoulder can also lead to pain in the shoulder joint and ultimately it can lead to AC, literature reported the use of a pressure algometer as an outcome measure to check the pressure pain threshold (PPT) of the MTrPs (Gurudut et al., 2019).

The diagnosis of AC is often one of exclusion. Early in the disease process, AC may clinically appear similar to other shoulder conditions such as major trauma, rotator cuff tear, rotator cuff contusion, labral tear, bone contusion, subacromial bursitis, and cervical or peripheral neuropathy. Additionally, a history of a previous surgical procedure can lead to shoulder stiffness. If a history of these other pathologies is negative and if radiographs do not demonstrate osteoarthritis, then the diagnosis can be given.

A screening radiograph of the shoulder is imperative to diagnose AC. This rules out another possible diagnosis of loss of ROM that includes osteoarthritis, or chronic anterior or posterior dislocation (Manske & Prohaska, 2008).

2.1.9 Outcome Measures used in literature in subjects with Adhesive Capsulitis

2.1.9.1 The Shoulder Pain and Disability Index (SPADI)

SPADI was developed to measure current shoulder pain and disability in an outpatient setting. The SPADI contains 13 items that assess two domains; a 5-item subscale that measures pain and an 8-item subscale that measures disability. There are two versions of the SPADI; the original version has each item scored on a visual analog scale (VAS) and the second version has items scored on a numerical rating scale (NRS). The latter version was developed to make the tool easier to administer and score (Williams et al., 1995). The SPADI has since been used in both primary care for mixed diagnoses (Beaton & Richards, 1996; MacDermid et al., 2006) and surgical patient populations including rotator cuff disease (Ekeberg et al., 2008), osteoarthritis, and rheumatoid arthritis, adhesive capsulitis (Staples et al., 2010; Tveitå, et al., 2008), joint replacement surgery (Angst et al., 2007), and in a large population-based study of shoulder symptoms (Hill et al., 2011).

In the original version, the subject was instructed to place a mark on the VAS for each item that best represented their experience of their shoulder problem over the last week (Roach et al., 1991). Each subscale is summed and transformed to a score out of 100. A mean is taken of the two subscales to give a total score out of 100, a higher score indicating greater impairment or disability. In the NRS version (Williams et al., 1995) the VAS is replaced by a 0-10 scale, and the patient is asked to circle the number that best describes the pain or disability. The total score is derived in the same manner as the VAS version. In each subscale patients may mark one item only as not applicable and the item is omitted from the total score. If a patient marks more than two items as non-applicable, no score is calculated (Roach et al., 1991). A more recent systematic review has found reliability coefficients of ICC $\geq$ 0.89 in a variety of patient populations (Roy et al., 2009).

Internal consistency is high with Cronbach α typically exceeding 0.90 (Hill et al., 2011; Roy et al., 2009). The SPADI demonstrates good construct validity, correlating well with other region-specific shoulder questionnaires (Bot et al., 2004; Breckenridge & Mcauley, 2011; A. Paul et al., 2004; Roy et al., 2009).

2.1.9.2 Universal Goniometer

The measurements are generally used to assess limitations in ROM, determine appropriate interventions, and document treatment progression (Ekstrand et al., 1982; Gajdosik & Bohannon, 1987; Riddle et al., 1987). Clinically, the universal goniometer is most commonly used (Hayes et al., 2001; Riddle et al., 1987; Rome & Cowieson, 1996). Numerous studies have investigated the reliability of goniometry for both active and passive ROM. Boone et al (1978) looked at the intertester and intratester reliability of active ROM measurements taken on both upper and lower extremities using a goniometer in normal healthy subjects. They found that intertester reliability was greater for upper extremity motion (r= 0.86) than lower extremity (r= 0.58) and intratester reliability was high for both upper (r= 0.89) and lower extremities (r= 0.80) (Boone et al., 1978). Riddle et al (1987) compared intertester and intratester reliability of passive shoulder ROM in a clinical setting using two different-sized goniometers. They demonstrated that the ICC values for intertester reliability were high for flexion and abduction when using a large and small goniometer (0.84–0.89 respectively), but poor for extension (0.27–0.26). Intratester reliability for shoulder flexion, extension, and abduction was demonstrated to be high (0.94–0.98). Intertester reliability of horizontal abduction/adduction and internal rotation measurements were taken with large and small goniometers and shown to be poor (0.28–0.55), whereas external rotation measurements were high (0.88–0.90). Intratester reliability was high (0.87–0.99) for both horizontal abduction/adduction and internal/external rotation (Mullaney et al., 2010; Riddle et al., 1987).

2.1.9.3 Pressure Algometer

Algometers are devices that can be used to identify the pressure and/or force eliciting a pressure-pain threshold. It has been noted in pressure-pain threshold studies that the rate at which manual force is applied should be consistent to provide the greatest reliability. Most commonly, these devices have a 1-cm^2 pressure application surface and display force readings in newtons or kilograms of force. It has been noted that the force application should be perpendicular to the body surface, and the rate should be constant at an approximate rate of 1 $kg.cm^2.s^{1}$ (Kinser et al., 2009). These devices have high validity and reliability (Kinser et al., 2009) and acceptable intra-examiner reliability of pressure rate application. The between-session PPT across multiple sessions was reliable and without differences (Nussbaum & Downes, 1998).

2.1.9.4 Visual Analog Scale (VAS)

A VAS consists of a line, often 10 cm long, with verbal anchors at either end, similar to a Numerical Rating Scale (e.g., “no pain” on the far left and “the most intense pain imaginable” on the far right). The patient places a mark at a point on the line corresponding to the patient’s rating of pain intensity (Turk & Melzack, 2011). The line may be depicted with a horizontal or vertical orientation, though a horizontal line is generally preferred. The VAS has often been recommended as the measure of choice for the assessment of pain intensity. Substantial evidence supports its validity, and the VAS is sensitive to treatment effects. Though most studies suggest minimal differences in sensitivity among rating scales, significant differences that do emerge generally favor a VAS over a Verbal Rating Scale (VRS) or a Numerical Rating Scale (Price et al., 1994).

2.2 MANAGEMENT OF ADHESIVE CAPSULITIS

Most AC cases can be managed in the primary care setting with conservative management, which includes Electrotherapy management, Oral medications, Exercise /Manual Therapy, and Contemporary techniques with Physiotherapy.

2.2.1 Electrotherapy management for Adhesive Capsulitis

Electrophysical agents (EPA) are commonly employed in physical therapy interventions (PTI) for AC in clinical settings. EPA aimed to decrease pain and enhance function via an increase of the different types of physical energies in the body tissues (Watson, 2010). Besides, several EPA exists, and we can classify them as (a) Electrical stimulation agents including “Transcutaneous Electrical Nerve Stimulation (TENS)” and “Interferential Therapy (IFT)”. (b) Thermal agents include “Shortwave Diathermy (SWD)”, “Microwave Diathermy (MWD)”, and “Therapeutic Ultrasound (UST)”. (c) Non-Thermal Agents include “Low-Level Laser Therapy (LLLT)”, and “Extracorporeal Shockwave Therapy (ESWT)”.

IFT includes the interaction of two medium-frequency currents, resulting in a low-frequency 'beating' response in deep tissues (Beatti et al., 2010). Literature suggests that IFT is effective in pain relief, function, and ROM improvement in AC (Cheing et al., 2008). In contrast, TENS delivers electrical stimulation to activate the underlying nerves employing electrodes mounted over the intact skin adjacent to the pain source (Jones & Johnson, 2009). In AC, Dewan and Rohit (2011) checked the efficacy of TENS and IFT and concluded that both TENS and IFT were effective in treating AC, but IFT was more effective in decreasing pain severity and restoring function in the shoulder for people with AC (Dewan & Rohit, 2011).

Furthermore, Continuous SWD is the transmission of a continuous stream of electromagnetic short wave radiations to achieve a deep heating effect in soft tissues (Allen, 2006). Recently, deep diathermic heating along with stretching proved more effective than superficial heating to treat AC (Leung & Cheing, 2008). Also, MWD uses microwaves to heat superficial tissues such as superficial muscles and joints (Steven et al., 2009). Literature shows that MWD, along with physical exercises, is not efficient in reducing pain and disability as compared to UST along with physical exercise programs (Haque et al., 2015) as UST delivers energy using a crystal sound head to deep tissue areas via ultrasonic waves (at frequencies of 1 or 3 MHz and intensities of 0.1 watts per sq. cm

and 3 watts per sq. cm) (Allen, 2006). Further use of UST to reduce pain, increase ROM, and function in AC was not recommended in the literature (Dogru et al., 2008).

Furthermore, LLLT generates a laser beam capable of transmitting light energy to tissue depths beneath the dermis (Peplow et al., 2010). "LLLT can modulate acute inflammation by causing a reduction in the levels of pro-inflammatory cytokines such as interleukin-1 alpha (IL-1 alpha), interleukin-1 beta (IL-1 beta), tumor necrosis factor-alpha (TNF-alpha), and also an increase in the levels of anti-inflammatory growth factors and cytokines such as basic fibroblast growth factor, platelet-derived growth factor, transforming growth factor-beta, that contribute to pain cessation" (Peplow et al., 2010). LLLT is a viable choice for the conservative management of shoulder pain caused by AC in the elderly, with a favorable clinical outcome of more than 90 percent and clinically effective in both the short and medium-term (David & Nga-Yue, 2015); however, insufficient evidence to support LLLT may produce significant improvement of shoulder ROM in AC subjects (Breugel & Bär, 1992).

Finally, ESWT is an evolving form of treatment for pain management caused by various musculoskeletal disorders (Cheing & Chang, 2003). Shock waves are nonlinear sound waves that have a high peak pressure but a low tensile amplitude, a short ascent time, and a short duration (10 ms). Literature reported the effectiveness of ESWT in combination with other physical modalities for the management of pain, restricted ROMs, and shoulder disability in AC and ESWT is a safer modality for the management of AC in diabetic subjects and has proven to be effective in both short and long-term pain modulation (Lee et al., 2017; Santoboni et al., 2017). On the other hand, the shock wave's pulse length is extremely short (3 to 5μs) and is produced at low frequencies, it is minimally absorbed by the tissues, and therefore no thermal effect has been created (Cheing & Chang, 2003). Therefore, ESWT, along with other modalities, yielded a better functional recovery in AC subjects than ESWT alone. This suggestion is further buoyed by Seyam et al. (2018), who reported that ESWT, along with therapeutic exercises and manual therapy, effectively reduced shoulder pain, disability, and increased ROM in AC subjects with diabetes mellitus

(Seyam et al., 2018). In brief, some EPAs, such as IFT, TENS, SWD, LLLT, and ESWT, can effectively improve shoulder pain, ROMs, and disability in AC, while others, such as MWD, UST, are ineffective. To support the efficacy of various EPAs, high-quality studies with bigger sample sizes, structured approach, well-defined ideal treatment time and mode, and long-term follow-up are needed.

2.2.2 Medical management for Adhesive Capsulitis

2.2.2.1 Effect of oral corticosteroids therapy for Adhesive Capsulitis

Oral corticosteroid (OC) therapy has been administered for the early management of AC to improve shoulder pain and ROMs. Literature reported that short courses of OC decreased healing time and improved shoulder mobility (Buchbinder et al., 2006). In addition, studies reported a reduction in pain with 30 mg of prednisone a day for just three weeks in AC (Margaretha et al., 2014; Nagy et al., 2013). As well, a Cochrane review also reported the short-term benefit of OC in AC, and it could not be sustained beyond six weeks (Buchbinder et al., 2006), and there is no substantial difference in long-term pain relief and improvement in ROMs in AC with OC, but the short-term efficacy of OC has been confirmed (Lorbach et al., 2010). In addition, the literature also compared the effectiveness of OC with other medications and exercises. Canbulat et al. (2015) found that in conjunction with pregabalin, paracetamol, proton pump inhibitor, and home exercises, OC substantially improved the pain and ROMs in AC. They reported that OC significantly reduced short-term rest pain and significantly reduced pain with movement by up to one year (Canbulat et al., 2015). Moreover, Lakhani et al. (2016) discovered that OC significantly decreased AC pain and rapidly improved ROMs in the short-term and after one year also (Lakhani et al., 2016). Conversely, few studies revealed that OC had a very doubtful benefit in AC and was not successful in improving AC pain and ROMs, and they claimed that OC offers poor results in the same condition (Binder et al., 1986; Cyriax, 1954; Wang et al., 2017). Therefore, there is inconsistency in the use of OC for managing patients with AC, and needed a detailed study to check the efficacy of OC with other therapeutic modalities in improving pain and ROMs in subjects with AC.

2.2.2.2. Effect of oral nonsteroidal anti-inflammatory drug therapy for Adhesive Capsulitis

Oral pharmacological agents are a staple for subjects who suffer from any type of pain including AC. The most common oral medications used for AC are nonsteroidal anti-inflammatory drugs (NSAIDs) (Ewald, 2011). In addition, NSAIDs are medicines that are widely used to relieve pain and reduce inflammation and are the most prescribed medications for treating conditions such as AC, these drugs along with rest are usually considered a first-line treatment, however, their use does not change the natural course of the disease (Cho et al., 2019). There have been few studies that evaluated the effectiveness of NSAIDs for the treatment of AC. NSAIDs are generally recommended for short-term pain relief during the early inflammatory stages of AC (D'Orsi et al., 2012; van der Windt et al., 1995). In a Randomized control trial (RCT) by Ranalletta et al, (2016) oral NSAIDs were compared directly to a single corticosteroid injection which showed the injection provided faster pain relief and quicker time to the improvement of shoulder function (Ranalletta et al., 2016). Furthermore, an RCT looking at diabetic subjects with a concomitant diagnosis of AC found that both NSAIDs and intra-articular corticosteroid injection were efficacious yet there was no significant difference between the two (Dehghan et al., 2013). However, the effects may not last longer than six weeks. The combination of NSAIDs with physiotherapy intervention is more efficient in terms of restoring normal shoulder function and reducing pain (Chan et al., 2017). One study has also shown that the addition of calcitonin to this regimen might further improve the outcome after 6 weeks versus PTI and NSAIDs with a placebo. However, more randomized controlled trials would be necessary to establish the role of calcitonin in the treatment of AC (Rouhani et al., 2016).

2.2.3 Therapeutic exercises, mirror therapy, and manual therapy for Adhesive Capsulitis

2.2.3.1 Therapeutic exercises for Adhesive Capsulitis

Therapeutic exercises have traditionally been a cornerstone of treatment for AC (Ewald, 2011). Literature reported that studies utilized therapeutic exercises to treat AC subjects of different stages from I to III, and these exercises were beneficial for pain relief and improved function at all stages (Griggs et al., 2000; Pajareya et al., 2004). Aggressive physiotherapy intervention can exacerbate pain and reduce adherence to the treatment regimen; therefore, care should be taken in subjects with a high degree of pain and stiffness (Ewald, 2011).

(a) Effect of therapeutic exercises on shoulder pain in Adhesive Capsulitis

A regular functional exercise program may improve the subject's pain status and functional recovery in AC. Particularly, stretching performed by the therapist in "forward elevation", "ER", "horizontal adduction", & "IR" leads to a satisfactory improvement in pain status in 90 percent of the individuals (Chan et al., 2017), and the level of tissue irritation in the subject should decide the intensity of the exercises (Kelley et al., 2013). In addition, Kivimäki et al. (2007) reported that "manipulation under anesthesia" (MUA) paired with a regular exercise program was not much effective as the therapist-instructed home exercise program alone was effective in pain reduction in AC. (Kivimäki et al., 2007). It is worth mentioning that exercise within a pain-free limit produces better outcomes than high-intensity exercises with painful motion in the shoulder. Diercks and Stevens (2004) concluded that intensive physical treatment and supervised neglect exercise programs had been shown to have beneficial outcomes. Exercises performed by the subject up to & above the pain tolerance, passive stretching, mobilization of the glenohumeral joint, and a home exercise program were all part of the intensive physical therapy group. The supervised neglect group was given the same exercise program as the rigorous exercise group, but they were warned not to exercise beyond their pain tolerance. They concluded that supervised neglect was superior to intensive physical therapy in pain reduction in AC (Diercks &

Stevens, 2004). Therefore, home-based shoulder girdle exercise within the pain-free limit may produce a better reduction in pain outcomes in subjects with AC (Margaretha et al., 2014).

(b) Effect of therapeutic exercises on shoulder ROMs in Adhesive Capsulitis

Therapeutic exercises are the standard non-pharmacological therapy, which is commonly prescribed in clinical settings for the management of AC. Literature reported that subjects with stage 2 idiopathic AC were investigated and given a home-based training regimen of passive stretching exercises for the shoulder, including "forward elevation", "ER", "horizontal adduction", and "IR". At the end of the exercise program, 90 percent of subjects reported satisfactory outcomes in shoulder ROMs. However, among 10 percent of poor outcomes, five subjects underwent manipulation under anesthesia and/or arthroscopic release for a better outcome of a function (Griggs et al., 2000). Instead, Kivimäki et al. (2007) evaluated the influence of a home exercise program in combination with manipulation under anesthesia and a home exercise program alone for improving shoulder ROMs in AC. The study found that a home exercise program alone was as beneficial as manipulation under anesthesia paired with a home exercise program in enhancing shoulder ROMs in AC (Kivimäki et al., 2007). Similarly, supervised neglect "exercises within a pain threshold limit, pendulum exercises, and active exercises within painless ROMs" was proven to be superior to intense physical treatment in increasing ROMs in AC (Diercks & Stevens, 2004). Therefore, home-based shoulder exercises within pain-free limits may produce better improvement in shoulder ROMS in subjects with AC.

(c) Effect of therapeutic exercises on shoulder disability in Adhesive Capsulitis

Home exercise programs may improve the disability in AC subjects without combining them with any other treatment options. Kivimäki et al. (2007) reported that a therapist-instructed home exercise program alone was equally effective in decreasing shoulder disability in AC as compared to MUA combined with a home exercise program (Kivimäki et al., 2007). It is worth noting that exercises within pain-free limits could give a better improvement in shoulder disability as compared to high-intensity shoulder exercises.

Diercks and Stevens (2004) reported that supervised neglect of idiopathic frozen shoulder syndrome is preferable to passive stretching and mobilization in terms of functional outcome (Diercks & Stevens, 2004). Therefore, therapists instructed home exercise programs within pain-free limits may produce better improvement in shoulder disability in subjects with AC.

2.2.3.2 Mirror therapy for Adhesive Capsulitis

Mirror therapy (MT) is a simple, inexpensive, and most importantly, patient-centric type of treatment used to improve mobility in upper extremity disorders (Baskaya et al., 2018).

(a) Effect of mirror therapy on shoulder pain, ROMs, and disability in Adhesive Capsulitis

When combined with multimodal treatment, MT may reduce shoulder pain, ROMs, and disability in AC patients. Notably, it gives an immediate effect on improving outcomes of the shoulder when followed by multimodal treatment, including manual therapy and exercises to gain further improvement (Louw et al., 2017). Moreover, for AC, one prospective randomized controlled study reported that MT applied to AC in combination with standard physical therapy methods can improve outcomes related to the shoulder in subjects with AC (Baskaya et al., 2018). Therefore, to confirm whether MT can further contribute to the improvement of AC in combination with PTI, more studies with bigger sample sizes, structured approach, well-defined ideal treatment time and mode, & long-term follow-up are needed to support MT's efficacy by neuroimaging techniques.

2.2.3.3 Manual Therapy for Adhesive Capsulitis

a. Maitland mobilization for Adhesive capsulitis

- **Effect of Maitland mobilization on shoulder Pain in Adhesive Capsulitis**

Maitland presents different sets of widely employed manual therapy techniques for treating shoulder disability in AC. Maitland mobilization (MM) has been studied in various studies in subjects with AC (Bulgen et al., 1984; Cavalleri et al., 2020; Johnson et al., 2007;

Nicholson, 1985; Rizwan et al., 2019; Sathe et al., 2020; Vermeulen et al., 2000, 2006). Literature reported MM alone significantly reduced the pain among AC subjects with mild to moderate pain intensity (Bulgen et al., 1984). However, another study reported that MM, along with active exercise, substantially reduced pain for four weeks of management (Nicholson, 1985). Whereas Vermeulen et al. (2000) tested the efficacy of the end-range of MM approach in AC and found that out of seven subjects, five reported no pain, and two reported pain after three months of treatment regimen and nine months of follow-up (Vermeulen et al., 2000). However, End-range mobilization techniques and therapeutic exercise were also found to be the most effective in reducing pain (Cavalleri et al., 2020). Again, Vermeulen et al. (2006) compared "high-grade MM (grades III and IV) techniques" to "low-grade MM (grades I and II) techniques" unaccompanied by exercises, and they found that pain at rest, pain during movement, and pain at night improved more in a low-grade group at 12 months of follow-up as compared to high-grade group (Vermeulen et al., 2006). Moreover, a study reported that both anterior and posterior glide mobilization was effective in pain reduction in AC (Johnson et al., 2007). Similarly, recent literature also reported the beneficial effect of MM in subjects with AC to improve shoulder pain (Sathe et al., 2020; Wu et al., 2021). Conversely, literature also reveals no pain reduction in AC till the initial six months of management including MM with advice and shoulder exercises (Chen et al., 2009). This allows the conclusion that MM can substantially reduce pain in AC subjects, but pain persists in the subjects even after complete treatment. So, there is a need for the study to check the efficacy of MM along with other specialized techniques like MTrP-DN.

- **Effect of Maitland mobilization on shoulder ROMs in Adhesive Capsulitis**

The MM incorporates the use of accessory oscillatory movements to alleviate mechanical stiffness. Literature reported the beneficial effect of MM along with active exercises after four weeks of management, and all the shoulder motions significantly improved with MM (Nicholson, 1985). Moreover, with the end-range mobilization approach of MM, both the active and passive ROMs of the shoulder considerably improved after ninety days of

management for AC (Vermeulen et al., 2000). Again, one more research compared “high-grade (grades III and IV) mobilization techniques” with “low-grade (grades I and II) mobilization techniques” without using exercises and found substantial improvements in ROMs in two groups in the initial ninety days; however, the high-grade mobilization group proved to be more effective, but a minority of comparisons accomplished statistical significance, and a minority of comparisons did not reach statistical significance (Vermeulen et al., 2006). According to Johnson et al. (2007), a “posteriorly directed joint mobilization” procedure was more efficacious than an “anteriorly directed mobilization” procedure in increasing external rotation ROM in AC (Johnson et al., 2007). Another study, however, endorsed Vermeulen et al. 2000 by reporting that end-range and mid-range mobilization methods of MM were more efficacious than mobilization with movement in increasing shoulder ROMs in AC (Yang et al., 2007). In addition, high-grade mobilization (grades III and IV) significantly improves glenohumeral joint ROMs compared to the low (grades I and II) mobilization approaches during the first 3 months, even though there has been no substantial change in long-term outcomes (Vermeulen et al., 2006). Furthermore, Johnson et al. (2007) discovered that a “posteriorly directed joint mobilization method” was more efficient than an “anteriorly directed mobilization method” in increasing lateral rotation ROM for AC (Johnson et al., 2007).

Similarly, recent literature also reported the beneficial effect of MM in subjects with AC to improve shoulder ROMs (Sathe et al., 2020; Wu et al., 2021). On the other hand, literature also reported no improvement in shoulder ROMs until joint mobilization with advice and shoulder exercises were included in the initial six months of management (Chen et al., 2009). In contrast, a study reported that MM was not superiorly effective for improving ROMs to other treatment regimens (Bulgen et al., 1984). This allows the conclusion that MM can substantially enhance the shoulder ROMs in AC, but it took four weeks to 3 months’ time period that is a very disabling condition and also put an economic burden on the subjects, so there is a need for the study to check the efficacy of MM along with other specialized techniques like MTrP-DN, etc. to reduce the time of management.

- **Effect of Maitland mobilization on shoulder disability in Adhesive Capsulitis**

Literature reported the effectiveness of end-range mobilization techniques in AC subjects after three months of treatment; four subjects reported excellent, two subjects reported good, and one subject reported moderate improvement in shoulder disability (Vermeulen et al., 2000). Additionally, both high- and low-grade MM approaches substantially reduced shoulder impairment in the first three months, and there was no substantial difference in long-term results after three months (Vermeulen et al., 2006). At the same time, end-range mobilization was more effective in reducing shoulder disability than mobilization with movement (Yang et al., 2007). As well as, Cavalleri et al. (2020) also reported that end-range mobilization approaches and rehabilitative exercises are the most efficient in improving shoulder function (Cavalleri et al., 2020). Literature also reported no improvement in shoulder disability until joint mobilization with advice and shoulder exercises were included in the initial six months of management of AC (Chen et al., 2009). This allows the conclusion that many studies evaluated the effectiveness of MM in AC (Bulgen et al., 1984; Johnson et al., 2007; Nicholson, 1985; Vermeulen et al., 2000, 2006), and some of them said that it's effective (Nicholson, 1985; Vermeulen et al., 2006); some said that it's effective only for short term (Vermeulen et al., 2006) and on the other hand some noted that it's not effective at all (Chen et al., 2009) in reducing shoulder disability. None of the study results showed complete recovery in AC, so there is a need for the study to check the efficacy of MM along with other specialized techniques like MTrP-DN, etc., to achieve complete recovery.

2.2.4 Contemporary techniques with Physiotherapy for Adhesive Capsulitis

2.2.4.1 Effect of Hydrocorticosteroid injections in Adhesive Capsulitis

Corticosteroid injection (CSI) has significant anti-inflammatory and pain-relieving effects (Sun et al., 2016) and wide use of these injections has been documented in the conservative management of AC (Bal et al., 2008). Literature reported that few studies have shown the efficacy of CSI to improve pain, ROM, and disability in AC (Griesser et al., 2011). Arslan and Çeliker (2001) compared local CSI and physical therapy for AC and

found that there was initially no substantial improvement in shoulder pain and ROMs but later demonstrated considerable improvement (Arslan & Çeliker, 2001), Whereas another research indicated that pain relief was only apparent in the first week of treatment, but it was not substantially reduced later on (Widiastuti-Samekto & Sianturi, 2004). In addition, Ryans et al., (2005) also confirmed that during the initial 6 weeks, CSI showed substantial pain relief and improvement in ROM and disability but not at 16 weeks (Ryans et al., 2005). Other studies also endorsed Ryans et al., (2005) and said that CSI offers rapid pain relief and improvement in ROMs for AC subjects in the short term (particularly in the first 6 weeks) and that long-term results tend to be comparable to other therapies, including placebo (Koh, 2016; Sharma et al., 2016; Song et al., 2014; Xiao et al., 2017). In addition, several systematic reviews also concluded that intra-articular CSI was effective in improving pain, ROMs and disability in the AC compared to placebo and physiotherapy, but the results were not sustained after 6 weeks (Buchbinder et al., 2003, 2006, 2008; Griesser et al., 2011). However, Wang et al., (2017) conducted a meta-analysis and supported the previous studies by claiming that intra-articular CSI was more effective in short-term pain relief and increase passive ROMs, but this improvement was not sustained in the long-term (Wang et al., 2017). Some recent studies also reported the short-term (2-3 weeks) effectiveness of SCI in pain reduction and an increase in ROMs in AC (Sah et al., 2019; Shang et al., 2019).

We may infer from the literature review that SCI can provide initial improvements in shoulder pain, ROMs, and disability for the first 1 to 6 weeks in the AC. However, in contrast to physical therapy, CSI does not provide substantially additional benefits beyond 6 to 12 weeks. There have been mixed findings in research comparing CSI with manipulation under anesthesia or dilation. Image-guided injections also give pain, ROM, and disability improvements within the first 12 weeks, but their additional advantage over non-image-guided shoulder injections was inconclusive. There is little evidence that intra-articular CSI is successful and that high-quality primary research is needed.

2.3 MYOFASCIAL TRIGGER POINTS

2.3.1 Myofascial trigger points (MTrPs)

“MTrPs, also known as trigger points (TrPs), are hyperirritable sites found in tight bands of muscle fibres that are unpleasant on compression and may cause referred pain, motor dysfunction, and autonomic abnormalities” (Fernández-de-las-peñas et al., 2019; Travell et al., 1999).

2.3.2 Types of Myofascial Trigger points

There are mainly two types of MTrPs:

Type 1: An active MTrPs is usually sensitive and refers to pain on compression that the subject recognizes, also inhibits full muscular lengthening, and diminishes muscle strength (Khanittanuphong & Upho, 2020; Simons et al., 1999b).

Type 2: A latent MTrP concerning impulsive pain is clinically quiescent; it is only painful and produces a referred pain pattern with palpation. However, it reduces muscular flexibility, causes muscle weakening, and may cause a local twitch reflex when stimulated with needles (Paul & Verma, 2018; Simons et al., 1999).

2.3.3 Impact of MTrPs on Muscles Function

A muscle is a soft tissue that includes protein filaments of actin and myosin that slip past each other, creating a contraction that affects both the length and the shape of the muscle. According to the literature, the existence of MTrPs in the muscles may induce a variety of alterations, including inflexibility, loss of strength, intramuscular mobility dysfunction, and decreased PPT (Efstratiadis et al., 2018; Fischer, 1988; Grieve et al., 2011; Öztürk et al., 2016)**.** Kim et al. (2017) also reported decreased strength relative to normal muscle in the upper trapezius muscle with MTrPs (Kim et al., 2017)**.**

2.3.4 Impact of MTrPs on Joints Function

The normal joint function can be defined as a joint's capacity to move during its entire ROM, and many authors have postulated a clinical link between both MTrPs and joint function impairments (Fernández-De-Las-Peñas, 2009; Maitland et al., 2000). The existence of MTrPs and joint hypomobility in subjects with neck pain has been studied, and a significant relationship among MTrPs in upper fibres of the trapezius muscle and the presence of joint hypomobility in the C3-C4 segment was discovered (Fernandez-De-Las-Penas et al., 2005) and also there is a link between MTrPs and joint dysfunctions and literature also reveals a postulated theory, i.e., "enhanced tension of the knotted muscular bands and facilitation of motor function can retain displacement stress on the joints, resulting in an MTrPs causing joint dysfunction" (Fernández-De-Las-Peñas, 2009).

2.4 MYOFASCIAL TRIGGER POINTS IN ADHESIVE CAPSULITIS

MTrPs in the muscles of the shoulder and surrounding areas may be a source of pain and disability in AC. It was reported that active TrPs in subscapularis muscle are identified to be a significant factor in producing pain and restriction in ROMs in the shoulder joint in AC (Lewit, 1991; Simons et al., 1999; Ughreja et al., 2019). In addition, literature reported the restriction of shoulder ROM due to the presence of TrPs in "Supraspinatus", "Infraspinatus", "Teres major", "Teres minor", "Deltoid", "Pectoralis major", "Subscapularis" and "Latissimus dorsi" muscles of the shoulder girdle (Gerwin, 1997). Besides, Sukumar & Lawrence (2014) and Clewley et al. (2014) also confirmed the cause of pain and reduced ROMs in AC subjects is the development of MTrPs in the muscles around the glenohumeral joint. (Clewley et al., 2014; Sukumar & Lawrence, 2014). In addition to tight joint capsules, ligaments, and muscles, the MTrPs formation in the shoulder girdle muscles could augment pain, ROM, and disability in subjects with AC of the shoulder joint.

2.5 CONSERVATIVE MANAGEMENT OF MYOFASCIAL TRIGGER POINTS

Conservative management can be classified into Electrotherapy management, Manual therapy, and Contemporary techniques.

2.5.1 Electrotherapy Management for myofascial trigger points

Different forms of modality-based physical therapies have been reported in the literature to treat MTrPs. This includes TENS, UST, and LLLT.

2.5.1.1 Effect of Ultrasound therapy for myofascial trigger points

In UST, sound waves with a frequency of over 20,000 Hz are used to treat soft tissue-related pain conditions and to promote tissue healing in clinical settings (Gam et al., 1998). There is ample literature reporting the efficacy of UST in improving pain and PPT related to MTrPs. These study results showed the UST could effectively improve the symptoms of MTrPs (Ilter et al., 2015; Yildirim et al., 2018). While considering the different types of UST, the continuous UST is significantly more beneficial than the pulsed as compared with the sham UST in reducing rest pain related to MTrPs (Ilter et al., 2015). Similarly, a high-power static continuous UST reduced pain in active trapezius MTrPs more effectively than a conventional motion-based UST (Majlesi & Ünalan, 2004). Furthermore, a study that looked at the immediate anti-nociceptive effect of UST on the sensitivity of MTrPs found a significant but brief rise in PPT since five minutes of 1 W /sq. cm, 100 percent 1 MHz (Srbely & Dickey, 2007). Srbely et al. (2008) reported that UST had a brief neurosegmental anti-nociceptive impact on shoulder MTrPs could temporarily improve pain sensitivity (Srbely et al., 2008). On the other hand, contradictory evidence for the use of UST in the management of MTrPs is also reported in the literature. Those studies reported that UST is not at all effective in reducing pain in MTrPs (Dommerholt & McEvoy, 2011; Rickards, 2006). Likewise, a study on the efficacy of UST for MTrPs (Xia et al., 2017) reported there may be a significant effect of UST therapy on pain in MTrPs, but the high risk of bias renders the influence of US on pain inconclusive, and the supporting evidence is extremely weak, due to the extremely low study quality,

incompleteness of patient-reported outcomes, and very small sample sizes. Nonetheless, the influences of UST on MTrPs must be confirmed by large-sample size, high-quality RCTs with bias protections that assess important outcomes.

2.5.1.2 Effect of Low-Level Laser Therapy for myofascial trigger points

LLLT, also known as Photobiomodulation, is a fast-growing technology employed to treat MTrPs (Avci et al., 2013; Cotler et al., 2015). In the light of reported literature, it is conceivable that LLLT is effective in pain reduction and improvement of PPT related to MTrPs (Altan et al., 2005; Ceccherelli et al., 1989; Demirkol et al., 2015; Gur et al., 2004; Ilbuldu et al., 2004). In addition, literature compared the LLLT with pharmacotherapy, splint therapy, and other advanced treatment methods to find out improvement in pain and PPT related to MTrPs (Altindiş & Güngörmüş, 2019; Demirkol et al., 2015). The results showed that LLLT could provide more favorable results than splint therapy in subjects with MTrPs (Altindiş & Güngörmüş, 2019). Similarly, the effect of the LLLT was significantly more significant than that of polarized LLLT in treating MTrPs (Shahimoridi et al., 2020). Moreover, literature reported significant beneficial effects of LLLT than the non-steroidal anti-inflammatory drugs (NSAIDs) in improving pain related to MTrPs (Khalighi et al., 2016). Whereas, Kiralp et al. (2006) discovered that LLLT is just as efficacious as MTrPs injection in the cure of myofascial pain (Kiralp et al., 2006). Therefore, LLLT may be beneficial as a short-term intervention modality for improving pain and PPT related to MTrPs. However, a high-quality study is warranted to determine the long-term efficacy, the most efficient type of laser, and the optimal dose, length, and frequency of treatment with an optimal sample size.

2.5.1.3 Effect of Transcutaneous Electrical Nerve Stimulation for myofascial trigger points

TENS is a pain-relieving non-invasive peripheral stimulation treatment that uses pulsed electrical currents administered across the intact surface of the skin to stimulate underneath nerves and create electroanalgesia (Johnson, 2007). It is the most well-studied electrotherapy modality for the treatment of MTrPs (Ahmed et al., 2019; Ardiç et al., 2002;

Graff-Radford et al., 1989; Hou et al., 2002; Hsueh et al., 1997; Lee et al., 1997; Smania et al., 2005). The majority of previous research looked at the immediate impact of TENS and found a significant improvement in MTrPs discomfort and PPT after a ninety days check-up (Ardiç et al., 2002). In attenuating MTrPs pain, the high-frequency, high-intensity TENS with 100-Hz and 250-ms stimulation was by far the most efficacious, but it is not effective on PPT of MTrPs (Farina et al., 2004; Graff-Radford et al., 1989). Literature compared the effectiveness of TENS in combination with other electrotherapy modalities and manual therapy and reported that TENS and IFT were more effective in reducing MTrPs pain in combination with other manual or physical therapies (Hou et al., 2002). Additionally, studies compared TENS to Electrical Muscle Stimulation (EMS), finding that TENS provided better pain alleviation than EMS (Ardiç et al., 2002; Hsueh et al., 1997). Application of TENS along with Kinesiotaping and exercises can decrease pain severity and increase PPT related to MTrPs (Gokmen et al., 2017). Recent studies reported the effectiveness of TENS in improving pain intensity at the location of the MTrPs (Ahmed et al., 2019). On the whole, TENS can improve pain and PPT related to MTrPs, but it is harder to draw any clear conclusions from these findings on the efficacy of medium or long-term care because of its low validity score (Ardiç et al., 2002). Therefore, high-quality studies with a large sample size are needed to investigate the efficacy of TENS alone or in combination with other sophisticated physiotherapy procedures.

2.5.2 Manual Therapy for myofascial trigger points

2.5.2.1 Trigger Point Compression Release for myofascial trigger points

“Trigger point compression release (TPCR)”, also known as “ischemic compression (IC)”, is a manual therapy technique that comprises moderate compression, commonly administered with the fingers to the MTrPs of the majority of the human body's muscles (Moraska et al., 2013; Travell et al., 1999; Travell & Simons, 1983, 1992). Besides, the MTrPs are compressed perpendicularly by flat palpation or pincer grip with the finger or thumb of the clinician to compress contracted sarcomeres, leading to longitudinal elongation of it (Simons, 2002; Unverzagt et al., 2015). This compression should be

retained until the subject feels a reduction in discomfort; this adjustment can take 20 to 60 seconds or longer (Fryer & Hodgson, 2005). This compression can be administered for a long time (90 seconds) at a low pressure under the subject's PPT or for a brief duration (30 seconds) with a high pressure above the subject's PPT (Hou et al., 2002). The immediate decrease in MTrPs hypersensitivity from TPCR is demonstrated by a rise in PPT and is not produced by a clinician's decrease in palpation pressure (Fryer & Hodgson, 2005). Similar effects have been observed in the literature in comparison with advanced non-invasive and invasive treatment options, for example, TPCR as well as transverse friction massage for MTrPs with such an equivalent decrease in VAS (4.6 pre-treatment, 3.8 post-treatment for TPCR group, 4.9 pre-treatment, 4.2 post-treatment for massage therapy group) and increase in PPT (1.8 kg/cm2 pre-treatment, 2.2 kg/cm2 post-treatment for IC group, 2.0 kg/cm2 pre-treatment, 2.35 kg/cm2 post-treatment for massage therapy group) for both treatments (Fernández-de-las-Peñas et al., 2006). Moreover, in subjects who have MTrPs, TPCR was superior to sham ultrasound in instantly reducing pain (Gemmell et al., 2008). Besides, another study reported that IC with passive stretching gave a more beneficial effect in reducing pain in MTrPs as compared to IC alone (Kostopoulos et al., 2008). Additionally, better improvement in MTrP pain with IC combined with TrPs injection as compared to injections alone (Kim et al., 2013). A recent study reported that TPCR and DN both are effective in reducing MTrP pain, but DN shows more remarkable improvement (VAS: 6.5/2.4 pre-treatment/post-treatment for DN group, 6.23/3.33 pre-treatment/post-treatment for TPCR group) (Ziaeifar et al., 2019). Furthermore, Benito-de-Pedro et al. (2019) reported that DN (2.63/1.94 kg/cm2 pre-treatment/ post-treatment) more effectively improved PPT as compared to TPCR (2.62/2.38 kg/cm2 pre-treatment/ post-treatment) in latent MTrPs of the triceps surae muscle (Benito-de-Pedro et al., 2019). In short, TPCR can minimize MTrP pain efficiently and enhance PPT alone and in conjunction with other therapeutic approaches. Literature has shown that in MTrPs, DN is more productive and beneficial than IC. As a result, high-quality research is entailed to verify TPCR's efficacy in comparison to DN.

2.5.2.2 Massage Therapy for myofascial trigger points

“Massage therapy is the scientific manipulation of the body's soft tissues, with manual methods such as providing fixed or moveable pressure, gripping and manipulating muscles and body tissues at its core” (Al-Yousef et al., 2019). Consequently, massage can be considered a way to stretch the knotted band and enhance local blood flow. “Kneading”, “rolling”, “friction”, & “stripping strokes” across and around a knotted band are some of the most common massage techniques (Beck, 2006; Shah, et al., 2015). Previous studies have shown a reduction in MTrP pain with massage (Fernández-de-las-Peñas et al., 2006; Moraska et al., 2017) and assessed the efficacy of massage therapy in combination with other advanced physical therapy techniques. Trampas et al. (2010) reported that massage in combination with modified Proprioceptive Neuromuscular Facilitation stretching gave an immediate reduction in MTrP pain (VAS: 3.0 pre-treatment, 2.1 post-treatment) and improvement in PPT (2.35 pre-treatment, 2.94 post-treatment) (Trampas et al., 2010). Furthermore, PPT at MTrPs is supplemented by single and multiple massage applications, and the pain tolerance of MTrPs has a great potential to increase; additional PPT benefit has been observed even after several massage treatments (Moraska et al., 2017). On the other hand, massage was reported to lower the frequency and severity of MTrPs in the literature, but the influence on neck and shoulder discomfort was minimal (Gam et al., 1998). In addition, Friction massage has short-term effects on TrPs, and even three massage sessions in MTrPs did not improve the results, but it reduced the PPT (2.66 ± 0.89 to 2.25 ± 0.76; $P = 0.02$), which indicated that massage not only failed to ameliorate the MTrPs but may have stimulated these points (Mohamadi et al., 2017). In this situation, most of the studies reported beneficial effects of massage on MTrP pain reduction and increased PPT, but few of the studies said that massage stimulated the latent trigger points and converted them into active TrPs, leading to an increase in pain and reduction in PPT. In this situation, massage may be effective for active MTrPs but not for latent MTrPs; hence, it necessitates a high-quality study to demonstrate massage's efficacy in managing MTrPs.

2.5.2.3 Spray and Stretch for myofascial trigger points

Spray and Stretch (S&S) is a stretching technique that uses an instant topical vapour coolant that effectively resolves TrPs, and it was first used by Dr. Hans Kraus (1941) (Kraus, 1941). Literature compared the S&S with different physical therapy modalities and showed immediate positive effects of S&S on PPT and was more successful than a hot pack and UST when paired with a deep pressure massage, so literature recommends the use of S&S in the management of MTrPs (Dommerholt, 2020; Hong et al., 1993). In contrast, a study compared S&S to S&S combined with skin rewarming on MTrPs within the upper trapezius with a moist hot pack, and it showed, it improved VAS scores (pre-treatment 6.71, post-treatment 2.0) and cervical ROM (pre-treatment 10.55cm, post-treatment 8.47cm), but not the PPT of MTrPs (pre-treatment 2.73 $kg.cm^2$, post-treatment 4.38 $kg.cm^2$) by incorporating skin rewarming (Bahadir et al., 2010). Instead, Loosberg et al. (2016) checked the effectiveness of S&S (PPT 22.1 kPa) compared with post-isometric relaxation (PPT 25.6 kPa) in the management of TrPs, and they reported that there was no difference in both the techniques (Loosberg et al., 2016). Thus, S&S can immediately improve the PPT of MTrPs, but with other modalities, there is a difference in the efficacy of S&S. Some studies reported that S&S was effective for improving pain and ROMs with moist hot packs but not for PPT, and other studies reported that S&S was not effective with hot packs and UST, but in combination with deep pressure massage, it was effective in PPT. To confirm the efficacy of S&S in MTrPs, superior-quality studies with a higher number of samples are required.

2.5.3 MTrPs Management: Dry Needling Techniques

MTrP-DN is an invasive procedure used to treat MTrPs related musculoskeletal pain syndrome (Boyles et al., 2015). The MTrPs in the shoulder girdle muscles may be the source of pain. Biochemically, the release of acetylcholine due to abnormal sympathetic activity and local hypo-perfusion in the MTrPs results in hypoxia that causes a decrease in pH level releases bradykinin, potassium, substance P, and cytokines, which stimulate the free nerve ending in the muscle, and causes pain (Gallego-Sendarrubias et al., 2020).

Treating MTrPs using a dry needle induces micro-trauma and bleeding. Literature reported that MTrP-DN induced hyperemia could dilute the pain-sensitizing substances and relieve the pain. Also, Fernández et al. (2019) reported that DN also releases endogenous opioids such as β-endorphin, which inhibit the release of the substance P (Fernández-de-las-peñas et al., 2019). Literature related to the MTrP-DN technique endorsed its application as a method of pain management, but due to the complexity of the placebo needling design, this analysis did not confirm effectiveness beyond placebo (Cummings & White, 2001). However, in subjects of bilateral glenohumeral joint pain and active MTrPs of the infraspinatus muscle, MTrP-DN improves pain, ROM, and PPT (Hsieh et al., 2007).

In addition, literature reported improvement in verbal pain score and shoulder ROMs after the treatment with MTrP-DN for Infraspinatus, Teres minor, and Anterior deltoid muscles of female international volleyball players (Osborne & Gatt, 2010). Whereas numerous studies compared the MTrP-DN with Placebo DN and other available management options for TrPs, and most of them are in favour of DN management for MTrPs of different regions of the body (Bandy et al., 2017; Tesch et al., 2019). Uygur et al. (2019) said that DN seems to be a more reliable management approach than corticosteroid injection (CSI) (Uygur et al., 2019). Furthermore, Gattie et al. (2017) reported that DN was more successful than sham treatments or no treatment to alleviate pain immediately up to 12 weeks after application (Gattie et al., 2017). In contrast, Charles et al. (2019) concluded that evidence of DN is not more substantial than placebo in managing myofascial pain (Charles et al., 2019).

Similarly, when DN was compared to other therapies widely used in physical therapy, there were no significant variations in functional performance (Gattie et al., 2017). Thus, in the management of MTrPs, the quality of evidence for DNA varies from very poor to moderate compared to control groups, sham therapies, or other treatments. The drawbacks of limited sample sizes, ambiguous methodologies, poor blinding, and lack of control groups should be discussed in future studies.

2.6 MYOFASCIAL TRIGGER POINT DRY NEEDLING

MTrP-DN is a modern procedure involving inserting a fine needle into the skin and muscle to relieve MTrP pain.

2.6.1 Types of Dry needling (DN)

2.6.1.1 Superficial dry needling: In this procedure, a short needle of 0.3 mm to 10 mm is inserted into the skin, which touches the epidermal layer but is missing the bone or muscle. This needling technique targets the sensorimotor system and changes the sensory input, thus altering the motor output and resulting in a dramatic reduction of pain (Baldry, 2002; Griswold et al., 2019).

2.6.1.2 Deep dry needling: Deep DN directly targets the muscle to modify the perception of pain, influences scar tissue, or decreases tightness with the help of fine needles whose size range is between 15mm-125mm, and its efficacy has been illustrated in the literature (Francesco-Ceccherelli et al., 2002; Fernández-Carnero et al., 2017; Irnich et al., 2002; Itoh et al., 2007; Taşoğlu et al., 2017; Tekin et al., 2013).

2.6.1.3 Periosteal pecking dry needling: Periosteal pecking involves using fine dry needles to peck at the bone directly. This induces neuroendocrine responses that can benefit those with debilitating symptoms of osteoarthritis when it is performed intracapsular (Dunning et al., 2018).

2.6.1.4 Electrical Stimulation dry needling: The initiation of electrical stimulation to the needles induces a neuroendocrine reaction that is distinct from needles alone. This method of DN taps into various centers and pathways of pain control in the central nervous system, making it a potential alternative for subjects with chronic pain (Butts et al., 2016).

2.6.2 Models of MTrP-DN

Several DN techniques have been used, each based on its own set of theories, observations, and hypotheses. The three major DN models are: (a) the model of MTrPs, (b) the model of radiculopathy, and (c) the model of spinal segmental sensitization.

2.6.2.1 The model of MTrPs

MTrPs present as focal areas in muscle that appear stiff, hyper-contracted, and painful, particularly when palpated. The pathological process that leads to the development of MTrPs is still a mystery, but researchers thought that the altered behaviour of neuromuscular junction results in the formation of MTrPs in the muscle. In addition, changes in the activity of the acetylcholine receptor (AChR) take place which leads to greater production of Acetylcholine (Ach) which results in depolarization and increased tension in the muscle fibers. Furthermore, it produces constriction of blood flow to the muscles that create hypoxia in the muscle fibers, and it disrupts the mitochondrial metabolism that leads to increased production of reactive oxygen species that ultimately release the sensitizing substances like cytokines that produce an inflammatory response and give rise to pain and tenderness in the muscle fibers (Figure 2.1) (Dommerholt, 2004; Mcelroy & Chandel, 2017).

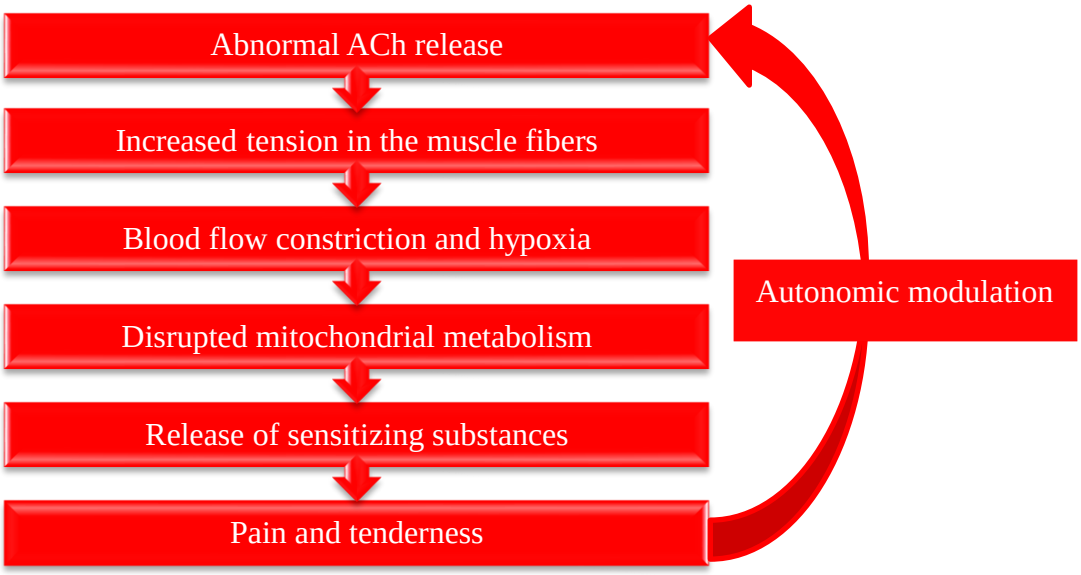

Figure 2. 1 Schema chart of MTrPs model.

2.6.2.2 The model of Radiculopathy

Radiculopathy is a disease caused by a compressed nerve within the spine, leading to pain, loss of sensation, tingling, or weakness along the nerve's path. Gunn (1997) proposed a radiculopathy model for the development of MTrPs and advocated for the notion that myofascial pain has always been secondary to radiculopathy (Figure 2.2) (Gunn, 1997b). In addition, he proposed that shortening of the paraspinal muscles caused compression in the vertebrae, which resulted in the narrowing of the intervertebral disc space and intervertebral foramen, which resulted in the compression of the intervertebral disc, nerve roots, and the blockage of nerve impulses in the innervated structures, which is known as the A-trophic effect. Furthermore, A-trophic structures become highly irritable and develop super sensitive trigger points in the innervated muscles. However, the most appropriate treatment locations, according to Gunn, are always near the musculotendinous junctions. They are dispersed in muscles that are supplied by the primary anterior and posterior rami in a segmental or myotomal fashion. Since the primary posterior rami, such as the multifidus, and the primary anterior rami, along with the rest of the myotome, are

segmentally involved in the paraspinal muscles, rehabilitation must comprise both the paraspinal muscles and the more peripheral muscles (Figure 2.3) (Dommerholt, 2004; Gunn, 1997b).

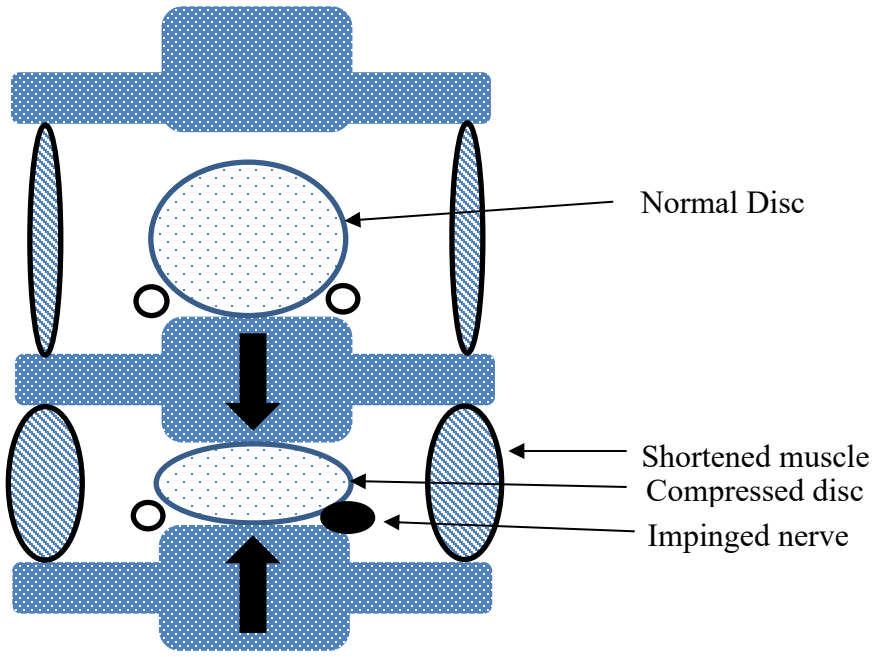

Figure 2.2 Shortened Paraspinal muscles across an intervertebral disk space can compress the disk (Gunn, 1997b).

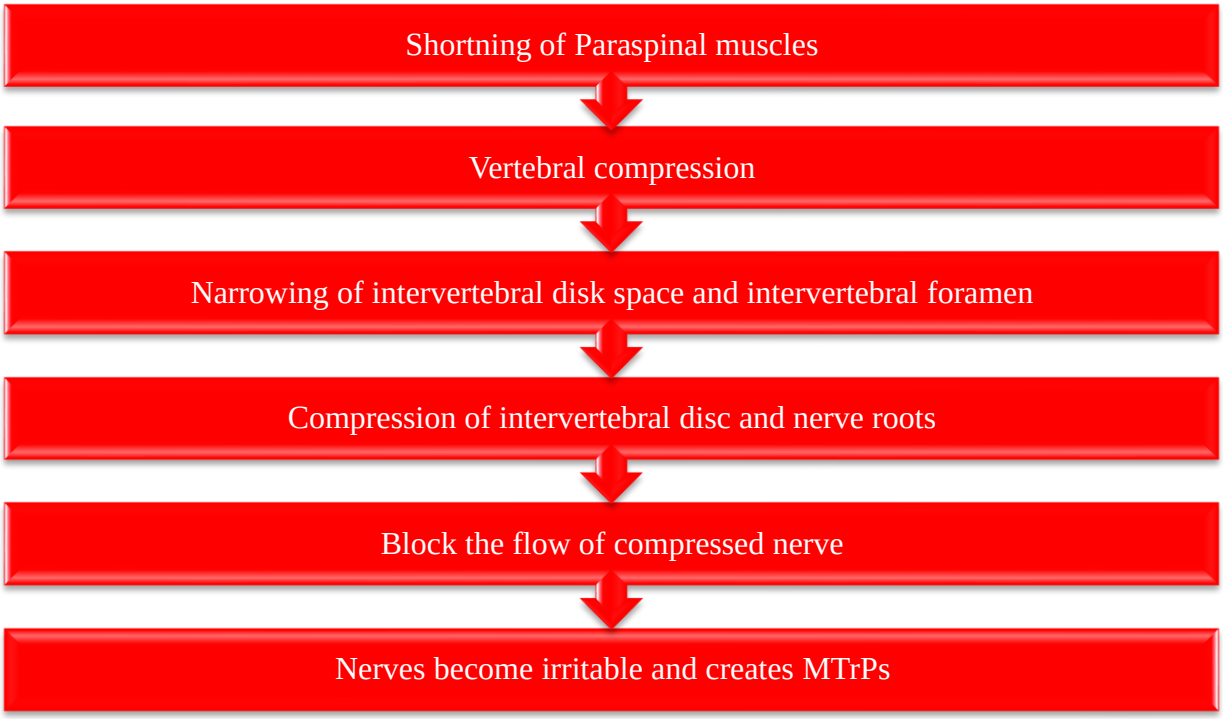

Figure 2. 3 Schema chart of radiculopathy model of MTrPs.

2.6.2.3 The model of Spinal Segmental Sensitization

Dr. Andrew Fischer (1999) created the spinal segmental sensitization (SSS) model. "The SSS is a 'hyperactive' state of the dorsal horn of the spinal cord that is caused by damaged tissue sending nociceptive **(**pain**)** input into the spinal cord." These nociceptive inputs then cause the associated spinal level dermatome (skin) to become oversensitive, the associated spinal level sclerotome (bone, ligaments, and joints) to become pain sensitive, and the associated spinal level muscles to develop MTrPs (Figure 2.4) (Fischer, 1999; Suputtitada, 2016).

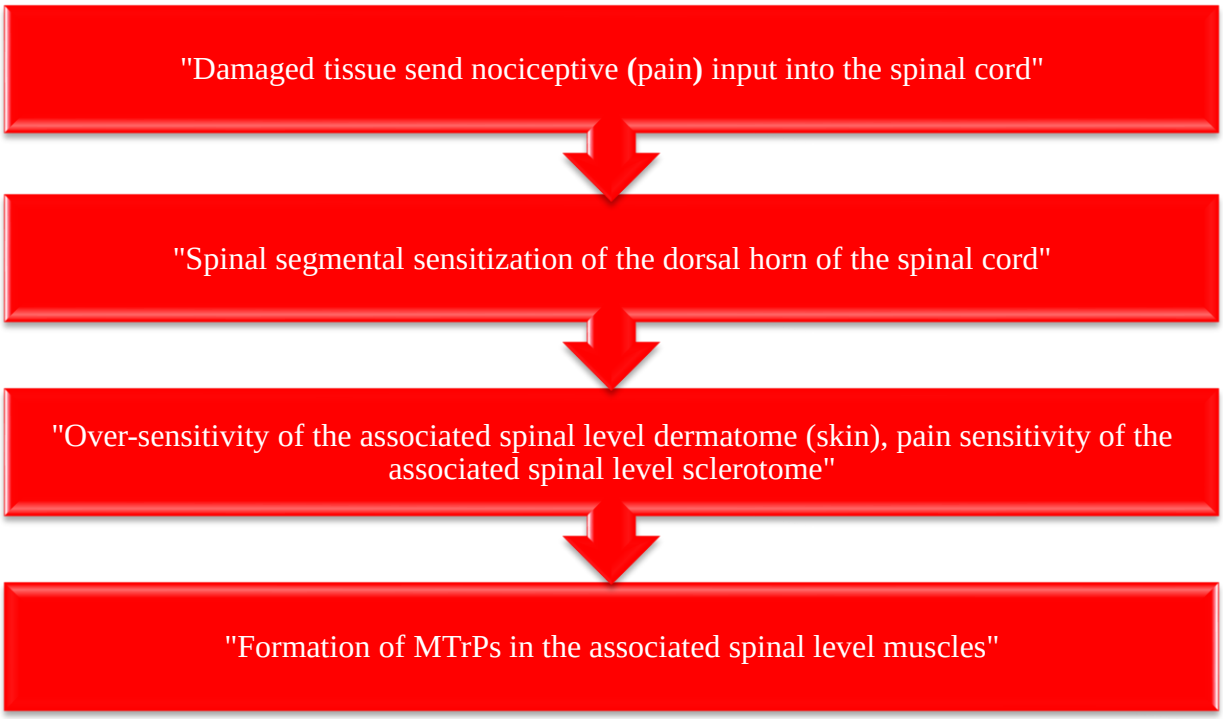

Figure 2. 4 Schema chart of Spinal segmental sensitization model of MTrPs.

2.7 EFFECT OF MTrP-DN ON MUSCLE PAIN

MTrPs have been identified as a leading source of pain (74% of subjects) in musculoskeletal conditions and are often treated with DN (Chou et al., 2012; Cummings & White, 2001). As has been previously reported in the literature that DN can relieve MTrP pain related to shoulder joint in different time spans like short, medium, and long term (Gerber et al., 2015; Gunn et al., 1980; Liu et al., 2015; Llamas-Ramos et al., 2014). In addition, direct needling of MTrPs was demonstrated to be efficient management and reduced the mean VAS score from 7.8 to 2.8, but the evidence from clinical trials that needling techniques have efficacy beyond placebo is neither supported nor refuted (Cummings & White, 2001; Hsieh et al., 2007). A closer look at the literature on the effectiveness of direct DN compared to needling elsewhere in the muscle presented conflicting results; similarly, previous studies failed to demonstrate the superiority of direct

needling into the MTrPs compared to non-penetrating sham intervention (Tekin et al., 2013; Tough et al., 2009). Thus, there is a need for a high-quality study with a large sample size to confirm the efficacy of direct and distant DN in relieving pain in muscles related to MTrPs.

2.8 EFFECT OF MTrP-DN ON JOINT RANGE OF MOTIONS

MTrPs can be associated with muscle dysfunction, weakness, and limited joint ROM. In the light of reported literature, it is conceivable that MTrP-DN has favourable efficacy in various musculoskeletal conditions in improving joint ROMs (Mejuto-Vázquez et al., 2014; Mendigutia-Gómez et al., 2016; Sedighi et al., 2017). DN improved shoulder girdle mobility in subjects with painful shoulder syndrome (Joanna et al., 2020). It is also well acknowledged that DN in combination with manual therapy and exercises improves ROMs in musculoskeletal conditions (Clewley et al., 2014; Sillevis & Wyss, 2020). Similarly, Clewley et al. (2014) support the efficacy of DN in improving shoulder ROMs in subjects with AC (Clewley et al., 2014). Likewise, one RCT with a small sample size (n=50, 25 received DN, and 25 received CPT) also reported the same (Sukumar & Lawrence, 2014). On the other hand, Hazar and Arslan (2014) reported that DN was no more effective in enhancing shoulder ROMs in subjects with AC (Hazar & Arslani, 2014). Thus, DN is effective in improving joint ROMs in musculoskeletal conditions, and this has been previously assessed only to a minimal extent, but available studies show inconsistency related to the effectiveness of DN in enhancing joint ROMs. Therefore, there is a need for a high-quality study with a large sample size to check the efficacy of DN in improving ROMs in subjects with AC.

2.9 EFFECT OF MTrP-DN ON PRESSURE PAIN SENSITIVITY

The MTrPs are the pain-sensitive points in the muscles. The PPT has commonly been employed to evaluate the MTrPs, which is the least force required to cause muscle pain (Maquet et al., 2004). Literature favours the efficacy of MTrP-DN in various musculoskeletal conditions by revealing the fact that three sessions of DN were more

effective for improving PPT than sham DN (Ceballos-Laita et al., 2020); similarly, DN, along with manual therapy, induced substantial improvement in PPT (Gallego-Sendarrubias et al., 2020). In addition, Wang-Price et al. (2020) reported that deep DN with needle manipulation induced more improvement in PPT than DN without needle manipulation (Wang-Price et al., 2020). On the other hand, literature compared the efficacy of DN with advanced therapeutic techniques and reported that DN was equally effective in improving PPT as compared to Kinesiotaping (Yılmaz et al., 2020), Ischemic compression (Behrangrad et al., 2020), and manual pressure techniques (Meulemeester et al., 2017). Thus, these studies have begun to provide insight into that MTrP-DN, manual therapy, and needle manipulation enhances the PPT of affected muscle with MTrPs.

2.10 EFFECT OF MTrP-DN ON SHOULDER DISABILITY

Subjects with MTrPs experience a certain amount of difficulty in daily activities. Literature reported that the Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) had a mean score of 61.68 in subjects with AC (Fernandes, 2015). MTrP-DN may be a treatment of choice among clinicians that reduces disability with improved quality of life. Literature reported that DN effectively reduces disability in different musculoskeletal conditions such as Low back pain, golfers elbow, etc. (Liu et al., 2018; Shariat et al., 2018). Similarly, Clewley et al. also reported that DN induced significant improvement in disability after thirteen treatment sessions. By the fifth intervention session, disability improved from 68 to 23 points on the Quick DASH, which is unquestionably more remarkable than the minimum clinically important difference (MCID) of 8 points (Clewley et al., 2014). In addition, DN, in combination with other therapies such as LASER therapy and standard physical therapy, significantly reduces functional disability (Liu et al., 2018). Instead, literature reported that DN was equally effective in reducing disability as other therapeutic techniques, i.e., the Strain–Counterstrain technique (Segura-Ortí et al., 2016). Thus, DN is more successful than no treatment, sham DN, and standard physical therapy for reducing impairment in subjects with AC but no distinction in disability outcomes occurs compared to other physical therapy techniques.

2.11 NEEDLING WITH OR WITHOUT PARASPINAL NEEDLING

The emerging body of knowledge on MTrP-DN in recent years was proposed to perform PSDN, which may intensify the clinical efficacy of local DN. DN should be done not only at the spot of MTrPs in the skeletal muscles but also in the paraspinal muscles with the same spinal nerve that innervates the painful muscles (Gunn, 1997b). Pathophysiologically, it is postulated that "spam of the paraspinal muscles, particularly the multifidus, is thought to cause intervertebral disk compression and narrowing of the intervertebral foramina or exerts direct pressure on the nerve root, resulting in peripheral neuropathy and the development of low threshold nociceptors and pain." Thus, the restrained flow of nerve impulses across all innervated structures may lead to weakness and hyperirritability of the muscles (Gunn, 1997; Kalichman & Vulfsons, 2010). The effectiveness of DN of MTrPs with and without paraspinal needling for 40 elderly subjects with myofascial pain syndrome was studied in a single-blinded RCT. A total of 18 subjects received three sessions per week of local MTrP-DN for the upper trapezius, whereas 22 subjects received PSDN treatment for the same muscle. The group that received paraspinal DN had more persistent subjective pain relief than the group that received DN alone at four weeks of follow-up. The PSDN group demonstrated substantial enhancement in depression & cervical ROM as compared with the DN group alone. The authors proposed that paraspinal DN is a safer approach to treat myofascial pain syndrome in elderly subjects than MTrP-DN alone. This study, which only included an older population, was relatively small and used inadequate blinding techniques. Therefore, the findings may be verified in good quality studies before recommending the paraspinal needling approach for the management of MTrP syndrome (Hyuk et al., 2007).

2.12 DRY NEEDLING THERAPY FOR ADHESIVE CAPSULITIS

Literature supports the efficacy of DN in treating various musculoskeletal (Dunning et al., 2013; Fusco et al., 2018; Liu et al., 2015; McDevitt et al., 2020; Pavkovich, 2015; Uygur et al., 2017), neurological (Mendigutia-Gómez et al., 2016; Mendigutía-Gómez et al., 2020) and sporting conditions (Huntly & Berdejo-del-Fresno, 2014) in clinical practice.

However, literature is scarce, particularly on the management of AC. A case series of AC subjects treated with MTrPs of shoulder girdle muscles with DN for 13 sessions over two weeks ultimately results in clinically substantial improvements in pain intensity, ROM, and disability (Clewley et al., 2014). DN contributes to a variety of central and peripheral modifications that reduce pain and inflammation (Silva et al., 2011; Zhang et al., 2014), increase ROM (Koppenhaver et al., 2016; Osborne & Gatt, 2010), and trigger tissue changes (Goldman et al., 2013; Langevin, Churchill, & Cipolla, 2001; Langevin, Churchill, Fox, Badger, et al., 2001), including the deactivation of MTrPs (Dunning et al., 2013). On the other hand, Hazar and Arslan (2014) reported in a pilot RCT that DN has not produced much improvement in pain, ROM, and disability compared with control groups. In addition, the authors proposed a high-quality study design to verify the clinical efficacy of DN for improving functional outcomes in subjects with AC (Hazar & Arslani, 2014). Therefore, a need for a high-quality study with an appropriate sample size to evaluate the clinical efficacy of DN for the management of subjects with AC is warranted (Table 2.3).

Table 2. 3 Dry Needling therapy for Adhesive capsulitis

Authors	Study design	Methodology and Intervention	Outcome measures	Result and conclusion
Clewley et al. (2014) (Clewley et al., 2014)	Case report One subject (54 years of age, female subject) included left shoulder adhesive capsulitis (stage: 2) from the last 5 months.	The subject received 13 treatment sessions over 6 weeks. Session 1: Thrust manipulation, cervicothoracic region, Over-the-chair thoracic extension. Session 2: Thrust manipulation, cervicothoracic and thoracic, AC and SC joint mobilization, Passive ROM shoulder flexion, abduction and external rotation, Over-the-chair thoracic extension, Upper-body ergometer. Session 3: Same as session 2 along with Active ROM exercises for shoulder flexion and abduction, MTrP-DN for upper trapezius.	▪ Numerical Pain Rating Scale (NPRS). ▪ Shoulder Pain and Disability Index (SPADI). ▪ Quick Disability of the Arm, Shoulder, and Hand questionnaire	SPADI reduced from 55 scores (baseline) to 38 scores after 5 treatment sessions and 5 scores after 13 treatment sessions. Quick DASH reduced from 68 scores (baseline) to 25 scores after 5 treatment sessions and 7 scores after 13 sessions of treatment. NPRS with activity reduced from 8/10 (baseline) to 2/10 after 13 treatment sessions, and NPRS without activity reduced from 4/10 (baseline) to 0/10 after 13 treatment sessions. ROM also improved significantly in post-reading compared to pre-reading.

Authors	Study design	Methodology and Intervention	Outcome measures	Result and conclusion
		Session 4: Thrust manipulation, cervicothoracic region, MTrP-DN for upper trapezius, deltoid, and infraspinatus, Upper-body ergometer, Active ROM exercises for shoulder flexion, and abduction. Session 5: Thrust manipulation, cervicothoracic region, Glenohumeral, AC, and SC joint mobilization, with PROM shoulder flexion, abduction, and external rotation, MTrP-DN for upper trapezius, levator scapula, deltoid, and infraspinatus, Upper-body ergometer, Active ROM exercise for shoulder flexion, and abduction, Isotonic exercises for the rotator cuff and deltoid. Session 6: Same as session 5 along with MTrP-DN for deltoid only.	(Quick DASH).	The authors concluded that MTrP-DN can be used as an adjunct treatment in subjects with AC. The outcomes showing significant improvement in shoulder ROM, pain, and function, especially after the addition of dry needling, suggest a potential benefit of this intervention in AC.

Authors	Study design	Methodology and Intervention	Outcome measures	Result and conclusion
		Session 7 and 8: Glenohumeral joint mobilization, PROM into flexion, abduction, and external and internal rotation, added towel stretch for shoulder internal rotation. Session 9 to 11: High-grade glenohumeral mobilizations and shoulder PROM, Progressed prone scapulothoracic and supine serratus exercises with increased resistance and repetitions. Session 12 and 13: Continued with shoulder exercises for rotator cuff and deltoid strengthening. Active assisted ROM for improving ROM.		
Sukumar & Lawrence (2014)	Single blinded randomized	50 subjects with AC were randomly allocated into two groups: the IMMT group (14 males and 11 females) and the CPT group (12 males and 13 females).	▪ SPADI, ▪ Universal goniometer (to access shoulder	In the DN group, the mean and standard deviation of SPADI reduced from 110.08 ± 7.44 (Pre-test) to 10.76 ± 3.13 (Post-test), and Shoulder

Authors	Study design	Methodology and Intervention	Outcome measures	Result and conclusion
(Sukumar & Lawrence, 2014)	control trial.	Subjects in the IMMT group were treated with intramuscular manual therapy (superficial and deep dry needling), 4-6 sessions in two-week duration, and subjects were instructed to perform free exercises during the 2nd week period of intervention. The areas of myofascial trigger points in the upper trapezius, supraspinatus, and deltoid muscles were identified with help of flat and/or pincer palpation. Then the suitable length sterilized acupuncture needles were inserted into the skin in a suitable position for the subject. Once the needles were inserted into the myofascial trigger points, the contractile nodule was deactivated by the mechanical stimulus given by the needle manipulation. Most of occasions local twitch response was elicited from the trigger points.	abduction ROM)	abduction ROM improved from 89.68 ± 11.99 (pre-test) to 165.40 ± 6.10 (post-test). In the CPT group, the mean and standard deviation of SPADI reduced from 111.84 ± 5.16 (Pre-test) to 23.84 ± 4.93 (Post-test), and Shoulder abduction ROM improved from 89.1 2 ± 8.16 (pre-test) to 147.80 ± 10.34 (post-test). The authors concluded that IMMT is a more effective treatment technique than CPT interventions and it can be used as a primary intervention tool in treating AC of the shoulder. Still, further studies needed with a larger sample size are required to confirm this study's results.

Authors	Study design	Methodology and Intervention	Outcome measures	Result and conclusion
		The needles were moved in a different direction without removing the needle completely out of the skin to deactivate adjacent satellites or associated trigger points. Another 25 subjects in the CPT group received transcutaneous electrical nerve stimulation, therapeutic ultrasound, passive/active stretching, and free exercises for two weeks.		

Note: AC: Acromioclavicular; PROM: Passive range of motion; ROM: Range of motion; SC: Sternoclavicular, MTrP-DN: Myofascial trigger point dry needling, IMMT: Intramuscular manual therapy, CPT: Conventional physiotherapy.

CHAPTER III

METHODOLOGY

CHAPTER OVERVIEW

This chapter provides information on research design, sampling methods, data collection procedures, and statistical tools used for data analysis.

3.1 RESEARCH DESIGN

This study was a single-blinded, randomized controlled, three-arm parallel-group clinical trial and was accepted by the Clinical Research Ethical Committee of Lovely Professional University of Applied Medical Sciences (LPU/IEC/2018/01/04) (Appendix- XI).

3.2 STUDY POPULATION

Subjects with clinically diagnosed adhesive capsulitis were taken into the study.

3.3 SAMPLING METHOD

A simple random sampling method was used.

3.4 SAMPLE SIZE

The sample size was determined by using the clinical superiority design formula with minimal detectable change (MDC 95%) as 18 points on shoulder pain and disability index (SPADI) with a standard deviation (SD) of 19 points from previous studies (Tveitå, et al., 2008; Zhong, 2009). Assuming a 95 percent confidence interval and 80 percent of power, the calculated sample size was 70 subjects per group with a total of 210 subjects (Angst et al., 2007; Schmitt & Di Fabio, 2004).

$$N = 2 X \left[\frac{Z_{1-\alpha} + Z_{1-\beta}}{\delta_0} \right]^2 X \ S^2$$

Where $Z_{1-\alpha}$ is taken at $\alpha = 95\%$

$Z_{1-\beta}$ is taken at $\beta = 20\%$

S is 19, which is taken from the previous article on SPADI in the case of AC (Tveitå, et al., 2008).

δ_0 is 8 taken from previous literature (Paul et al., 2004).

n = N X 3, Here N signifies sample size for a single group, But the present study has three groups.

Solution

$$N = 2 X \left[\frac{Z_{1-\alpha} + Z_{1-\beta}}{\delta_0} \right]^2 X \ S^2$$

$$N = 2 X \ \frac{(Z_{1-\alpha} + Z_{1-\beta})}{\delta_0}^2 X \ S^2$$

Where, $\delta_0 = \frac{\mu_1 - \mu_2}{2}$

Here, $Z_{1-\alpha} = 1.645$ at $\alpha = 95\%$

$Z_{1-\beta} = 0.842$ at $\beta = 20\%$

Standard deviation = 19

$\delta_0 = \frac{\mu_1 - \mu_2}{2} = 8$

$$N = 2\ X\ \frac{(1.645 + 0.842)^2}{8^2} \times 19^2$$

$$N = \frac{2 \times (2.48)^2 \times 361}{64} = \frac{2 \times 6.2 \times 361}{64} = 69.9 = 70$$

N = 70, (N is the sample size of a single group, but we have three groups (n) in this present study)

So, n = N × 3

n = 70 × 3 = 210 total sample size.

3.5 SELECTION CRITERIA

Subjects were included and excluded from the study as per the following criteria.

3.5.1 Inclusion criteria

Subjects who were (1) clinically diagnosed patients of AC based on the history, physical examination, and radiology, if necessary (2) aged between 40-65 years (3) male or female (4) having pain and restriction in the shoulder for three months or more along with palpable, taught, tender nodule or band within muscles of the shoulder girdle and (5) having normal cognitive function were recruited for the study.

3.5.2 Exclusion criteria

The subjects who had (a) skin disease around the shoulder and neck (b) surgical history around the neck, (c) taken anticoagulant medication within three days before study recruitment (d) history of malignancy-related pain within six months before the study (e) received injections in the trigger points to be punctured within three months prior study (f) extreme fear of needles (g) uncooperative behaviour were eliminated from the study.

3.6 STUDY LOCATION

The study was conducted in the outpatient department, Kapoor bone and child hospital, and St. Soldier College (Co-Ed), Department of Physiotherapy, Jalandhar City, Punjab. India.

3.7 OUTCOME MEASURES

3.7.1 Shoulder Disability

Shoulder disability was assessed using the "Shoulder Pain and Disability Index" (SPADI), a globally acknowledged scale for measuring self-reporting pain severity and functional disability. This scale consists of a 13-item scale with subscales that include 5 items for pain and an 8-item for disability. SPADI has strong reliability coefficients of ICC > 0.89 and good internal consistency with Cronbach's alpha of 0.90 in various patient populations (Breckenridge & Mcauley, 2011). SPADI has a strong construct validity and is correlated to other region-specific shoulder questionnaires (Appendix- VIII) (Hill et al., 2011; Sudarshan et al., 2019).

Subjects have been asked to select the best count for pain level and the degree of difficulty using the shoulder involved. The pain scale was measured at 50 in total, while the disability scale was 80. A percentage was expressed as the total SPADI score. A score of 0 shows the best, and 100 shows the worst. A higher score suggests additional disability. Any question missed was omitted from the total score of each subscale when scoring SPADI.

3.7.2 Shoulder Range of Motion

Shoulder ROM was measured by using a "universal goniometer", and it has excellent intra-rater reliability (ICC- 3,k for goniometry 0.94) (Mullaney et al., 2010).

a. **Shoulder Flexion ROM:** The subjects were placed in a supine posture with the knees flexed to flatten the lumbar spine. The shoulder was positioned for abduction, adduction, and rotation at 0°. The forearm was also placed at 0° of supination and pronation. The

goniometer's stationary arm was aligned with the midaxillary line of the thorax and the moveable arm with the humerus's lateral midline, with the humerus's lateral epicondyle as a reference. Then subjects were asked to do shoulder flexion, and the therapist noted the degree of movement on the goniometer (Norkin & White, 1998).

b. **Shoulder Extension:** The subjects were placed in a prone position, with the head turned away from the shoulder being examined. The shoulder was placed for abduction and rotation at 0°. The elbow was placed in a slight bending position. The forearm was also positioned in a 0° of supination and pronation. The goniometer's fulcrum was placed near the acromial process. The goniometer's stationary arm was aligned with the thoracic midaxillary line and the moveable arm with the humerus's lateral midline, using the humerus's lateral epicondyle as a reference. Then subjects were asked to do shoulder extension, and the therapist noted the degree of movement on the goniometer (Norkin & White, 1998).
c. **Shoulder Abduction:** The Subjects were placed in a supine position. The shoulder was positioned at 0° of flexion and extension, as well as complete lateral rotation. The elbow was extended. The fulcrum of the goniometer was placed near the anterior aspect of the acromial process. The goniometer's stationary arm was parallel to the midline of the anterior aspect of the sternum, and the moveable arm was parallel to the medial midline of the humerus. Subjects were then asked to do shoulder abduction, and the therapist noted the degree of movement on the goniometer (Norkin & White, 1998).
d. **Shoulder Medial Rotation:** The subjects were placed in the supine position with the arm being tested at 90° of shoulder abduction. The forearm was perpendicular to the supporting surface and was at 0° of supination and pronation. The entire length of the humerus was rested on the supporting surface, but the elbow was not supported. A pad was placed under the humerus to position it at the level of the acromial process. The goniometer's fulcrum was placed over the olecranon process. Using the olecranon process and ulnar styloid as references, the goniometer's stationary arm was aligned perpendicular to the floor, and the moveable arm with the ulna bone. Then subjects were

asked to do shoulder medial rotation, and the therapist noted the degree of movement on the goniometer (Norkin & White, 1998).

e. **Shoulder Lateral rotation:** The subjects were positioned supine, with the arm tested at 90° of shoulder abduction. The forearm was perpendicular to the supporting surface and had a supination and pronation angle of 0°. The entire length of the humerus was rested on the supporting surface, but the elbow was not supported. A pad was placed under the humerus to position it at the acromial process level. The goniometer's fulcrum was placed over the olecranon process. Using the olecranon process and ulnar styloid as references, the goniometer's stationary arm was aligned perpendicular to the floor, and the moveable arm with the ulna bone. Then subjects were asked to do shoulder lateral rotation, and the therapist noted the degree of movement on the goniometer (Figure 3.1) (Norkin & White, 1998)

3.7.3 Pressure Pain Threshold (PPT)

The Pressure Pain Threshold (PPT) was measured using an instrument that detects the force that obtained a PPT called a pressure algometer. These devices have high validity and reliability (Kinser et al., 2009) and acceptable intra-examiner reliability of pressure rate application. The between-session PPT across multiple sessions was reliable and without differences (Nussbaum & Downes, 1998).

A device “pressure algometer” was used to evaluate the PPT of MTrPs in the muscles surrounding the glenohumeral joint before and after treatment. The subjects were first given a thorough explanation of the method. The algometer was used on the TrP region, with the metal (steel) rod at a right angle towards the skin's surface. The compression at a slow rate was applied to provide enough time for the subject to react when there is a pain sensation. The subjects were required to tell "pain" whenever their pain intensity or discomfort increased. Once the subject confirmed pain, the compression was stopped. The average value of three successive assessment readings with a 30-second interval (expressed in kilograms per square centimeter) was recorded to analyze data

related to PPT (Hsieh et al., 2007; Tsai et al., 2010). The overall reliability of this technique has previously been established (Figure 3.2) (Reeves et al., 1986).

3.7.4 Shoulder Pain

Shoulder pain was measured using the "Visual Analog Scale" (VAS), which is a self-reporting scale consisting of a horizontal 100 mm line with ratings starting from a score of 0 on the left side showing "no pain" and ending with a score of 100 on the right side indicating "worst pain" (Appendix- IX) (Katz & Melzack, 1999; Pulik et al., 2020). Subjects were instructed to mark an impression along this horizontal line to demonstrate their pain level (Hsieh et al., 2007; Tsai et al., 2010). It also has good reliability and validity (ICC for all paired VAS scores was 0.97) (Polly et al., 2001).

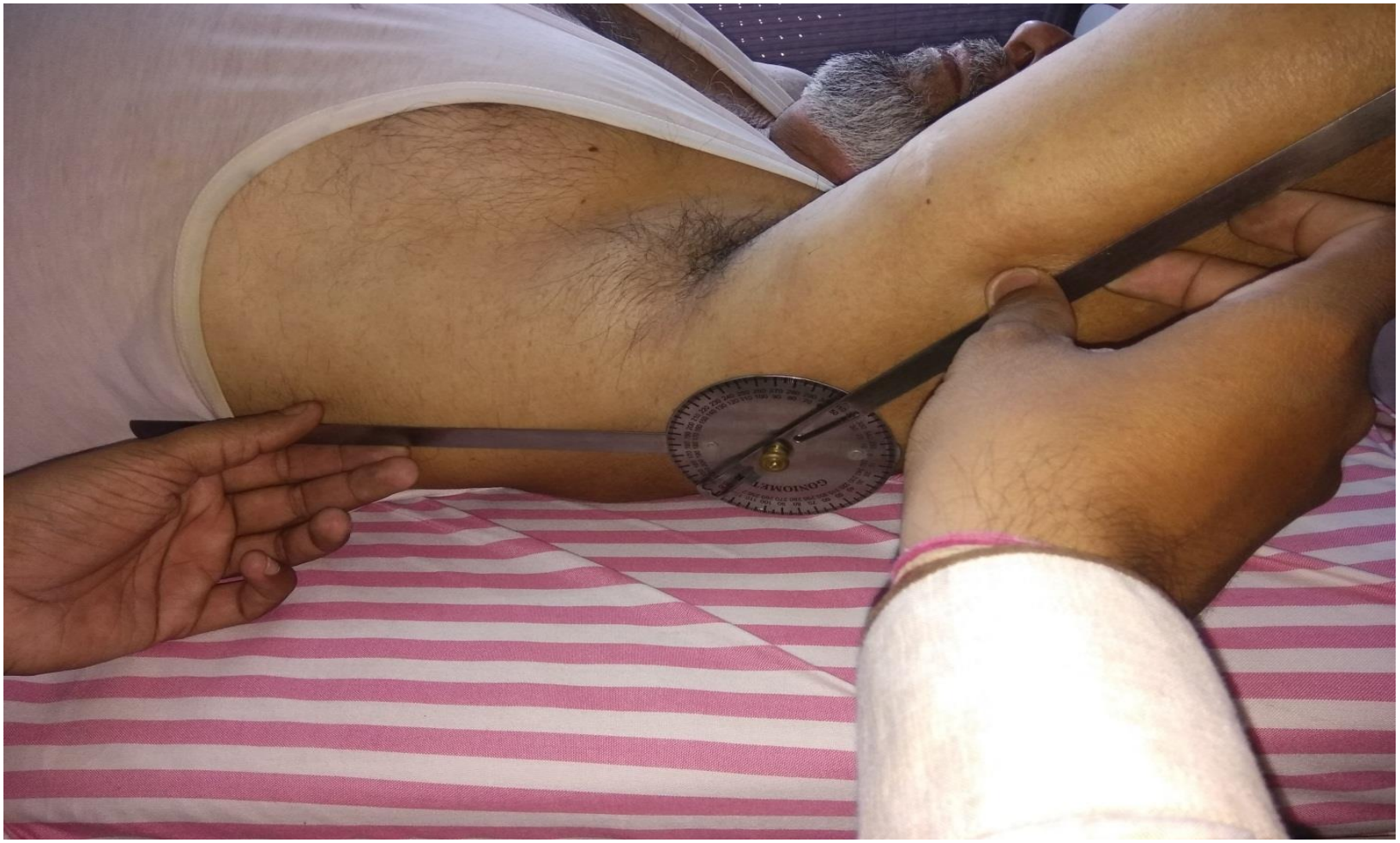

Figure 3. 1 Assessment of shoulder range of motion by Universal Goniometer.

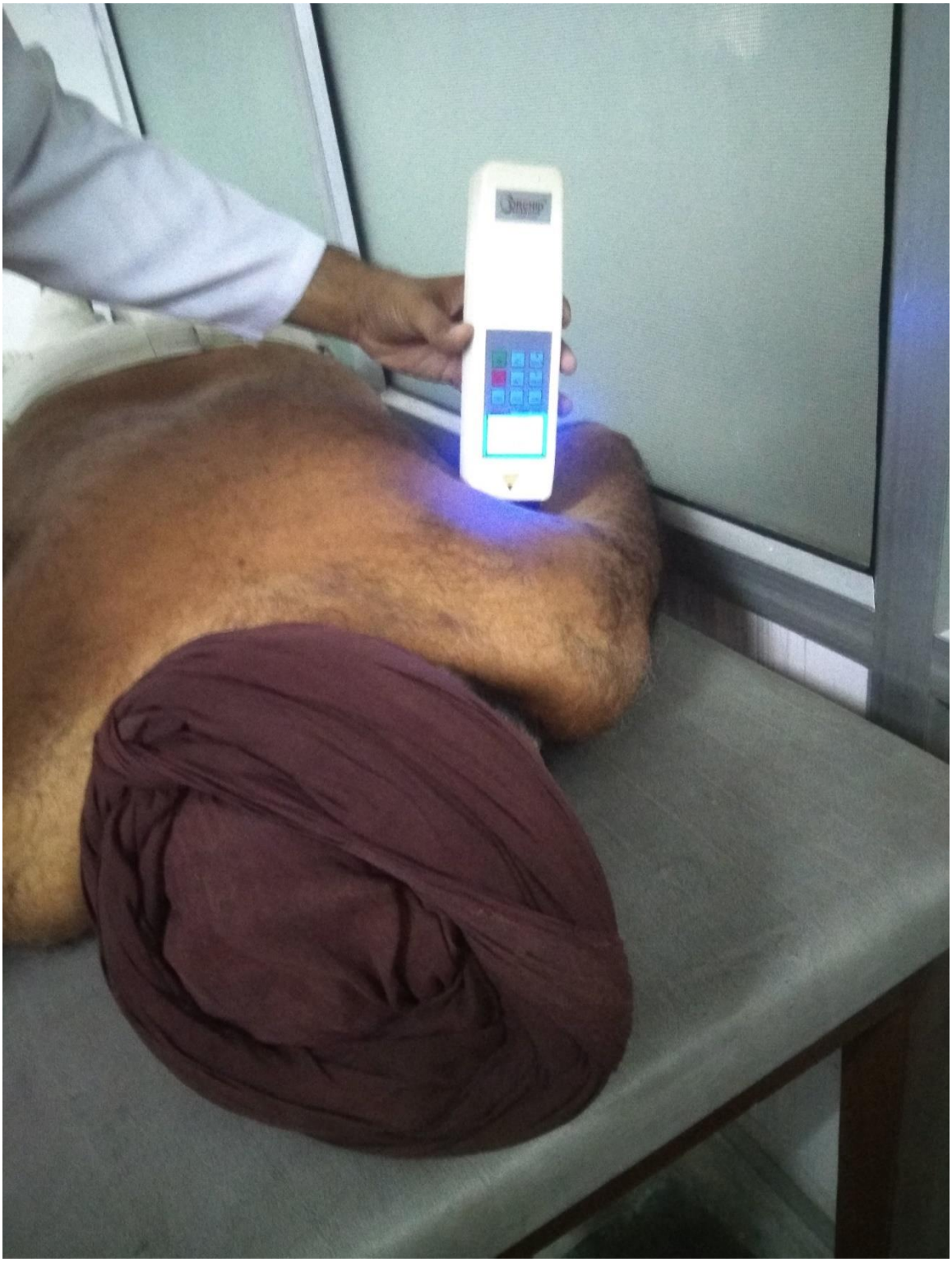

Figure 3. 2 Assessment of Pressure Pain Threshold by Pressure Algometer

3.8 PROCEDURE

The present research project was accepted by the Clinical Research Ethical Committee of applied medical sciences, Lovely Professional University (LPU/IEC/2018/01/04). A total of 237 subjects were initially recruited via orthopedics surgeon referral using the simple random sampling technique from May 2017 to March 2019. Twenty-seven subjects were excluded from the research. The orthopedics surgeon identified all these subjects based on their medical history, orthopedic physical examinations, and imaging, when needed, and recommended them to the physiotherapy department for treatment. In the physiotherapy department, all the subjects underwent a detailed evaluation procedure to confirm the diagnosis which includes thorough shoulder history and physical examination. History revealed that either the inciting events such as mild trauma occurred with the involved shoulder or a subject is having a history of slow onset of pain, felt near the insertion of the deltoid as well as the subject was unable to sleep on the affected side. The authors also confirmed with a thorough history, if subjects were having other medical diseases or history of surgeries that can lead to the development of AC such as type 2 diabetes, hyperthyroidism, Parkinson's disease, Cardiac disease, Coronary bypass surgery, and mastectomy. In addition, physical examination confirmed the diagnosis, if subjects showed gradual, progressive loss of both passive and active glenohumeral ROMs as well as if subjects were not showed any positive provocative tests for conditions other than AC in the shoulder joint. The subjects were included in the study according to inclusion criteria; those who were not fit into the study were excluded from the study. Before the study, each subject was informed about the study procedure and instructed to not take any medication during the treatment protocol, and received written informed consent. Then pre-intervention assessment was taken for shoulder pain by VAS, pain, and disability by SPADI, ROMs by Universal goniometer, and PPT of MTrPs by Pressure algometer for "Supraspinatus, Infraspinatus, Teres minor, Subscapularis, Deltoid, Pectoralis major, Teres major, and Upper Trapezius muscles". Then subjects were allocated to one of the three groups using a simple randomization process that includes the lottery method, in which we took samples in the multiple of three numbers, and then the slips with the names of each

sample were put in an empty box and mixed it well then one by one slip was picked from the box for different groups and accordingly subjects were allocated to following three groups:

(a) **Group 1:** Local myofascial trigger point dry needling (local MTrP-DN) group (n=70, 33 male and 37 female), subjects received local MTrP-DN for ten minutes in a session for the affected muscles for six alternative days followed by conventional physiotherapy treatment for successive twelve days.

(b) **Group 2:** Local myofascial trigger point dry needling (local MTrP-DN) along with paraspinal dry needling (PSDN) group (n=70, 35 male and 35 female), subjects received local MTrP-DN for ten minutes in a session for the affected muscles along with PSDN group of multifidus muscles at the nerve root levels of affected muscles around the shoulder joint for six alternative days followed by conventional physiotherapy treatment for successive twelve days.

(c) **Group 3:** Conventional physiotherapy (CPT) group (n=70, 30 male and 40 female), subjects received conventional physiotherapy treatment, which includes SWD (one session of 20 minutes per day), therapeutic ultrasound (one session of 10 minutes per day), TENS (one session of 20 minutes per day), joint mobilization (three sets of 10 repetitions with a rest interval of 30 seconds between each set), passive stretching exercises and active exercise (one session of 10 minutes per day) for successive twelve days.

Then the post-intervention assessment was measured at the end of twelve days.

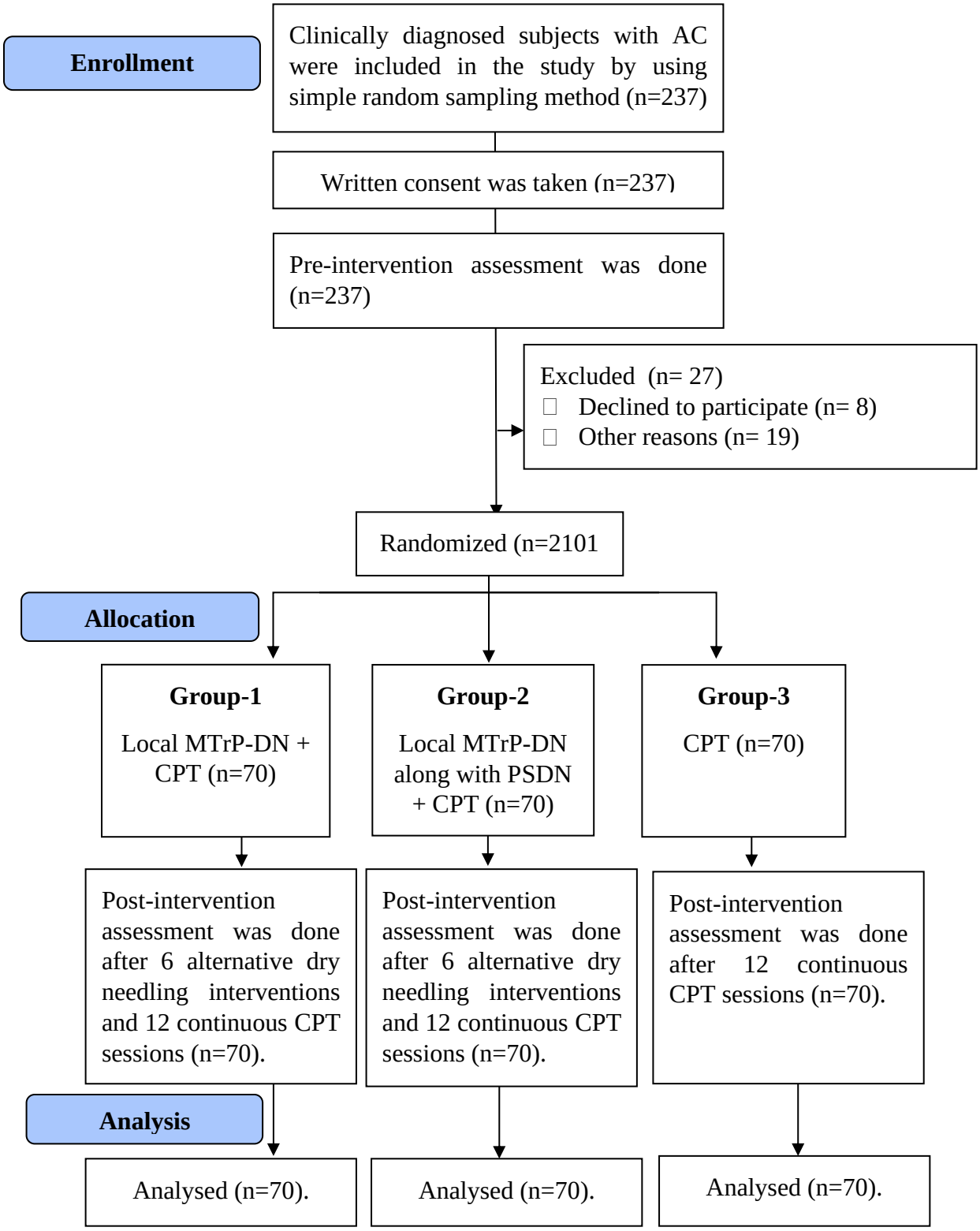

Figure 3. 3 Consort flowchart diagram.

3.8.1 DRY NEEDLING PROCEDURE

The MTrPs were detected via a thorough physiotherapy evaluation that includes history-taking and palpation techniques. During the history-taking process, the researcher ensures the initial onset of pain and the recurrence of pain are of muscular origin, and then used a flat palpation grip or pincer grip according to the muscle which needed to palpate to find out the presence of any palpable hardening of a taut band of muscle fibers passing through the tender spot in a shortened muscle. To further confirm the location of MTrPs, the researcher stimulated those taut bands with deep pressure to reproduce spot tenderness and jump sign, and if the muscle had more than one MTrPs then the researchers recorded the PPT value of the most sensitive one and researchers found that a central MTrP is characteristically a very tender, circumscribed, nodule-like spot that is located in the midportion of a taut band of skeletal muscle fibers and can cause referred pain. Moreover, it was followed by treatment with a 0.25 mm gauge of either 25 mm or 40 mm long acupuncture needles (Suzhou Tianxie) depending on the targeted muscle & subject's size (after Baima & Isaac, 2008). Fast-in/out movement technique of needle in a conical form employed to target various sensitive loci and looked for the local twitch response. The needle remained in the affected muscle for ten minutes. The needle was removed after 10 minutes, the hemostasis was maintained and there was no serious adverse effect reported by the subjects other than post dry needling soreness. In case of post dry needling soreness, the subjects were instructed to use cold therapy at home. A sharps container was used to dispose of the needle (after Osborne & Gatt, 2010)

3.8.1.1 Dry Needling technique for Supraspinatus muscle

Subjects were in the prone lying position. Flat palpation with appropriate pressure for MTrPs via the upper trapezius muscle was used to assess the Supraspinatus muscle. The needle was inserted after locating the MTrPs and directed toward the base of the supraspinous fossa (Figure 3.4) (Table 3.1) (after Bron et al., 2013).

3.8.1.2 Dry needling technique for Infraspinatus muscle

Subjects were in the prone lying position. The Infraspinatus muscle was accessed for MTrPs by using flat palpation with adequate pressure. The needle was inserted and directed towards the scapula after the MTrPs were located (Figure 3.4). (Table 3.1) (after Bron et al., 2013).

3.8.1.3 Dry Needling technique for Teres minor muscle

Subjects were in the prone lying position with the upper arm 90° abducted. The Teres minor muscle was accessed for MTrPs by using flat palpation just caudal to the shoulder joint. After localization of the MTrPs, the needle was inserted and directed towards the lateral border of the scapula (Figure 3.5) (Table 3.1) (after Bron et al., 2013).

3.8.1.4 Dry needling technique for Subscapularis muscle

Subjects were in the supine lying position with the upper arm 90° abducted and 90° externally rotated. This position brings the scapula more lateral allows optimized access to the muscle. The Subscapularis muscle was accessed for MTrPs by using a pincer grip just lateral to the scapula. After the localization of the MTrPs, the needle was inserted and directed parallel to the ribcage perpendicular to the scapula (Figure 3.6) (Table 3.1) (after Bron et al., 2013).

3.8.1.5 Dry needling technique for Deltoid muscle

Subjects were in the supine lying position for anterior fibers of the deltoid, in the prone lying position for posterior fibers of the deltoid, and the side-lying position for the middle fibers of the deltoid muscle. In all positions, the upper arm was slightly abducted and supported by a pillow. All the fibers of the deltoid muscle were assessed for MTrPs by using a flat grip. After localization of the MTrPs, the needle was inserted perpendicularly through the skin directly into the taut band against the humerus (Figure 3.7) (Table 3.1) (after Bron et al., 2013).

3.8.1.6 Dry needling technique for Pectoralis major muscle

Subjects were in the supine lying position with the arm slightly abducted. The pectoralis major has at least three separately identifiable components that each have their own referred pain pattern. The clavicular, sternal, and costal heads were examined independently using flat palpation with sufficient pressure. The pectoralis major muscle was grasped in the anterior axillary wall with the index and long fingers underneath the muscle, between the muscle and the chest wall. Then during the needling of all the heads of the Pectoralis major muscle, the needle was inserted and directed toward the shoulder joint (Figure 3.8) (Table 3.1) (after Bron et al., 2013).

3.8.1.7 Dry needling technique for Teres major muscle

Subjects were in the prone lying position with the arm slightly abducted. The Teres major muscle was accessed for MTrPs by using a pincer grip between the thumb and the second and third fingers. After localization of the MTrPs, the needle was inserted and directed ventrally and laterally (Figure 3.9) (Table 3.1) (after Bron et al., 2013).

3.8.1.8 Dry needling technique for upper Trapezius muscle

Subjects were in prone lying position with the arms in neutral. The Upper Trapezius muscle was accessed for MTrPs by using a pincer grip between the thumb and the second and third fingers. After localization of the MTrPs, the needle was inserted and directed ventrally and cephalad (Figure 3.10) (Table 3.1) (after Bron et al., 2013).

3.8.1.9 Dry needling technique for Cervical multifidus muscles

Subjects were in the prone lying position. Cervical multifidus muscles are not directly palpable. The needle was inserted perpendicular to the skin and parallel to the posterior spinous process, about 1cm lateral to the spinous process (Figure 3.11) (Table 3.1) (after Cesar et al., 2013). MTrP-DN was done at first and after the maintenance of homeostasis, it was followed by CPT.

Table 3. 1 Details of dry needling techniques including patient and shoulder position, palpation technique & direction of needle insertion

Sr.No	Muscle Name	Patient position	Shoulder position	Palpation Technique	The direction of needle insertion
1	Supraspinatus	Prone lying	Neutral	Flat palpation	Longitudinal to the frontal plane
2	Infraspinatus	Prone lying	Neutral	Flat palpation	Directed towards scapula
3	Teres minor	Prone lying	90° Abduction	Flat palpation	Directed towards the lateral border of the scapula
4	Subscapularis	Supine lying	90° abduction & 90° External Rotation	Pincer palpation	Directed parallel to the ribcage
5	Deltoid	Anterior fiber- Supine Middle fiber- Side-lying Posterior fiber- Prone lying	Slight Abduction	Flat palpation	Directed perpendicularly
6	Pectoralis major	Supine lying	Slight Abduction	Flat palpation	Directed towards shoulder
7	Teres major	Prone lying	Slight Abduction	Pincer palpation	The ventral and lateral direction
8	Upper Trapezius	Prone lying	Neutral	Pincer palpation	The ventral and cephalad direction
9	Cervical multifidus	Prone lying	NA	NA	Parallel to the posterior spinous process

3.8.2 Conventional Physiotherapy Management

The CPT management includes electrotherapeutic intervention, joint mobilization and exercises. In the CPT treatment protocol, UST was given first followed by TENS, joint mobilization, traditional passive stretching, active shoulder exercise with a towel, and SWD. The procedure of the electrotherapeutic interventions, joint mobilization and exercises are explained in the following sections.

3.8.2.1 Electrotherapeutic Intervention

In addition to DN, electrotherapeutic interventions with UST, TENS, and SWD, were also administered on the affected shoulder joint. Pulsed ultrasound was applied with a 1:4 pulse ratio and 1.5 W/cm2 of intensity for ten minutes (Figure 3.14) (Ansari et al., 2012). TENS was used to reduce pain by placing electrodes on the bellies of the deltoid and trapezius muscles and treating them with the protocols (frequency 100 Hz, 0.05ms duration, modulation pulse form, 9 volts) for 20 minutes. The current intensity was boosted until the subject reported a light tingling sensation without any observational muscle contraction (Figure 3.13) (Pantaleão et al., 2011). SWD (27.12 MHz) was administered for 20 minutes using a contra-planner approach with eightfold towel-wide spacing. According to the subject's feedback, the intensity was adjusted to produce comfortable warmth (Figure 3.12) (Guler-Uysal & Kozanoglu, 2004).

3.8.2.2 Joint Mobilization/ Exercises

The affected glenohumeral joint was treated with passive rhythmic glides, such as anteroposterior (Figure 3.15), posteroanterior (Figure 3.16), caudal (Figure 3.17), and caudal progression glides (Figure 3.18). Each glide was given for 30 seconds at the speed of 2-3 glides every second. Every glide was performed five times with a 30-second rest between each set. Additionally, the traditional passive stretching of the shoulder joint muscles was performed (Figures 3.19, 3.20, 3.21, 3.22, 3.23). Each stretch was given three times for 30 seconds, with 15 seconds of an interval between each stretch (Kumar et al.,

2012), and active exercises using a towel for 5 minutes were also performed (Figure 3.24) (Pajareya et al., 2004).

3.9 DATA ANALYSIS

The Statistical Program for Social Sciences (SPSS, v21) was used to analyze the collected data. Demographic information such as age, gender, and BMI was analyzed descriptively. The Shapiro-Wilk test, Z skewness, and Z kurtosis statistics were used to evaluate the normality of data. Whereas, Homogeneity of the data was determined using Levene's test. Paired t-test was used to compare means within the group for shoulder ROMs, VAS, SPADI, and PPT. Analysis of covariance (ANCOVA) was used to compare the means in between-group for shoulder ROMs, VAS, SPADI, and PPT. Post hoc comparisons were performed by using the Fisher least significant difference (LSD) test. Welch's ANOVA was used for between-group comparison for the data of PPT, and post hoc comparisons were made using the Games-Howell test in statistically significant results. A probability value (*p*-value) of less than 0.05 was considered significant.

Figure 3. 4 Application of myofascial trigger point dry needling in supraspinatus and infraspinatus muscle in subject with AC.

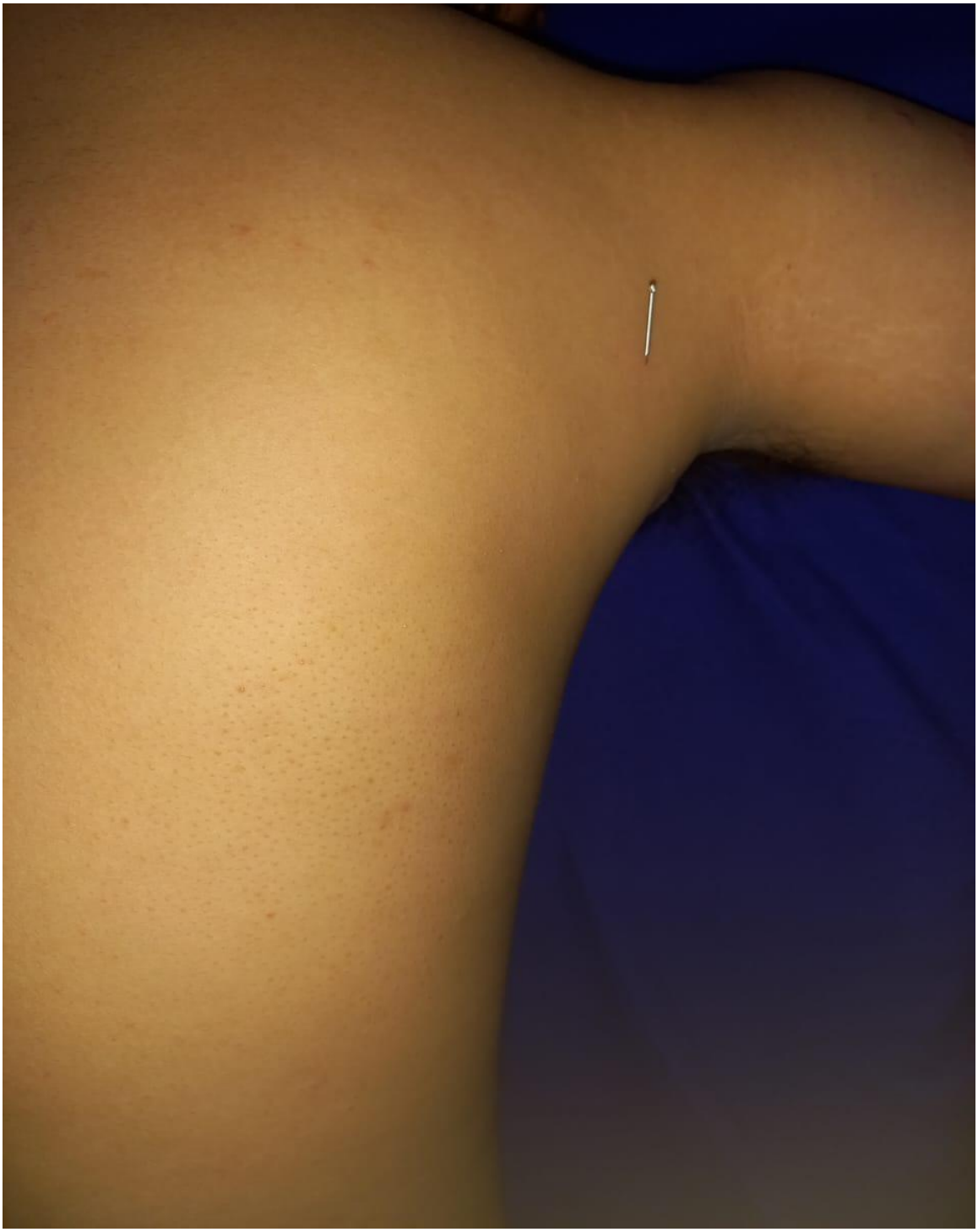

Figure 3. 5 Application of myofascial trigger point dry needle in teres minor muscle in subjects with AC.

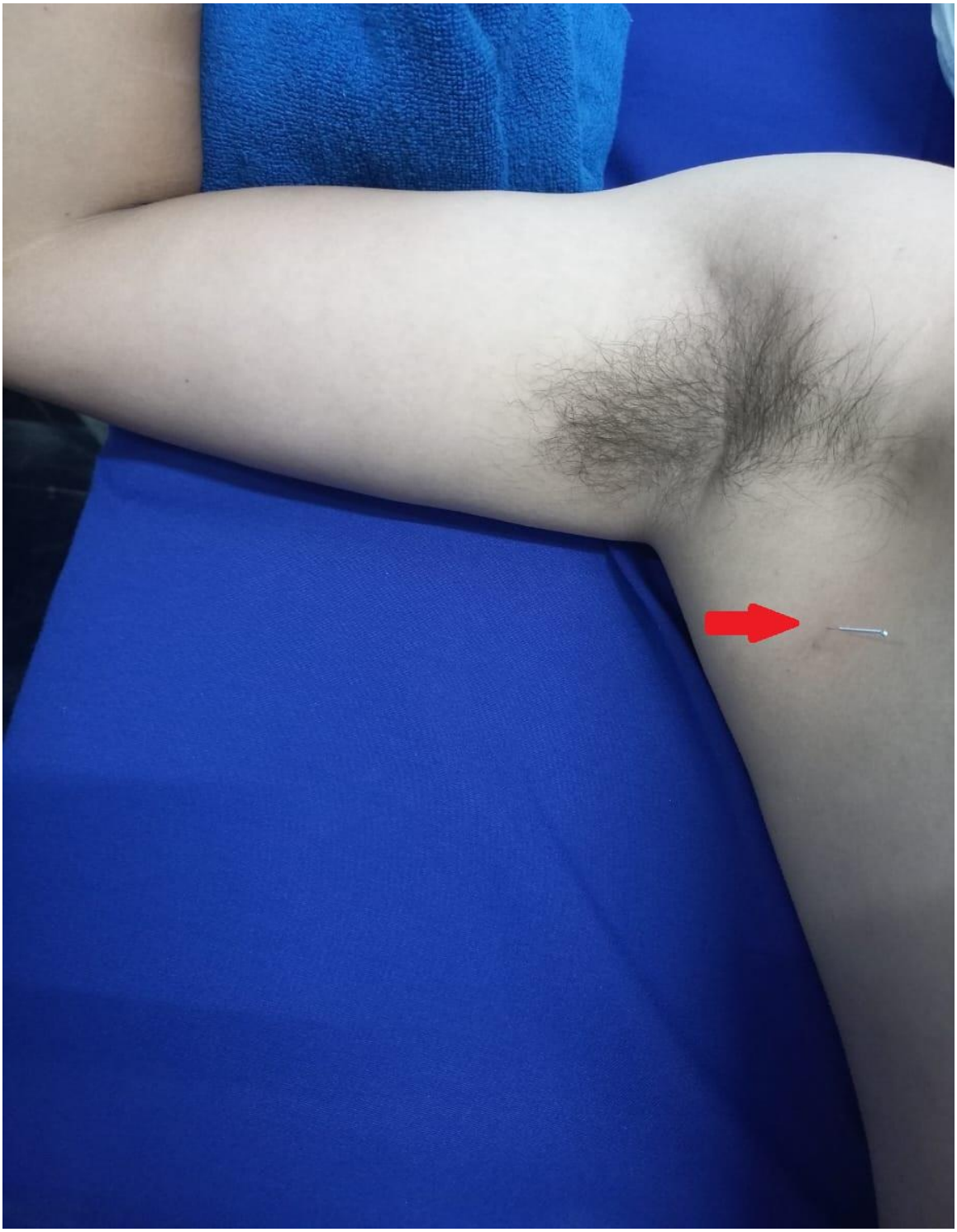

Figure 3. 6 Application of myofascial trigger point dry needle in subscapularis muscle in subjects with AC.

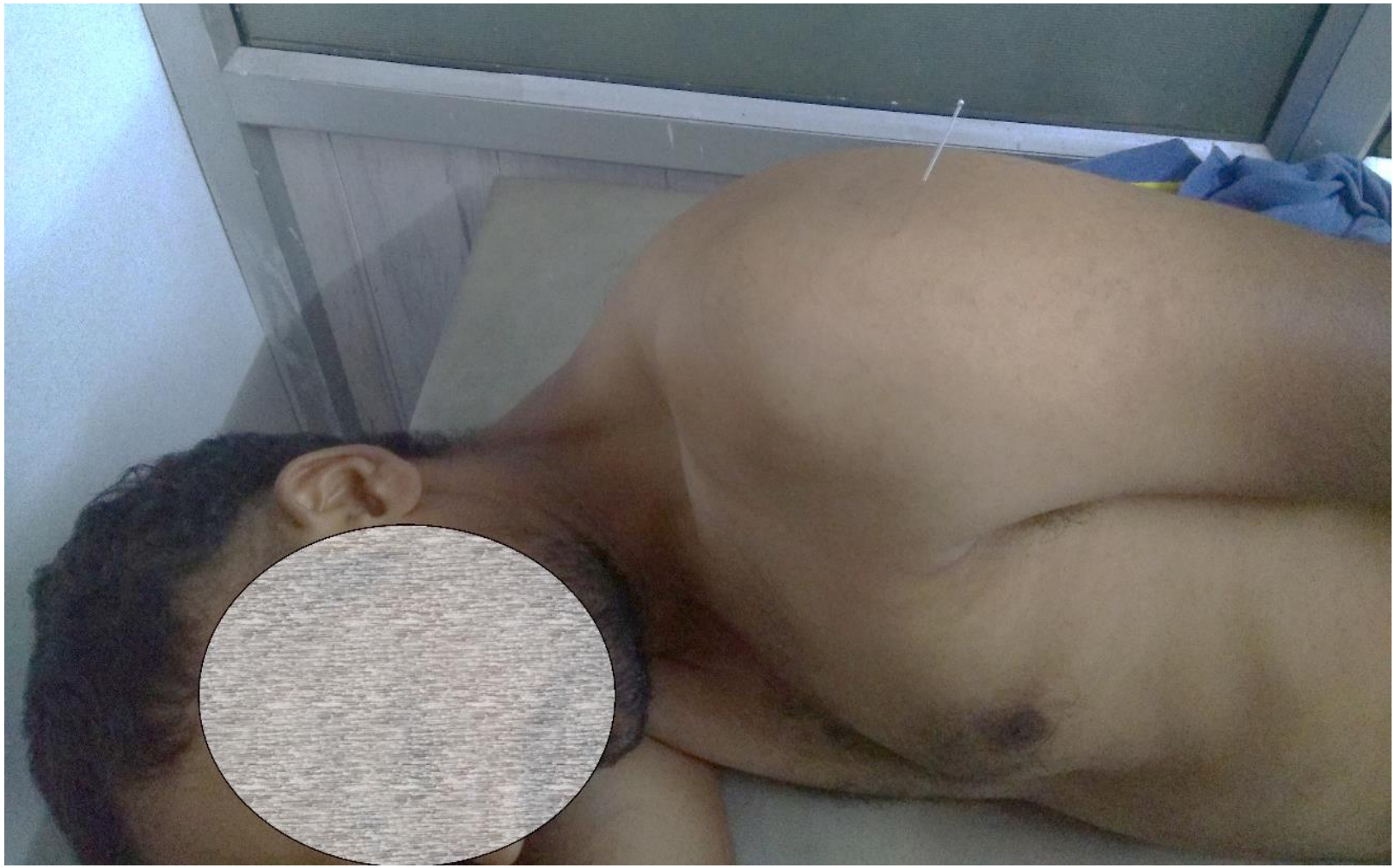

Figure 3. 7 Application of myofascial trigger point dry needle in deltoid muscle in subject with AC.

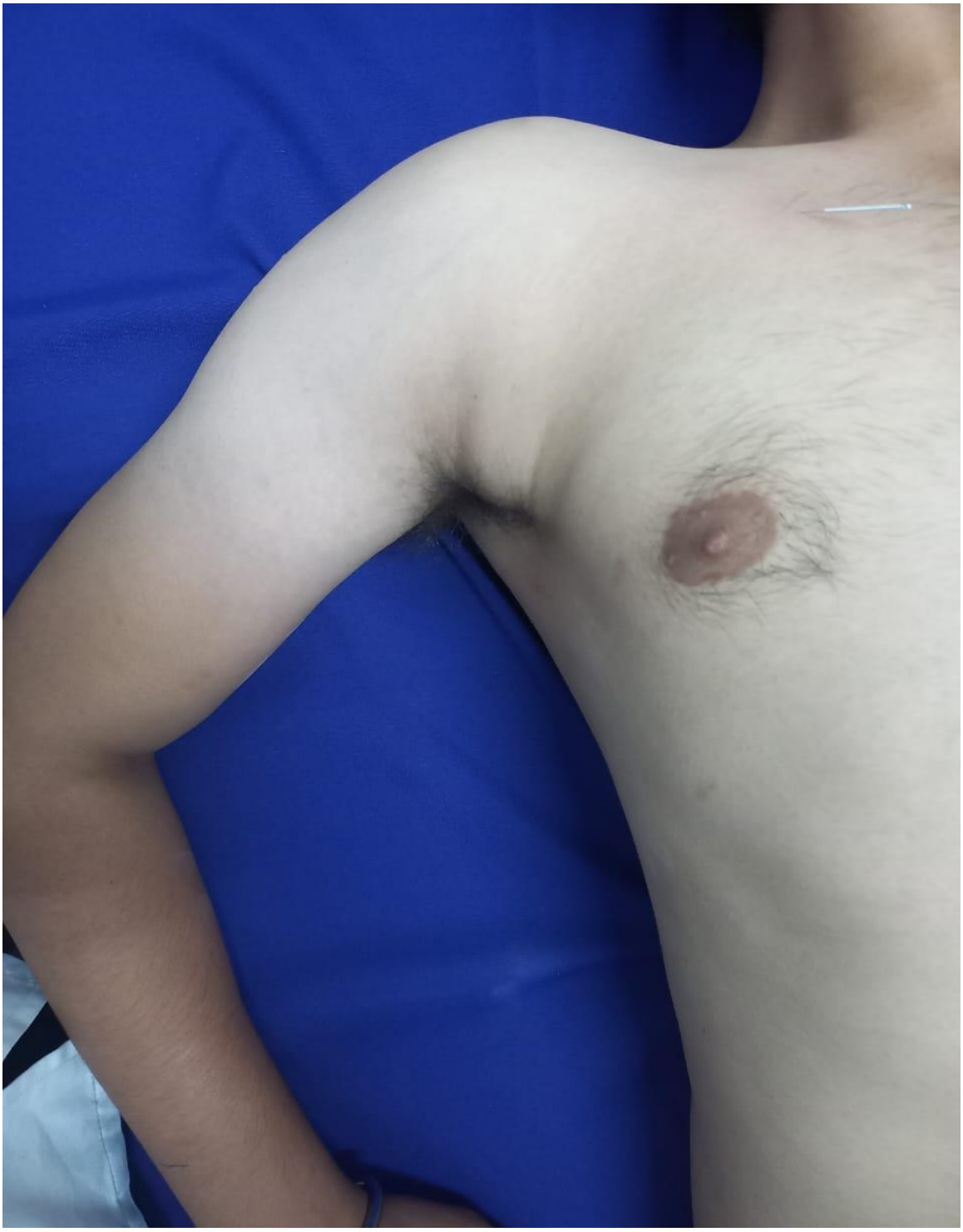

Figure 3. 8 Application of myofascial trigger point dry needle in pectoralis major muscle in subjects with AC.

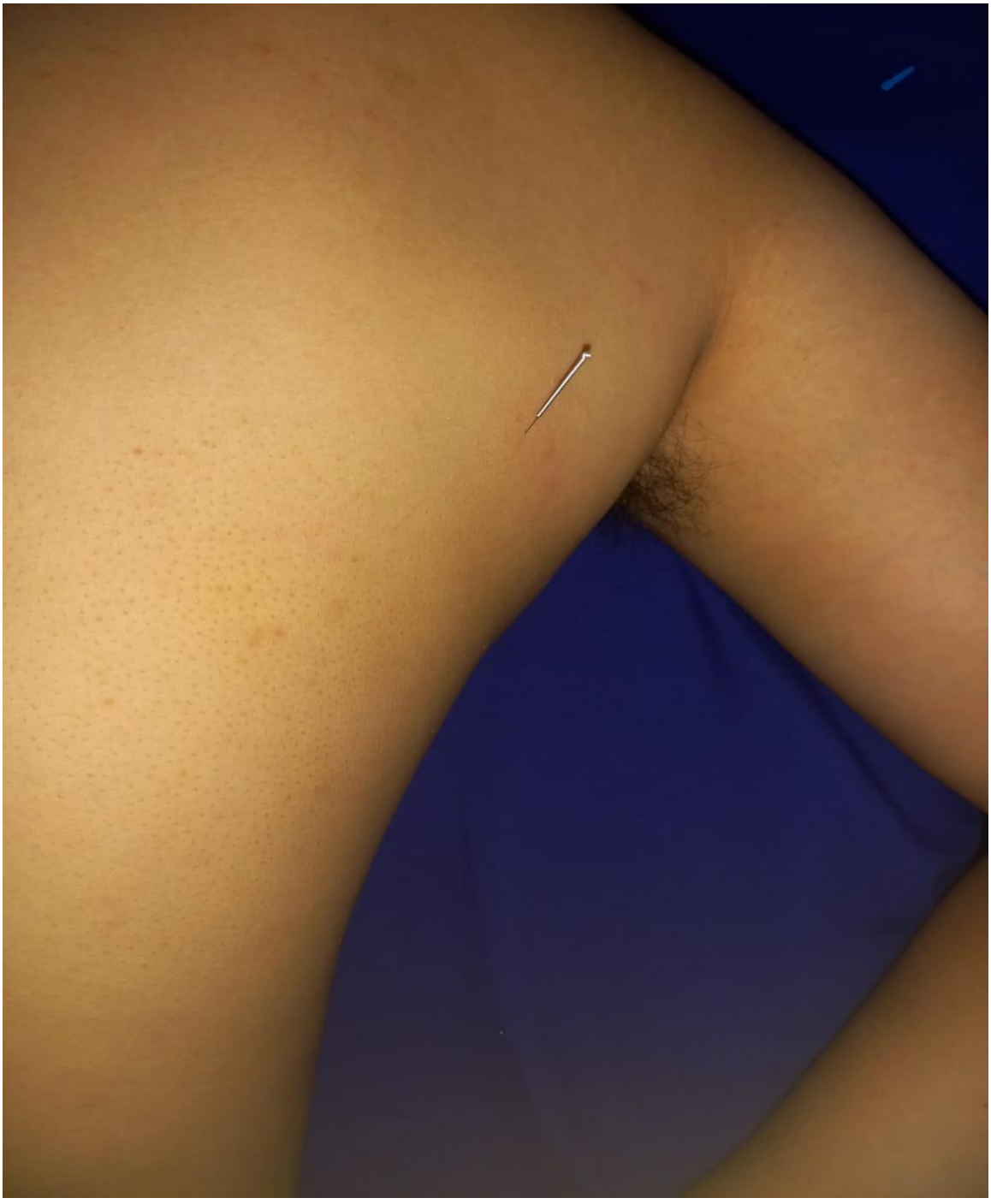

Figure 3. 9 Application of myofascial trigger point dry needle in teres major muscle in subjects with AC.

Figure 3. 10 Application of myofascial trigger point dry needle in Upper Trapezius muscle in subjects with AC.

Figure 3. 11 Application of dry needle in cervical multifidus muscle in subject with AC.

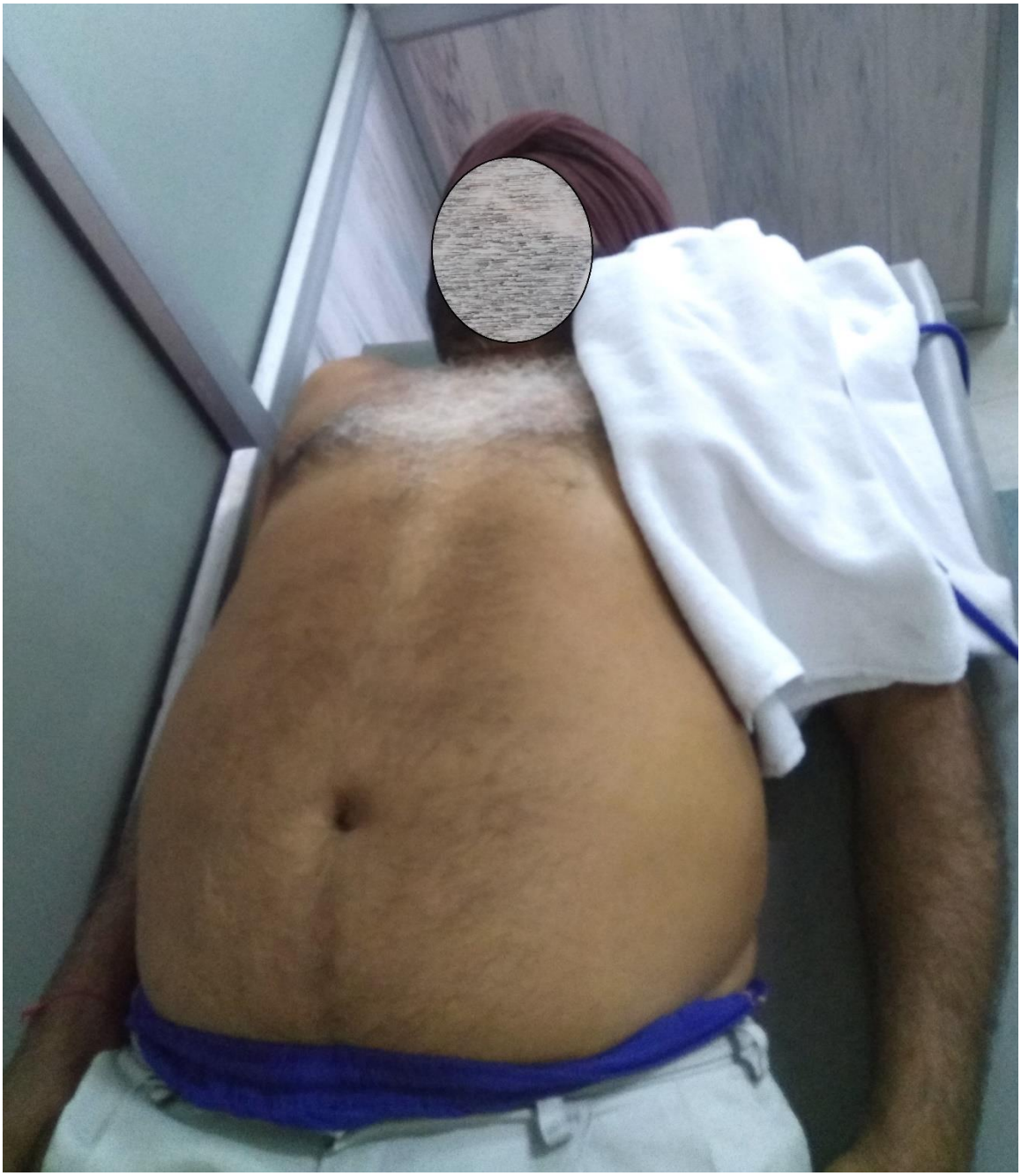

Figure 3. 12 Application of shortwave diathermy around the glenohumeral joint in subject with AC.

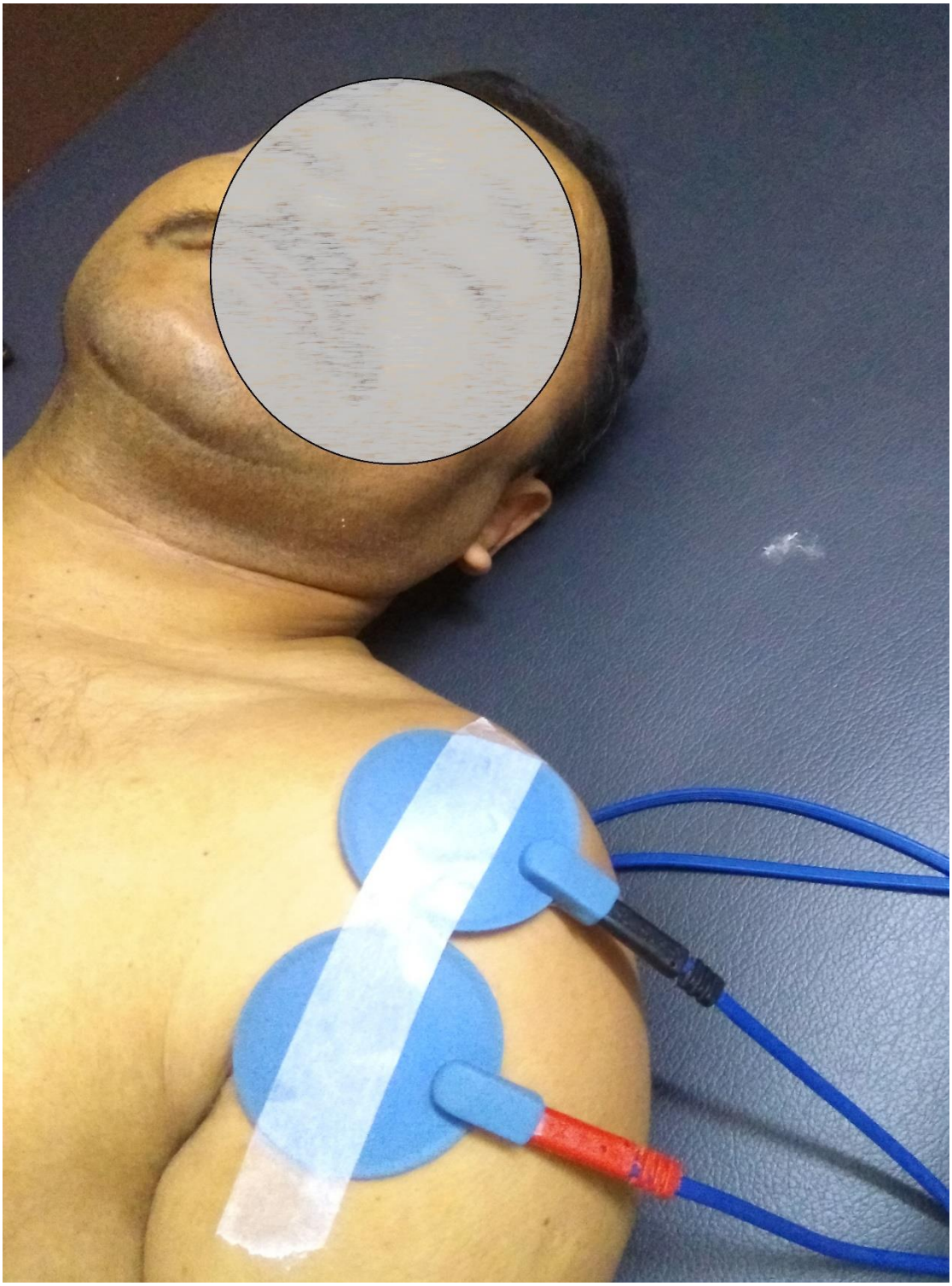

Figure 3. 13 Application of transcutaneous electrical nerve stimulation around the glenohumeral joint in subject with AC.

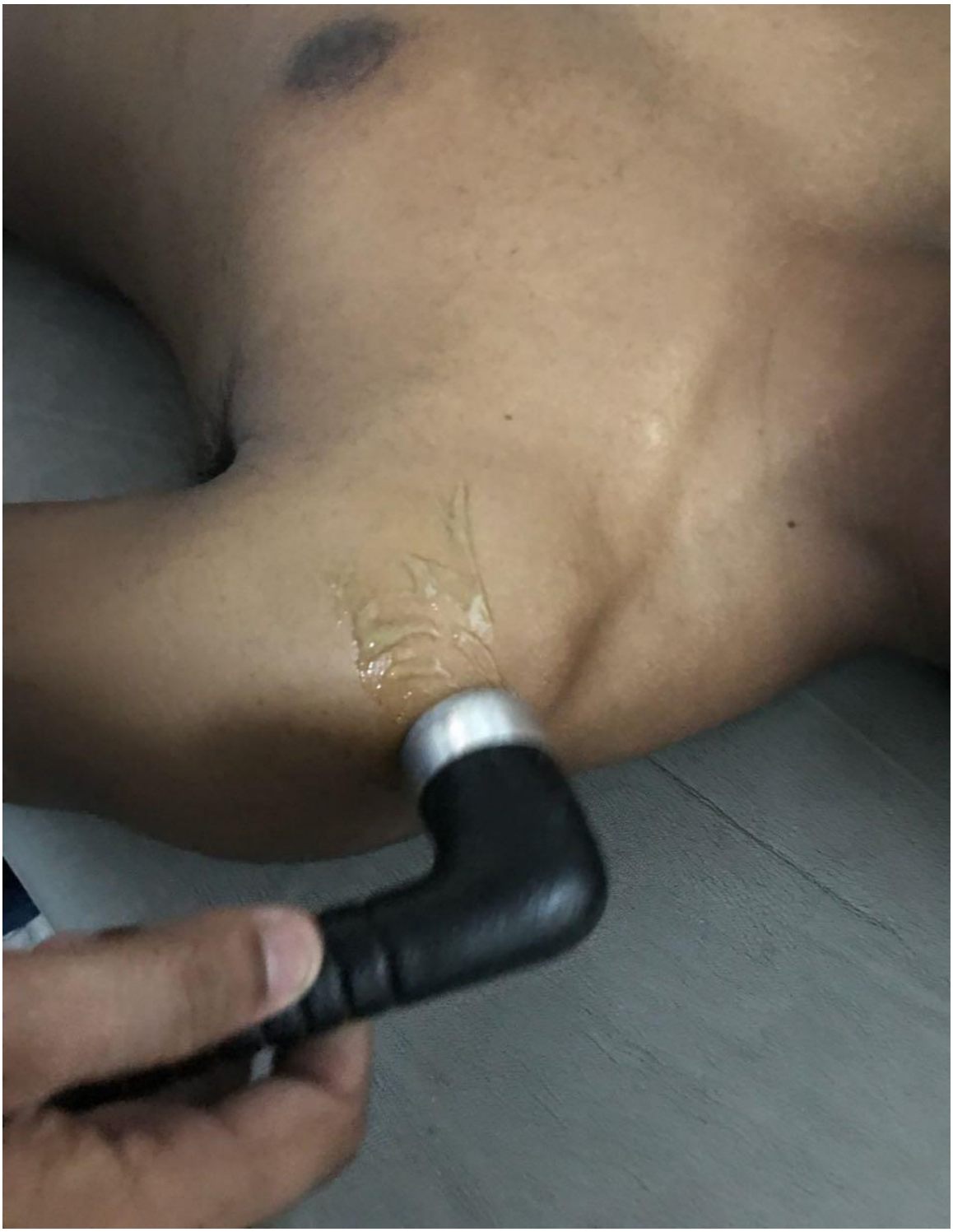

Figure 3. 14 Application of therapeutic ultrasound around the glenohumeral joint in subject with AC.

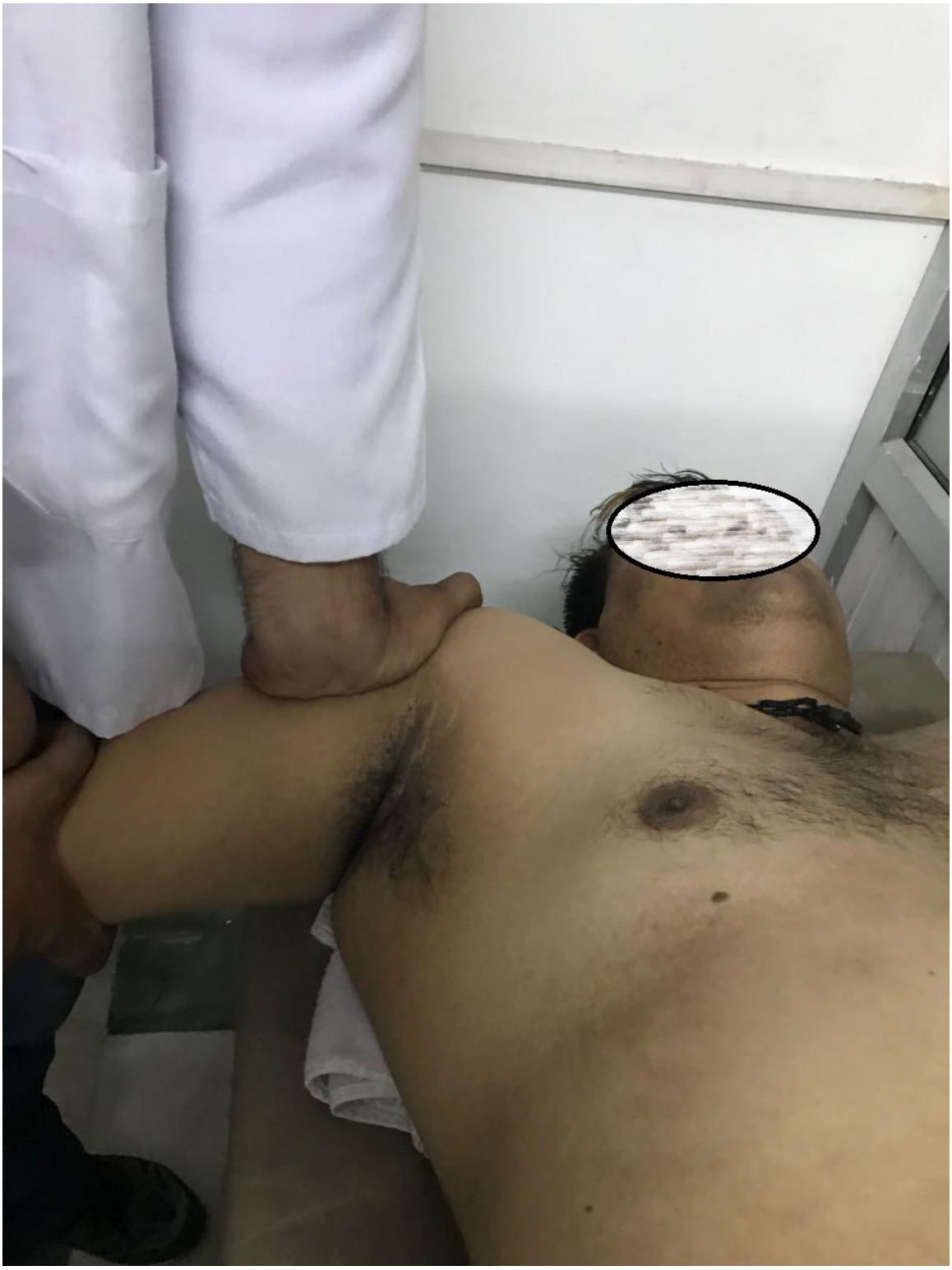

Figure 3. 15 Application of antero-posterior glide of glenohumeral joint in subject with AC.

Figure 3. 16 Application of postero-anterior glide of glenohumeral joint in subject with AC.

Figure 3. 17 Application of caudal glide of glenohumeral joint in subject with AC.

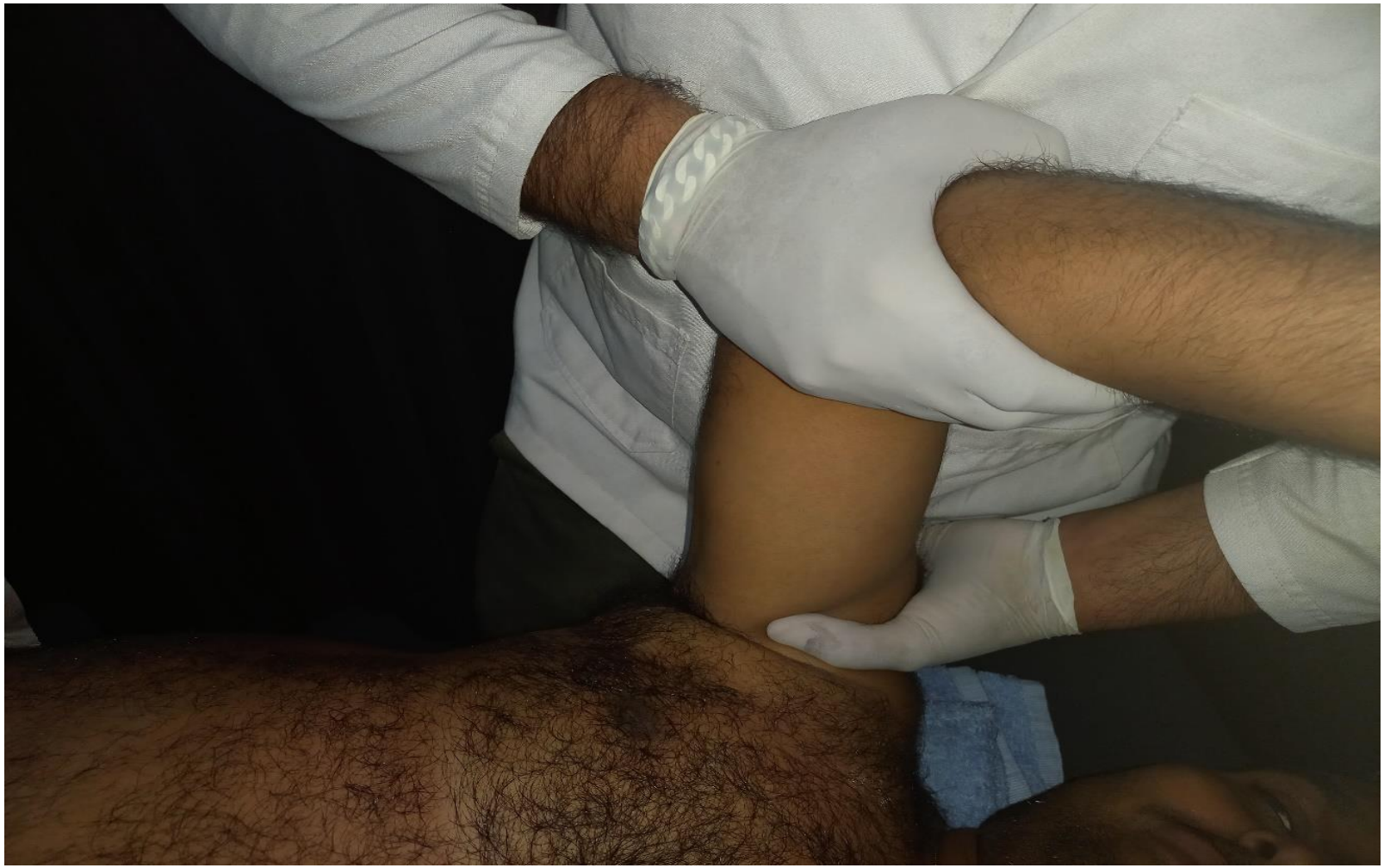

Figure 3. 18 Application of progressive caudal glide of glenohumeral joint in subject with AC.

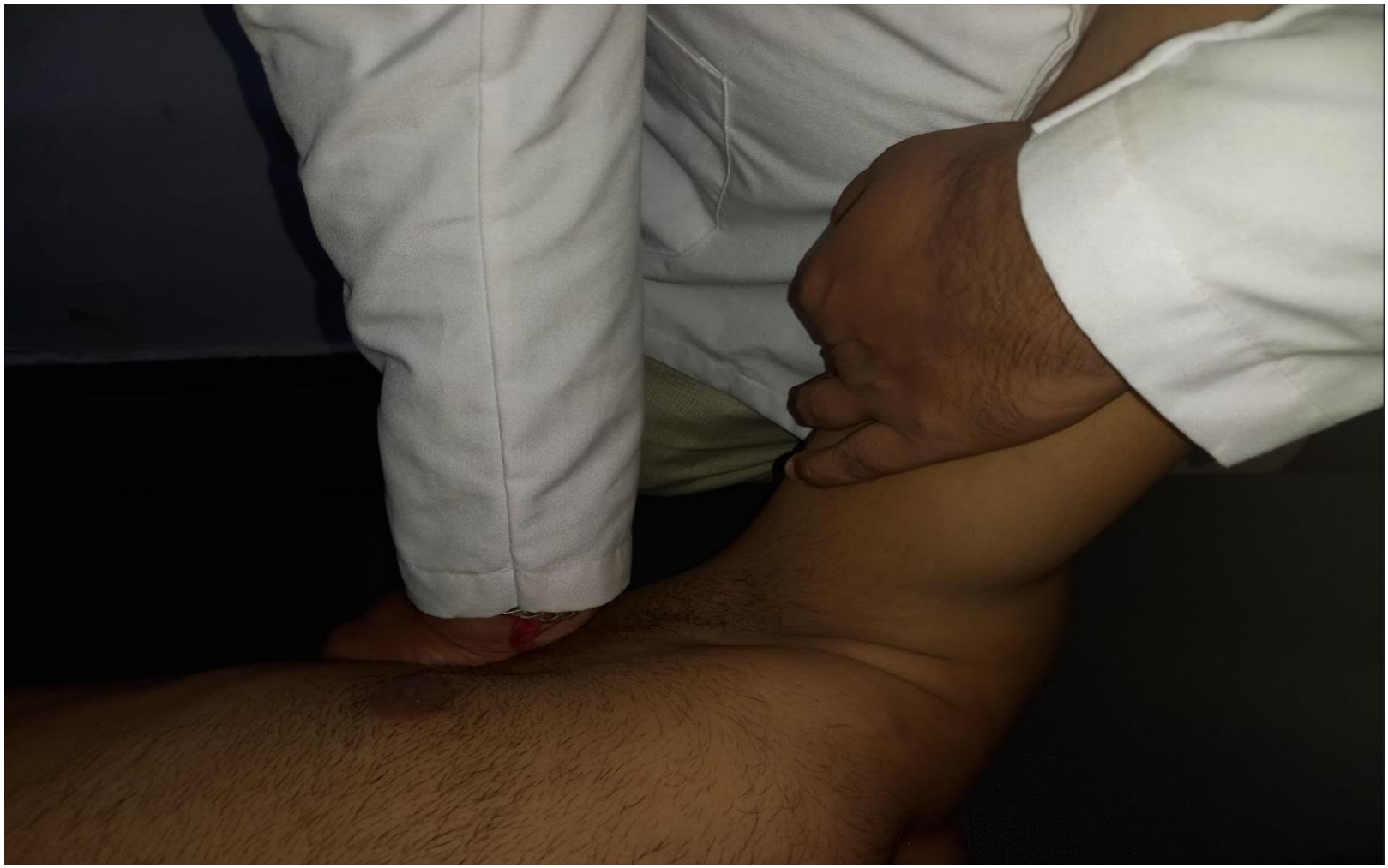

Figure 3. 19 Stretching of the shoulder extensor muscle to increase shoulder flexion range of motion in subject with AC.

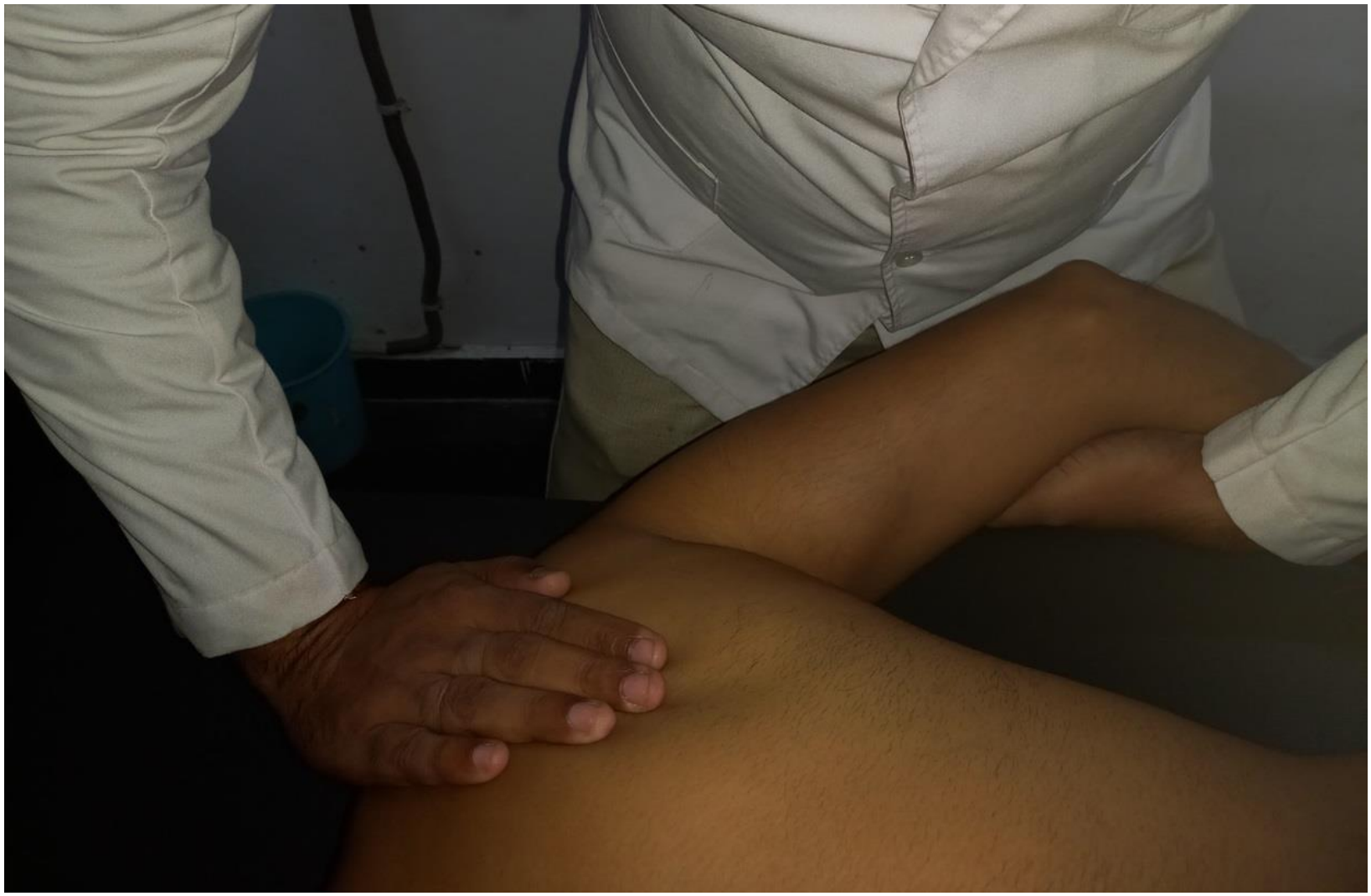

Figure 3. 20 Stretching of the shoulder flexor muscle to increase shoulder extension range of motion in subject with AC.

Figure 3. 21 Stretching of the shoulder adductor muscle to increase shoulder abduction range of motion in subject with AC.

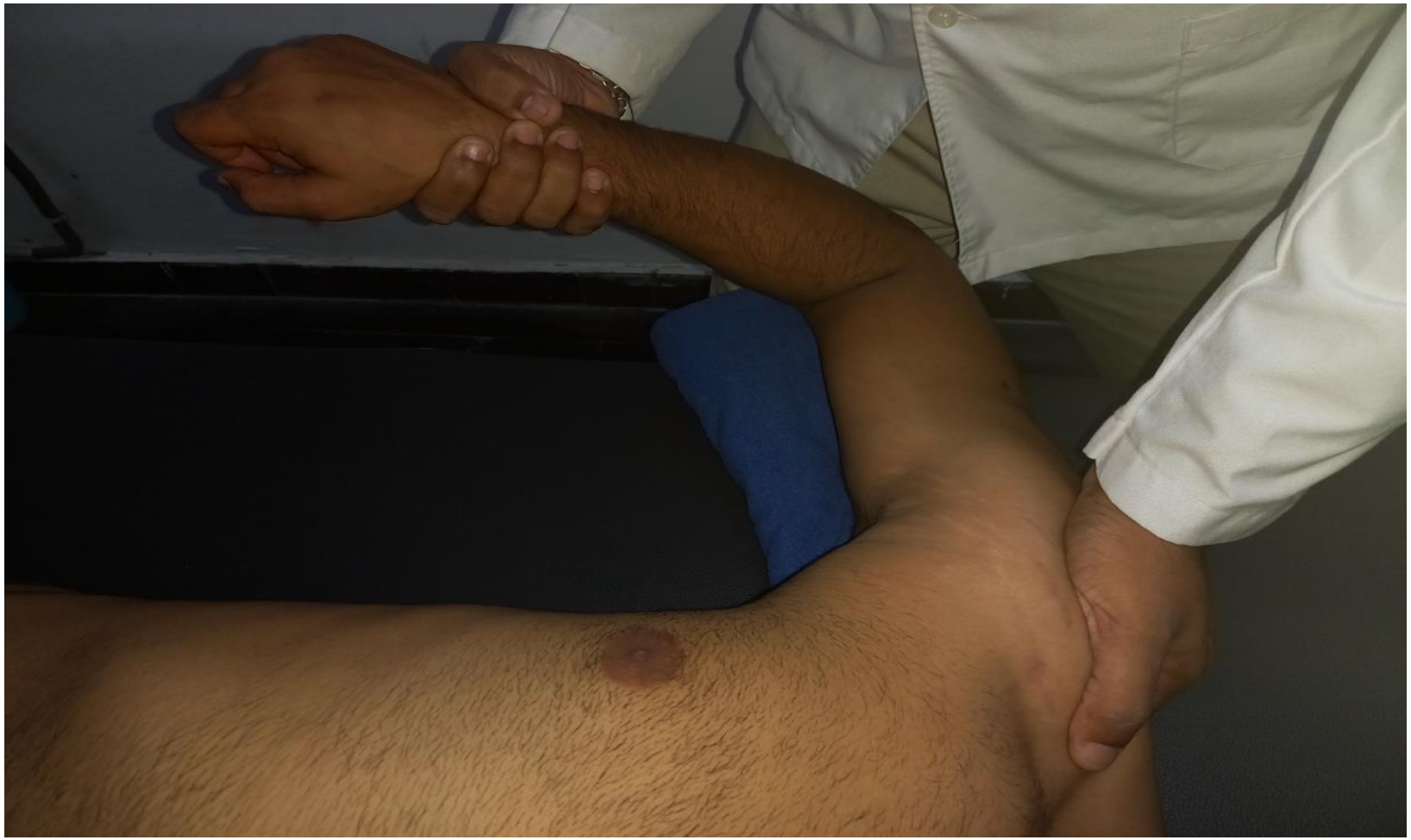

Figure 3. 22 Stretching of the shoulder external rotator muscles to increase shoulder internal rotation range of motion in subject with AC.

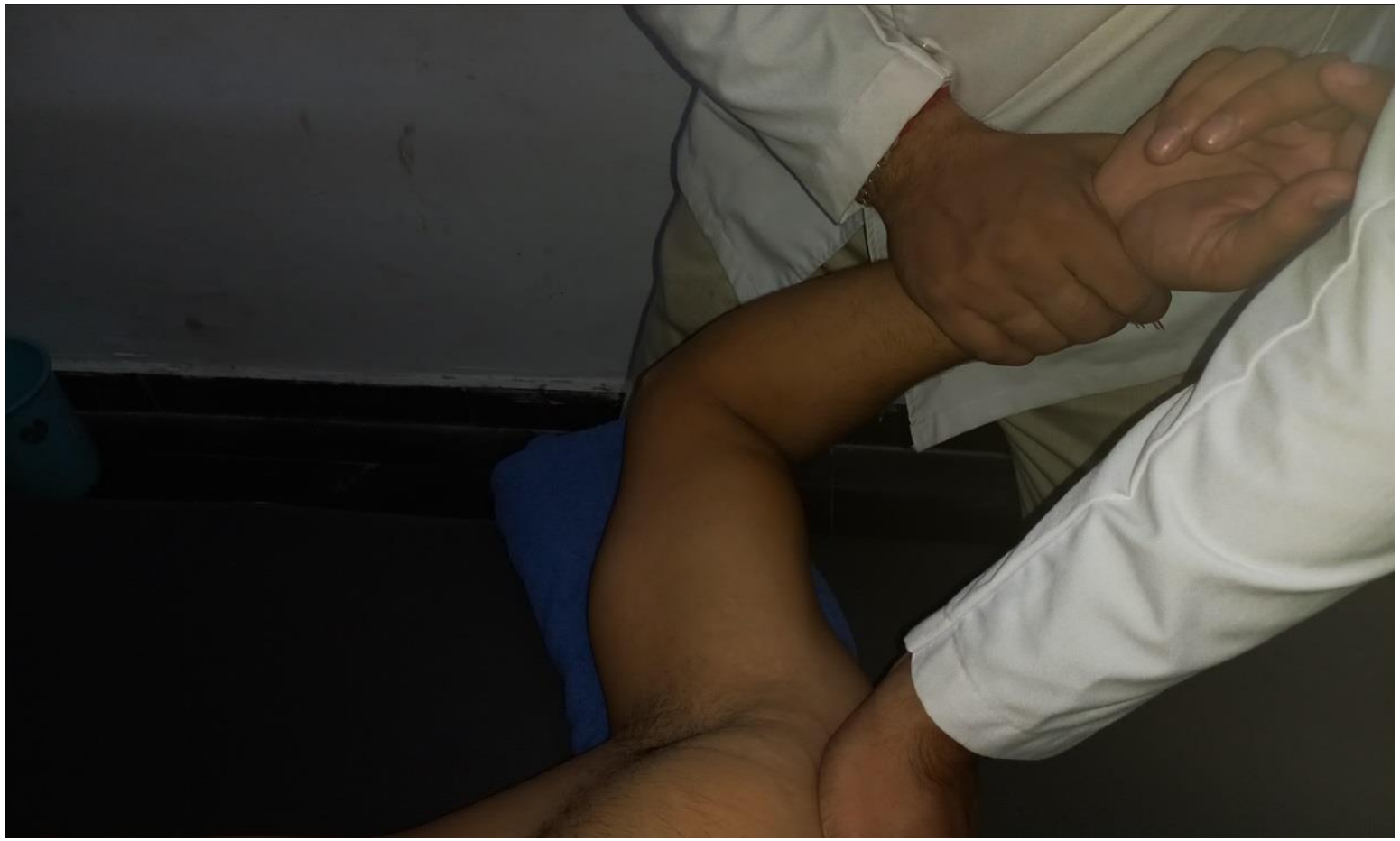

Figure 3. 23 Stretching of the shoulder internal rotator muscles to increase shoulder external rotation range of motion in subject with AC.

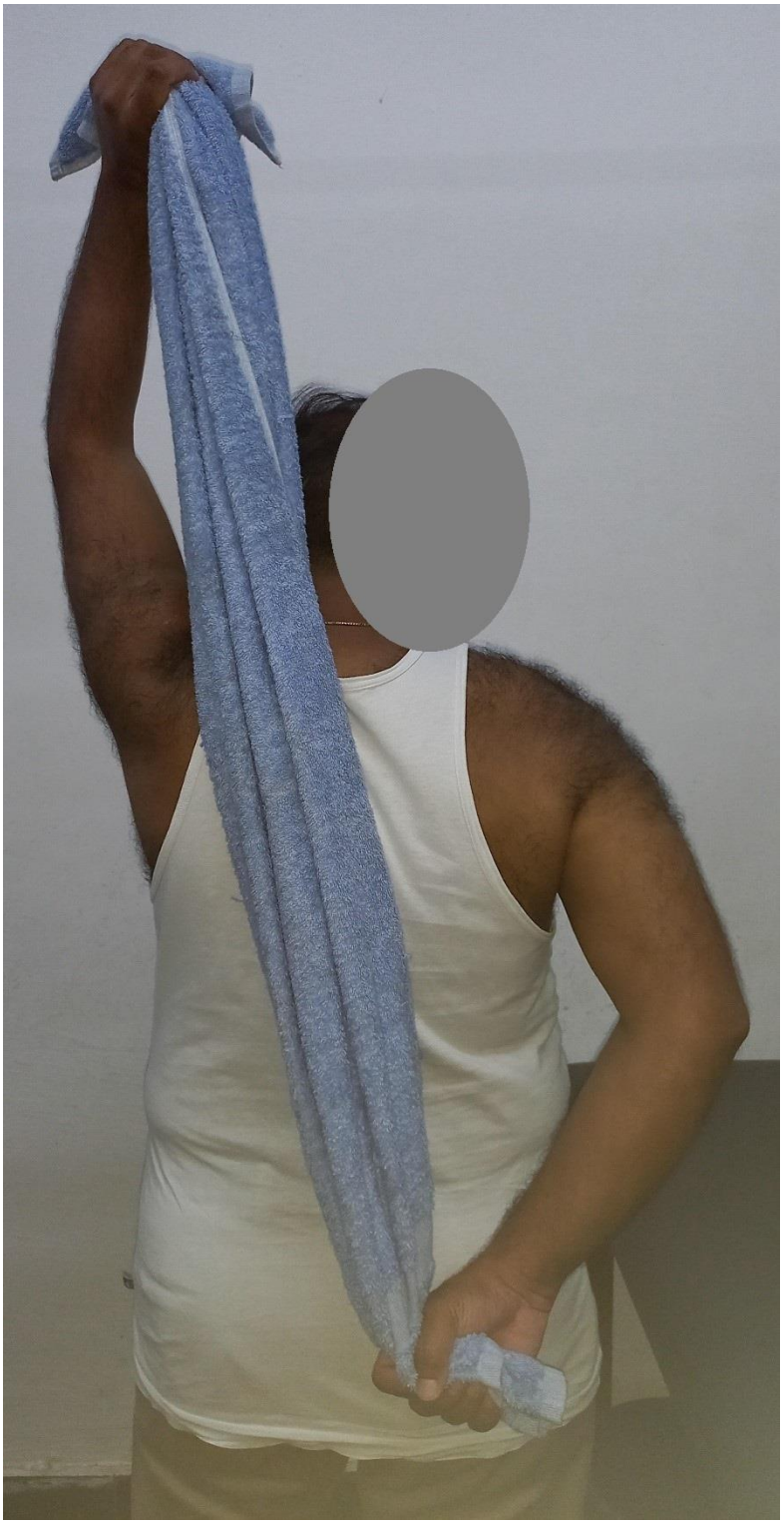

Figure 3. 24 Towel stretch exercise performed by subject with AC.

CHAPTER – IV

RESULTS

CHAPTER OVERVIEW

This chapter is dedicated to providing the results of this current study which describes the outcome measures like shoulder ROMs, pain, disability, and PPT in three groups.

4.1 DESCRIPTIVE ANALYSIS

Table 4.1 shows the demographic characteristics of 210 subjects (70 in each group) recruited in the study. In the local MTrP-DN group (Group-1), 33 (47.14%) males & 37 (52.85%) females with the mean and standard deviation of age were 54.4 ± 5.67 years, height was 5.51 ± 0.31 feet, weight was 67.5 ± 6.69 kg and BMI was 24.52 ± 1.32 kg/m^2. In Local MTrP-DN along with PSDN group (Group-2), 35 (50%) males & 35 (50%) females with the mean and standard deviation of age were 54.5 ± 5.50 years, height was 5.53 ± 0.29 ft, weight was 67.1 ± 6.67 kg, and BMI was 24.01 ± 1.37 kg/m^2. In the CPT group (Group-3), 30 (42.9%) males & 40 (57.14 %) females with the mean and standard deviation of age were 54.5 ± 5.64 years; height was 5.49 ± 0.33 ft., weight was 67.2 ± 6.94 kg, and BMI was 24.38 ± 1.58 kg/m^2 participated. All the demographic measures in the three groups were not statistically significant ($p > 0.05$) from each other, which shows the three groups are homogenous.

Table 4. 1 Baseline demographic characteristics and homogeneity of study subjects

Measure	Group – 1 n=70	Group – 2 n=70	Group – 3 n=70	*p-value*
	M ± *SD*	*M* ± *SD*	*M* ± *SD*	
Gender	Male= 33 (47.14%) Female = 37 (52.85%)	Male = 35 (50%) Female = 35 (50%)	Male = 30 (42.9%) Female = 40 (57.1%)	
Supraspinatus Ms#	27	30	27	
Infraspinatus Ms#	23	22	23	
Teres Minor Ms#	20	17	22	
Subscapularis Ms#	22	22	19	
Deltoid Ms#	13	14	16	
Pectoralis Major Ms#	16	16	16	
Teres Major Ms#	10	14	9	
Upper Trapezius Ms#	26	23	26	
Age (Years)	54.4 ± 5.67	54.5 ± 5.50	54.5 ± 5.64	0.99**
Height (Feet)	5.51 ± 0.31	5.53 ± 0.29	5.49 ± 0.33	0.80**
Weight (Kg)	67.5 ± 6.69	67.1 ± 6.67	67.2 ± 6.94	0.70**
BMI (kg/m^2)	24.52 ± 1.32	24.01 ± 1.37	24.38 ± 1.58	0.15**

Note. *Group - 1* represents the local myofascial trigger point dry needling group, *Group - 2* represents the local myofascial trigger point dry needling along with the paraspinal dry needling group, *Group - 3* represents the conventional physiotherapy group. *M* – Mean, *SD* - Standard deviation, *BMI* – Body Mass Index, **=*P*>0.05 (all three groups are homogeneous), # - Number of subjects who had MTrPs in that particular muscle, *Ms* - Muscle.

4.2 INFERENTIAL ANALYSIS- STATISTICAL TESTS

4.2.1 Normality testing

Shapiro -Wilk test was used to determine the normality of data and the *p*-value was less than 0.05 for all the parameters, and tests reject the hypothesis of normality. Furthermore, based on Z skewness and Z kurtosis statistics (Ghasemi & Zahediasl, 2012), the normality of the data was determined, and data of all the parameters in the three groups show the normal distribution because *p* values lie within -1.96 to 1.96 (Table 4.2, 4.3, 4.4).

Table 4. 2 Normality testing results of local MTrP-DN group (Group-1) based on the Z kurtosis and Z skewness statistics

Measures		Skewness			Kurtosis		
	Motions	*Statistic*	*SE*	*Z Skewness*	*Statistic*	*SE*	*Z Kurtosis*
Shoulder	Flexion	-0.182	0.287	-0.6*	0.655	0.566	1.1*
Range of	Extension	0.000	0.287	0.00*	-0.240	0.566	-0.42*
Motion	Abduction	0.062	0.287	0.21*	-0.580	0.566	1.02*
(Universal	Medial Rotation	-0.432	0.287	-1.50*	-0.239	0.566	-0.42*
Goniometer)	Lateral Rotation	-0.470	0.287	-1.63*	1.08	0.566	1.90*
Pain intensity	VAS	0.058	0.287	0.20*	-0.510	0.566	-0.90*
Disability	SPADI	-0.307	0.287	-1.0*	-0.566	0.566	-1.0*
Pressure Pain	Supraspinatus muscle	-0.496	0.448	-1.10*	1.33	0.872	1.52*
Threshold	Infraspinatus muscle	1.05	0.52	1.92*	1.39	0.935	1.48*
(Pressure	Teres Minor muscle	-1.00	0.512	-1.95*	0.433	0.992	0.43*
Algometer)	Subscapularis muscle	-0.513	0.491	-1.95*	1.58	0.953	1.57*
	Deltoid muscle	-0.855	0.616	-1.38*	1.25	1.19	1.05*
	Pectoralis Major muscle	-0.478	0.564	-0.84*	-0.528	1.09	-0.48*
	Teres Major muscle	0.760	0.687	1.10*	0.922	1.33	0.69*
	Upper Trapezius muscle	-0.89	0.456	1.95*	2.70	0.887	1.42*

Note. VAS - Visual Analog Scale, *SE* - Std. Error, SPADI - Shoulder Pain and Disability Index, * - Normal distribution

Table 4. 3 Normality testing results of local MTrP-DN along with PSDN Group based on the Z kurtosis and Z skewness statistics

Measures		Skewness			Kurtosis		
	Motions/ Tool	*Statistic*	*SE*	*Z Skewness*	*Statistic*	*SE*	*Z Kurtosis*
Shoulder	Flexion	0.031	0.287	0.10*	0.239	0.566	0.42*
Range of	Extension	-0.041	0.287	-1.4*	-0.416	0.566	-0.73*
Motion	Abduction	0.122	0.287	0.42*	-0.646	0.566	1.1*
(Universal	Medial Rotation	-0.433	0.287	1.50*	-0.419	0.566	-0.74*
Goniometer)	Lateral Rotation	-0.148	0.287	-0.51*	-0.453	0.566	-0.80*
Pain intensity	VAS	-0.221	0.287	-0.77*	-0.297	0.566	-0.52*
Disability	SPADI	0.036	0.287	0.12*	-0.659	0.566	-1.16*
Pressure Pain	Supraspinatus muscle	-0.356	0.427	-0.83*	1.17	0.833	1.40*
Threshold	Infraspinatus muscle	0.285	0.491	0.58*	-0.604	0.953	-0.63
(Pressure	Teres Minor muscle	-0.479	0.564	-0.84*	-1.12	1.09	-1.02*
Algometer)	Subscapularis muscle	0.051	0.491	0.10*	-0.823	0.953	-0.86*
	Deltoid muscle	-0.421	0.597	-0.70*	-0.40	1.15	-0.34*
	Pectoralis Major muscle	-0.066	0.564	-0.11*	-0.509	1.09	-0.46*
	Teres Major muscle	-0.282	0.597	-0.47*	-0.646	1.15	-0.56*
	Upper Trapezius muscle	-0.08	0.481	-0.16*	-0.477	0.935	-0.51*

Note. VAS - Visual Analog Scale, *SE* - Standard Error, *SPADI* - Shoulder Pain and Disability Index, * - Normal distribution.

Table 4. 4 Normality testing results of CPT group (Group - 3) based on the Z kurtosis and Z skewness statistics

Measures		Skewness			Kurtosis		
	Motions/ Tool	*Statistic*	*SE*	*Z Skewness*	*Statistic*	*SE*	*Z Kurtosis*
Shoulder	Flexion	0.492	0.287	1.7*	1.09	0.566	1.92*
Range of	Extension	0.073	0.287	0.25*	0.036	0.566	0.063*
Motion	Abduction	0.294	0.287	1.02*	-0.655	0.566	1.15*
(Universal	Medial Rotation	0.069	0.287	0.24*	-1.04	0.566	-1.8*
Goniometer)	Lateral Rotation	-0.476	0.287	1.65*	-1.07	0.566	-1.89
Pain intensity	VAS	-0.139	0.287	-0.48*	-0.094	0.566	-0.16*
Disability	SPADI	0.088	0.287	0.30*	-0.634	0.566	-1.12*
Pressure Pain	Supraspinatus muscle	0.726	0.448	1.62*	-0.231	0.872	-0.26*
Threshold	Infraspinatus muscle	0.749	0.481	1.55*	-0.474	0.935	-0.50*
(Pressure	Teres Minor muscle	0.747	0.491	1.52*	-0.382	0.953	-0.40*
Algometer)	Subscapularis muscle	-0.342	0.524	-0.65*	-1.08	1.01	-1.06*
	Deltoid muscle	-0.037	0.564	-0.06*	-0.761	1.09	-0.69*
	Pectoralis Major muscle	0.804	0.564	1.42*	-0.388	1.09	-0.35*
	Teres Major muscle	-0.916	0.717	1.27*	-0.636	1.40	-0.45*
	Upper Trapezius muscle	0.649	0.456	1.42*	0.503	0.887	0.56*

Note. VAS - Visual Analog Scale, *SE* - Standard Error, *Ms* – Muscle, *SPADI* - Shoulder Pain and Disability Index, * - Normal distribution

4.2.2 Effect of myofascial trigger point dry needling in local MTrP-DN group (Group-1).

4.2.2.1 Shoulder range of motion

Table 4.5 presents the comparison of shoulder ROMs pre and post-intervention in group 1. It is evident that the post-intervention flexion (154.2 ± 10.97) was significantly (t (69) = -33.84, $p \leq 0.05$) more than the pre-intervention score (108 ± 14.40). A similar trend was seen in extension, abduction, medial rotation, and lateral rotation ROMs. This indicates that the ROM of all the shoulder movements was significantly improved during post-intervention. The data is presented graphically in figure 4.1.

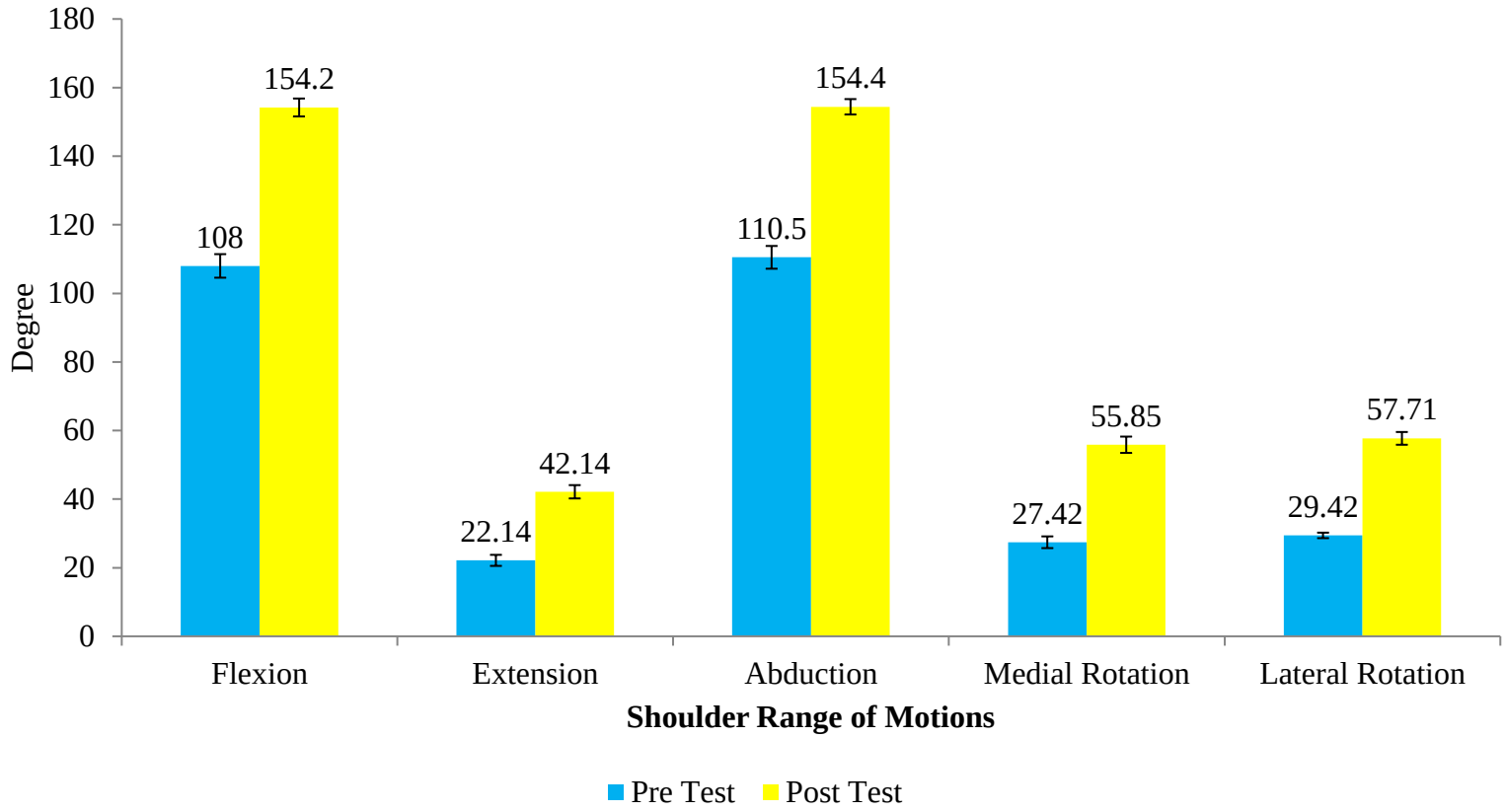

Figure 4.1 Mean and 95 % CI of pre and post-test readings of shoulder flexion range of motions in degrees for local MTrP-DN group (G-1).

4.2.2.2 Shoulder Pain

Table 4.5 displays the comparison of shoulder pain intensity of pre- and post-intervention in group 1. It is evident that the post-intervention shoulder pain (VAS) intensity (2.8± 0.44) was significantly (t (69) = 80.8, $p \leq 0.05$) less than the pre-intervention pain intensity (7.9 ± 0.04). This indicates that the shoulder pain was significantly improved during post-intervention. The data is presented graphically in figure 4.2.

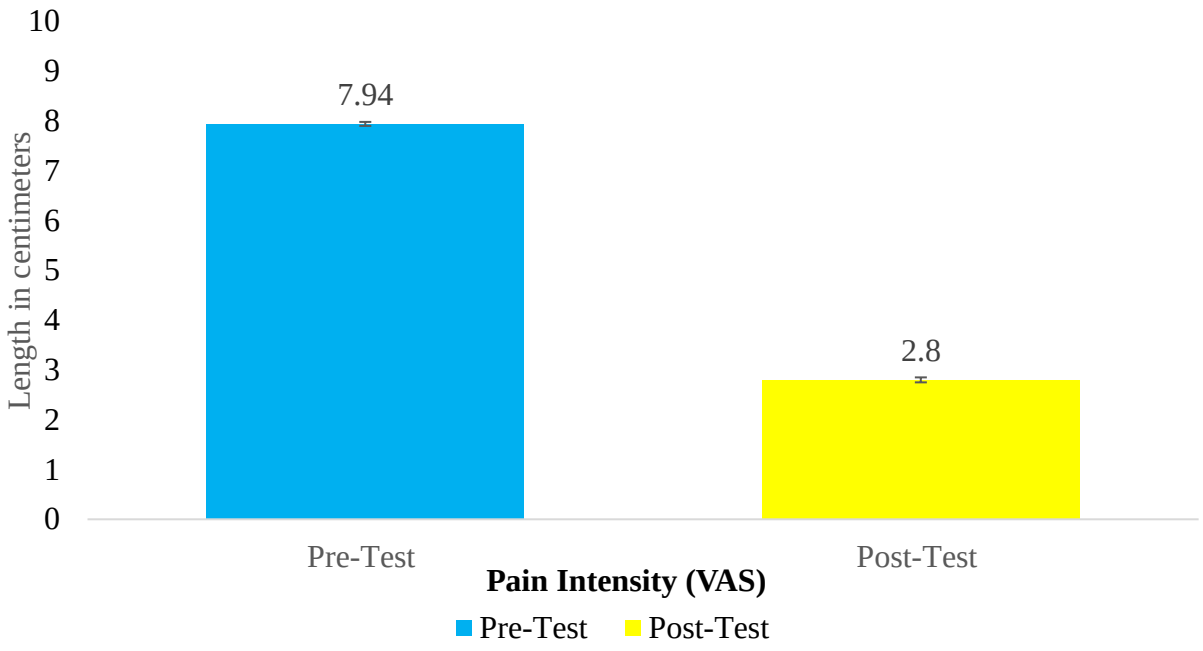

Figure 4. 2 Mean and 95 % CI of pre and post-test readings of shoulder pain (Visual Analog Scale) for local MTrP-DN group (Group-1).

4.2.2.3 Shoulder Disability

Table 4.6 displays the comparison of shoulder disability pre and post-intervention in group 1. It is evident that the post-intervention shoulder disability (SPADI) score (27.52 ± 3.8) was significantly (t (69) = 89.03, $p \leq 0.05$) less than the pre-intervention score (84.7 ± 0.53). This indicates that the shoulder disability was significantly improved during post-intervention. The data is presented graphically in figure 4.3.

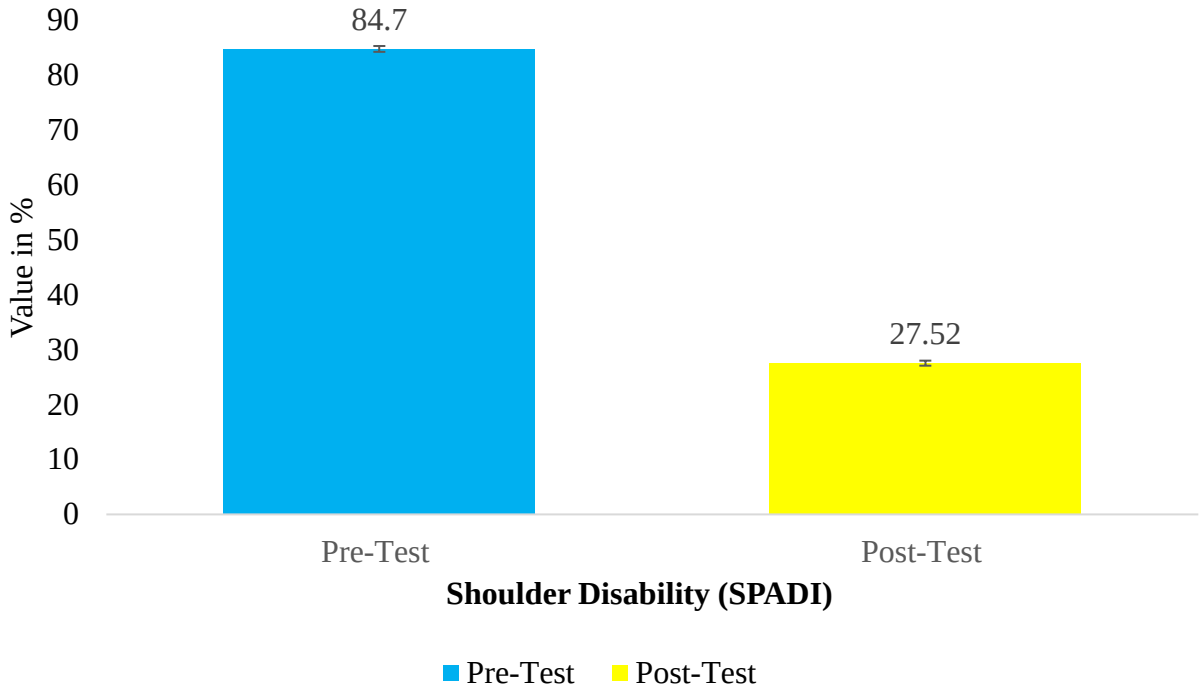

Figure 4. 3 Mean and 95 % CI of pre and post-test readings of SPADI for local MTrP-DN group (Group-1).

4.2.2.4 Pressure Pain Threshold

Table 4.6 displays the comparison of PPT of pre- and post-intervention in group 1. It is evident that the post-intervention PPT score of the Supraspinatus muscle (3.0 ± 0.07) was significantly (t (26) = -19.50, $p \leq 0.05$) more than the pre-intervention score (1.46 ± 0.26). A similar trend was visible in Infraspinatus, Teres minor, Subscapularis, Deltoid, Pectoralis major, Teres major, and Upper trapezius muscles. This indicates that the PPT of the muscles around the shoulder was significantly improved during post-intervention. The data is presented graphically in figure 4.4.

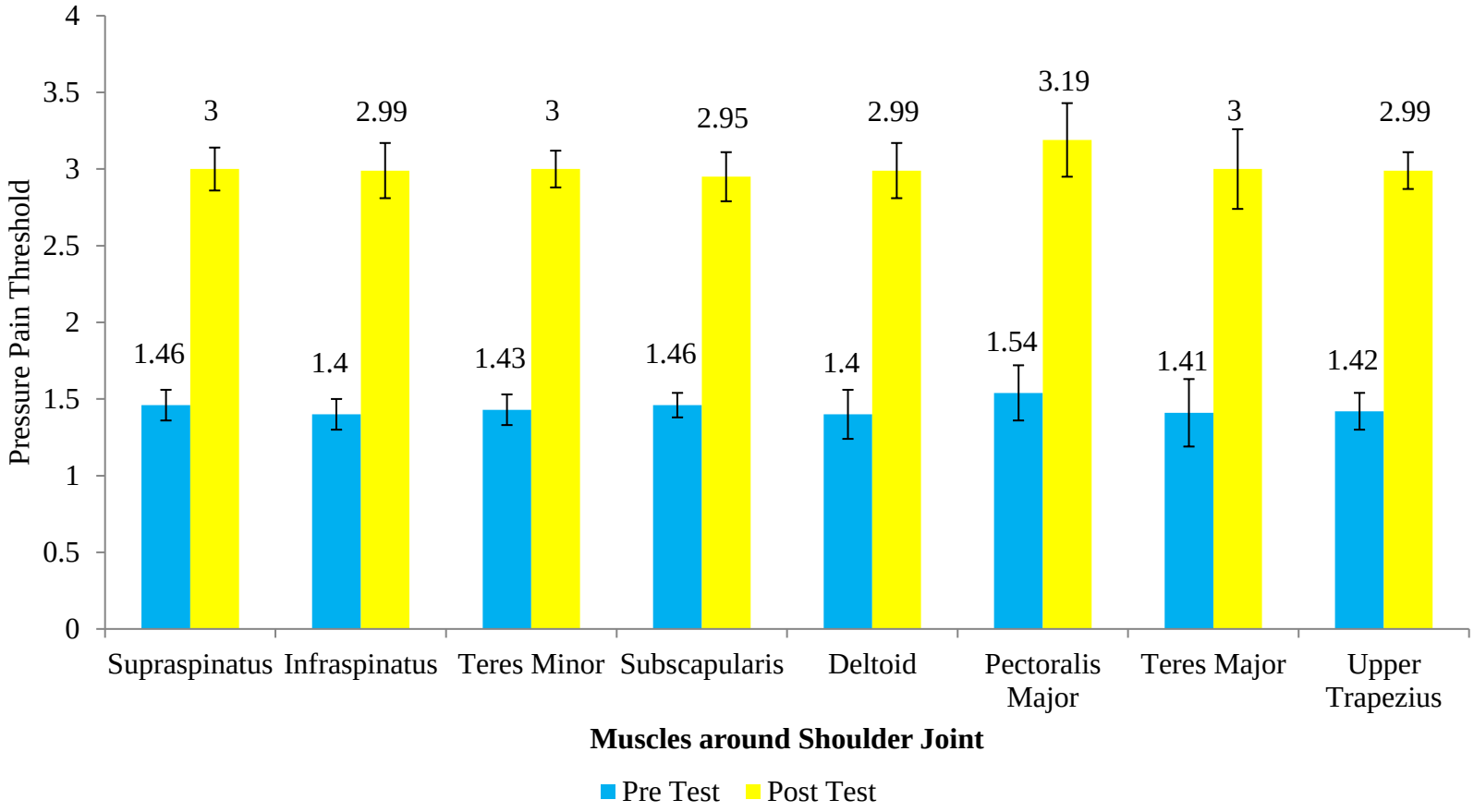

Figure 4. 4 Mean and 95 % CI of pre and post-test readings of Pressure Pain Threshold (PPT) for local MTrP-DN group (Group-1)

Table 4. 5 Comparison of shoulder ROMs, pain pre-test and post-test in local MTrP-DN group (Group-1) by paired 't' test.

Outcome Measures	Motion/ tools	Pre-Test		Post-Test		t	Cohen's d
		M ± SD	SE	M ± SD	SE		
Range of Motion	Flexion	108 ±14.4	1.72	154.2 ±10.9	1.31	-33.84*	3.64
	Extension	22.1 ± 6.7	0.81	42.1 ± 8.1	0.97	-27.25*	2.70
	Abduction	110.5 ± 13.9	1.6	154.4 ±9.4	1.1	-37.92*	3.76
	Medial rotation	27.4 ± 7.1	0.85	55.8 ± 9.9	1.1	-27.59*	3.34
	Lateral rotation	29.4 ± 3.3	0.40	57.7 ± 7.8	0.93	-33.74*	5.09
Pain Intensity	Visual analog scale	7.94 ± 0.39	0.04	2.80 ± 0.44	0.05	80.8*	12.2

Note. M - Mean, SD - Standard Deviation, SE - Standard Error, * = $p \leq 0.05$.

Table 4. 6 Comparison of shoulder disability, PPT pre-test and post-test in local MTrP-DN group (Group-1) by paired 't' test.

Outcome measures	Tools	Pre-Test		Post-Test		t	Cohen's d
		M ± SD	SE	M ± SD	SE		
Disability	SPADI	84.7 ± 4.4	0.53	27.52 ± 3.8	0.46	89.03*	13.9
Pressure pain threshold	Supraspinatus muscle	1.46 ± 0.26	0.05	3.0 ± 0.39	0.07	-19.50*	4.73
	Infraspinatus muscle	1.40 ± 0.26	0.05	2.99 ± 0.44	0.09	-25.67*	3.31
	Teres Minor muscle	1.43 ± 0.25	0.05	3.0 ± 0.31	0.06	-27.13*	5.60
	Subscapularis muscle	1.46 ±0.22	0.04	2.95 ±0.40	0.08	-23.14*	4.80
	Deltoid muscle	1.40 ± 0.29	0.08	2.99 ± 0.33	0.09	-17.56*	4.83
	Pectoralis Major muscle	1.54 ± 0.37	0.09	3.19 ± 0.48	0.12	-15.90*	3.88
	Teres Major muscle	1.41 ± 0.37	0.11	3.0 ± 0.43	0.13	-20.68*	3.97
	Upper Trapezius muscle	1.42 ± 0.30	0.06	2.99 ± 0.35	0.06	-27.58*	4.90

Note. M - Mean, SD - Standard Deviation, SE - Standard Error, SPADI - Shoulder Pain And Disability Index, * = $p \leq 0.05$.

4.2.3 Effectiveness of the local myofascial trigger point dry needling along with the paraspinal dry needling in the local MTrP-DN along with the PSDN group (Group-2).

4.2.3.1 Shoulder ROM

Table 4.7 displays the comparison of shoulder ROMs pre- and post-intervention in group 2. It is evident that the post intervention flexion (151.0 ± 10.78) was significantly ($t(69) = -42.34$, $p \leq 0.05$) more than the pre-intervention score (104.5 ± 13.0). A similar trend was visible in extension, abduction, medial rotation, and lateral rotation ROMs. This indicates that the ROM of all the shoulder movements was significantly improved during post-intervention. The data is presented graphically in figure 4.5.

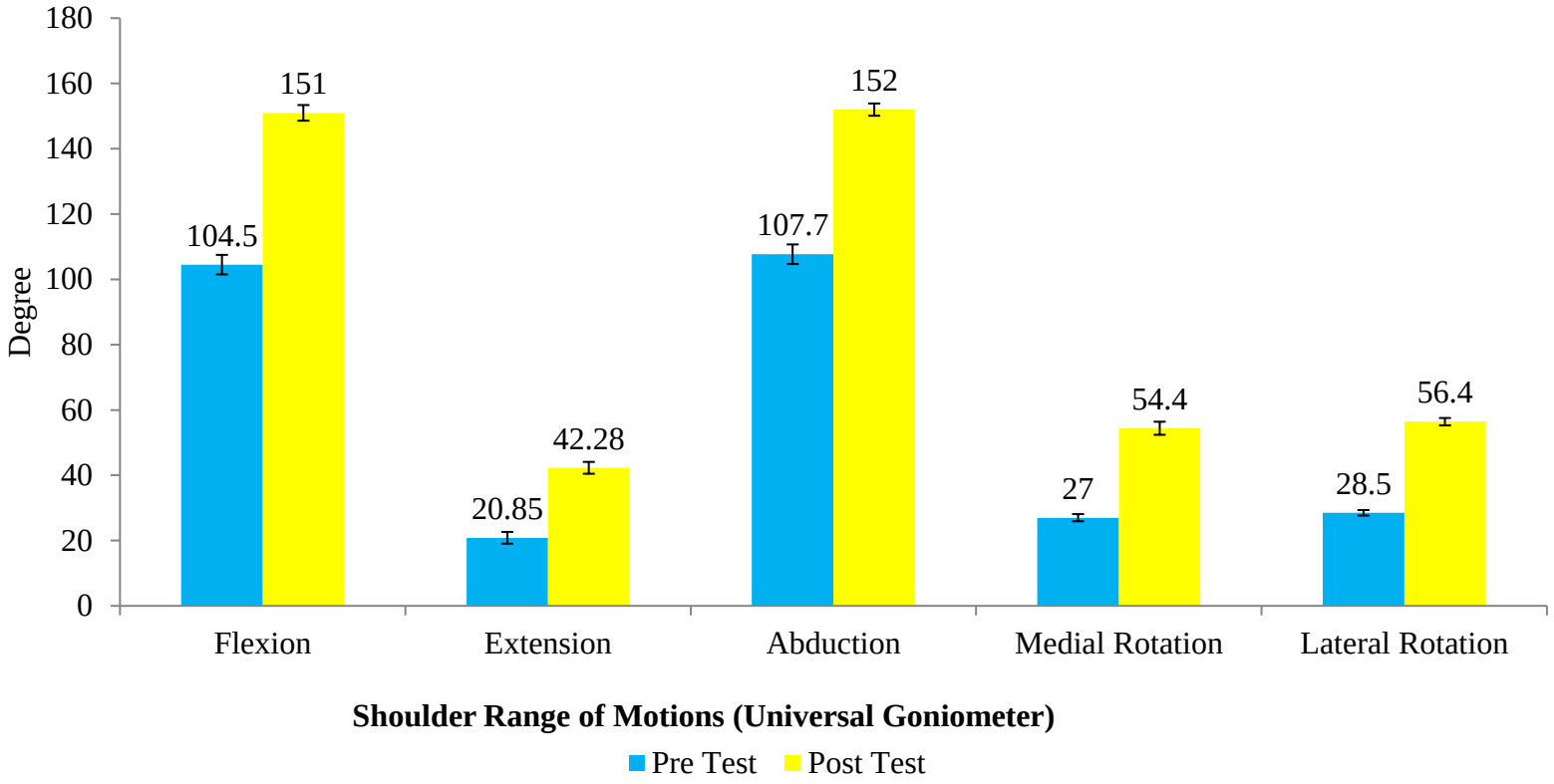

Figure 4. 5 Mean and 95 % CI of pre and post-test readings of shoulder flexion range of motions in degrees for local MTrP-DN along with PSDN group (Group-2).

4.2.3.2 Shoulder Pain

Table 4.7 presents the comparison of shoulder pain intensity pre and post-intervention in group 2. It is evident that the post intervention shoulder pain (VAS) intensity (2.71 ± 0.47) was significantly (t (69) = 78.40, $p \leq 0.05$) less than the pre-intervention pain intensity (7.97 ± 0.35). This indicates that the shoulder pain was significantly improved during post-intervention. The data is presented graphically in figure 4.6.

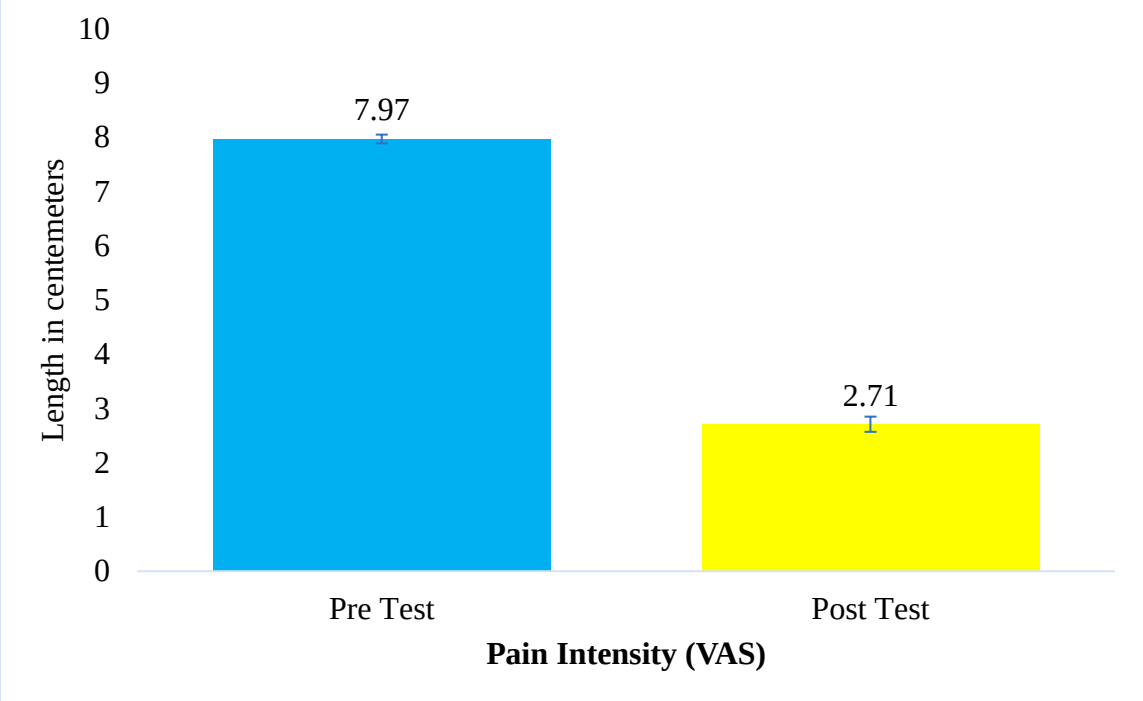

Figure 4. 6 Mean and 95 % CI of pre and post-test readings of shoulder pain (Visual Analog Scale) for local MTrP-DN along with PSDN group (Group-2).

4.2.3.3 Shoulder Disability

Table 4.8 displays the comparison of shoulder disability pre and post-intervention in group 2. It is evident that the post intervention shoulder disability (SPADI) score (28.1 ± 3.8) was significantly (t (69) = 80.29, $p \leq 0.05$) less than the pre-intervention score (84.6 ± 4.5). This indicates that the shoulder disability was significantly improved during post-intervention. The data is presented graphically in figure 4.7.

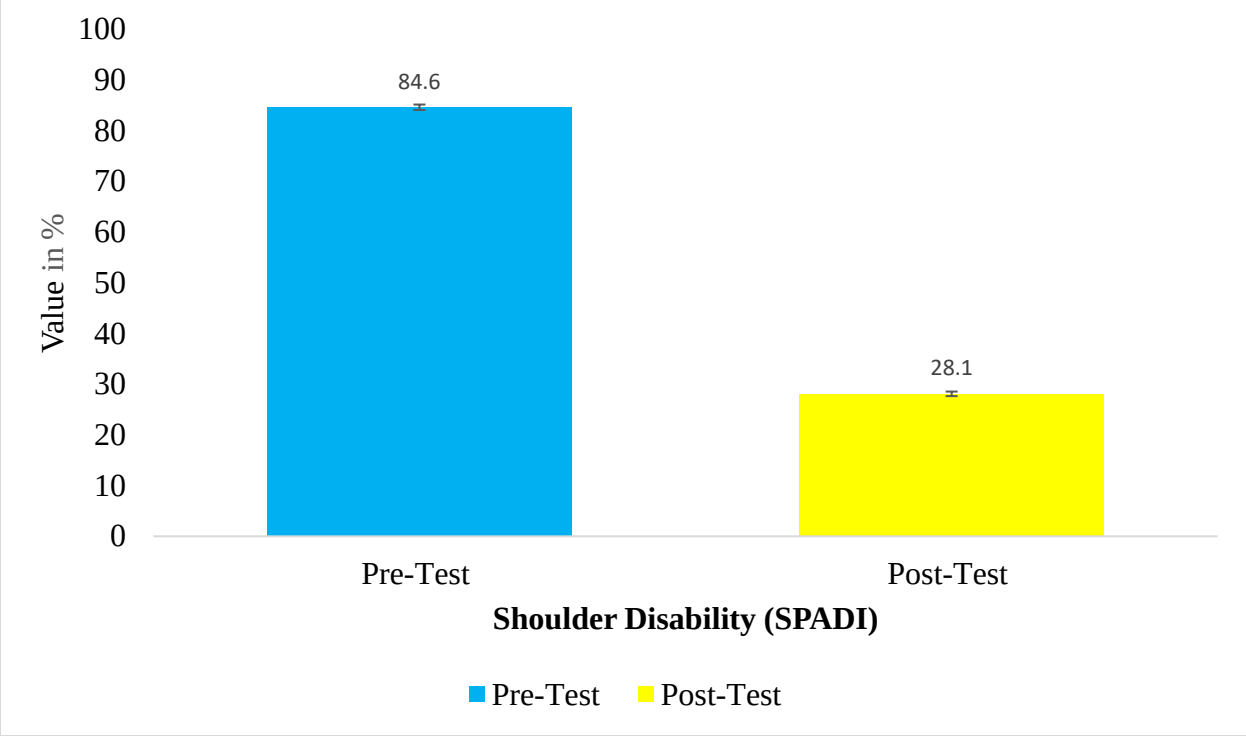

Figure 4. 7 Mean and 95 % CI of pre and post-test readings of Shoulder Pain and Disability Index (SPADI) for the local MTrP-DN along with the PSDN group (Group-2).

4.2.3.4 Pressure Pain Threshold

Table 4.8 displays the comparison of PPT of pre- and post-intervention in group 2. It is evident that the post intervention PPT score of Supraspinatus muscle (2.97 ± 0.41) was significantly (t (29) = -17.94, $p \leq 0.05$) more than the pre-intervention score (1.39 ± 0.19). A similar trend was visible in Infraspinatus, Teres minor, Subscapularis, Deltoid, Pectoralis major, Teres major, Upper trapezius muscles. This indicates that the PPT of the muscles around the shoulder was significantly improved during post-intervention. The data is presented graphically in figure 4.8.

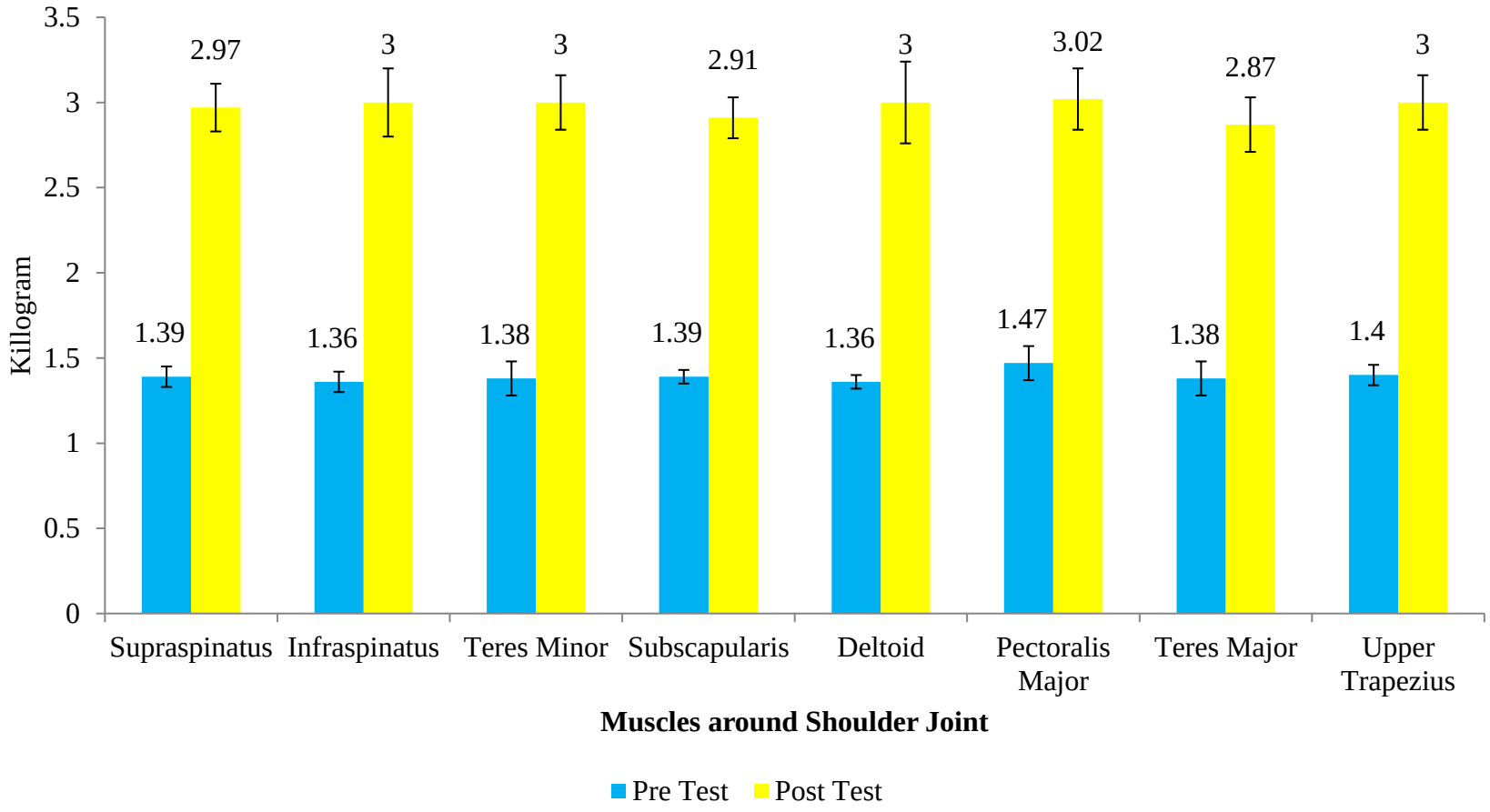

Figure 4. 8 Mean and 95 % CI of pre and post-test readings of Pressure Pain Threshold (PPT) for the local MTrP-DN along with the PSDN group (Group-2).

Table 4. 7 Comparison of shoulder range of motions, pain (VAS) pre-test and post-test in local MTrP-DN along with PSDN group (Group-2) by paired t-test.

Outcome measures	Motion/ tools	Pre-Test		Post-Test		t	Cohen's d
		M ± SD	SE	M ± SD	SE		
Range of Motion	Flexion	104.5 ±13.0	1.5	151 ±10.78	1.2	-42.34*	3.90
	Extension	20.85 ± 7.5	0.90	42.28 ± 7.6	0.91	-25.32*	2.83
	Abduction	107.7 ± 13.2	1.5	152.0 ± 7.9	0.94	-37.56*	4.19
	Medial rotation	27.0 ± 4.6	0.55	54.4 ± 9.1	1.0	-29.63*	4.00
	Lateral rotation	28.5 ± 3.5	0.42	56.4 ± 4.8	0.57	-38.12*	6.72
Pain Intensity	Visual Analog Scale	7.97 ± 0.35	0.04	2.71 ± 0.47	0.05	78.40*	12.68

Note. M - Mean, SD - Standard Deviation, SE - Standard Error, * = $p \leq 0.05$.

Table 4. 8 Comparison of shoulder disability (SPADI), Pressure pain threshold pre-test and post-test in local MTrP-DN along with PSDN group (Group-2) by paired t-test.

Outcome Measures	Tools	Pre-Test		Post-Test		t	Cohen's d
		M ± SD	SE	M ± SD	SE		
Disability	SPADI	84.6 ± 4.5	0.54	28.1 ± 3.8	0.45	80.29*	13.61
Pressure pain threshold	Supraspinatus muscle	1.39 ± 0.19	0.03	2.97 ± 0.41	0.07	-17.94*	5.26
	Infraspinatus muscle	1.36 ± 0.18	0.03	3.0 ± 0.48	0.10	-19.57*	4.96
	Teres Minor muscle	1.38 ± 0.21	0.05	3.0 ± 0.32	0.08	-25.96*	6.11
	Subscapularis muscle	1.39 ± 0.12	0.02	2.91 ± 0.31	0.06	-23.59*	7.06
	Deltoid muscle	1.36 ± 0.11	0.02	3.0 ± 0.45	0.12	-16.16*	5.85
	Pectoralis Major muscle	1.47 ± 0.23	0.05	3.02 ± 0.38	0.09	-17.51*	5.08
	Teres Major muscle	1.38 ± 0.21	0.05	2.87 ± 0.33	0.08	-19.99*	5.51
	Upper Trapezius muscle	1.40 ± 0.16	0.03	3.0 ± 0.40	0.08	-23.51*	3.33

Note. M - Mean, SD - Standard Deviation, SE - Standard Error, SPADI - Shoulder Pain And Disability Index, * = $p \leq 0.05$.

4.2.4 Effectiveness of conventional physiotherapy in the CPT group (Group-3).

4.2.4.1 Shoulder range of motions

Table 4.9 displays the comparison of outcome measures pre and post-intervention in group 3. It is evident that the post intervention flexion (143.2± 8.6) was significantly (t (69) = -39.21, $p \leq 0.05$) more than the pre-intervention score (101.1± 11.6). A similar trend was visible in extension, abduction, medial rotation, and lateral rotation ROMs. This indicates that the ROM of all the shoulder movements was significantly improved during post-intervention. The data is presented graphically in figure 4.9.

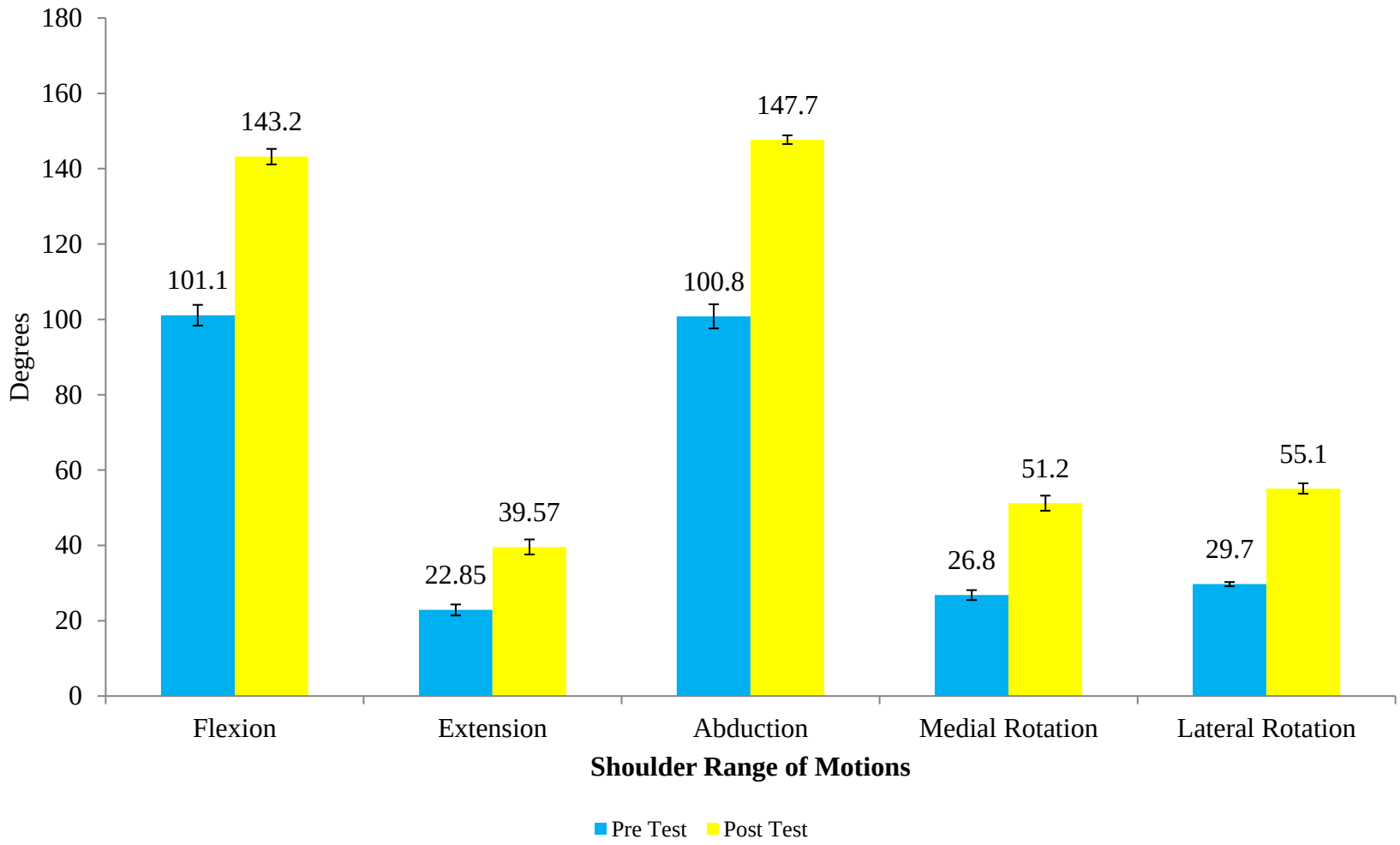

Figure 4. 9 Mean and 95 % CI of pre and post-test readings of shoulder range of motions in degrees for the CPT group (Group-3).

4.2.4.2 Shoulder Pain

Table 4.9 displays the comparison of shoulder pain-intensity of pre- and post-intervention in group 3. It is evident that the post intervention shoulder pain (VAS) intensity (3.8± 0.62) was significantly ($t(69) = 49.80$, $p \leq 0.05$) less than the pre-intervention pain intensity (7.9 ± 0.37). This indicates that the shoulder pain was significantly improved during post-intervention. The data is presented graphically in figure 4.10.

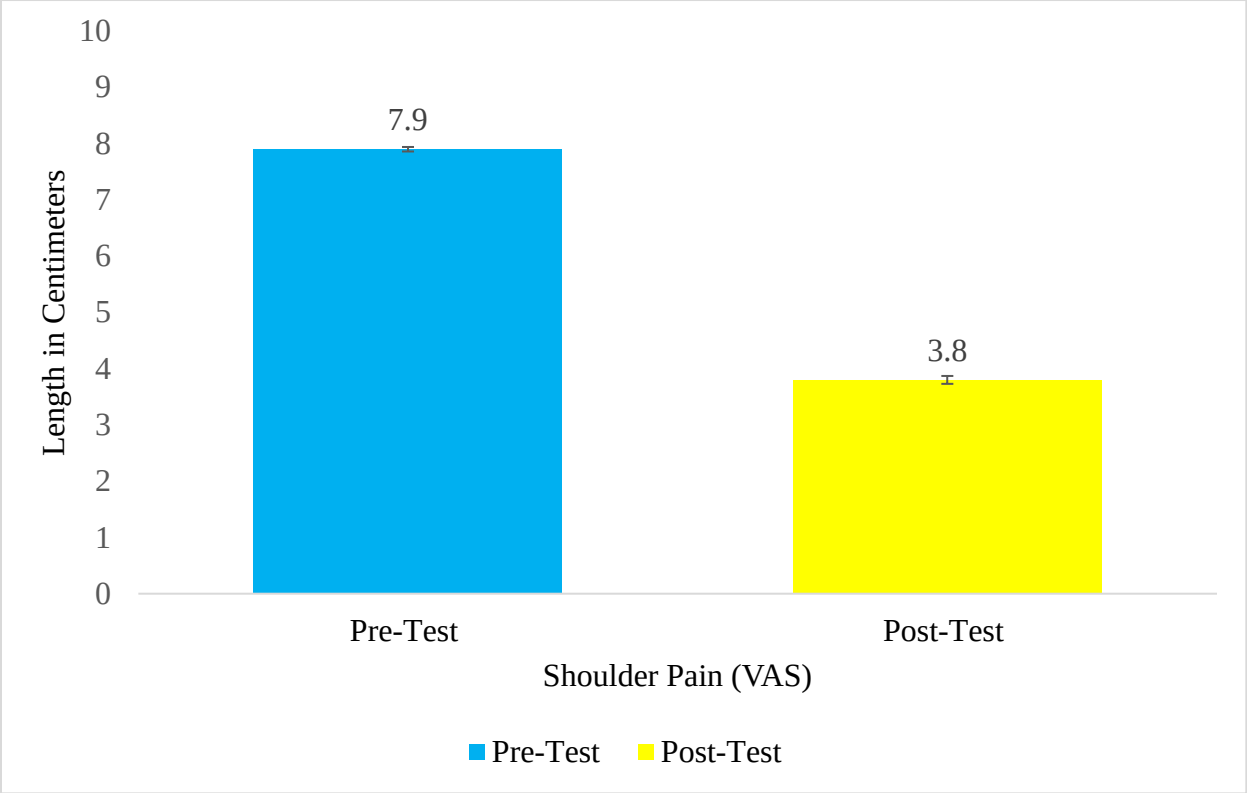

Figure 4. 10 Mean and 95 % CI of pre and post-test readings of shoulder pain (Visual Analog Scale) for the CPT group (Group- 3).

4.2.4.3 Shoulder Disability

Table 4.10 displays the comparison of shoulder disability pre and post-intervention in group 3. It is evident that the post intervention shoulder disability (SPADI) score (42.21 ± 4.1) was significantly (t (69) = 64.57, $p \leq 0.05$) less than the pre-intervention score (85.37 ± 4.4). This indicates that the shoulder disability was significantly improved during post-intervention. The data is presented graphically in figure 4.11.

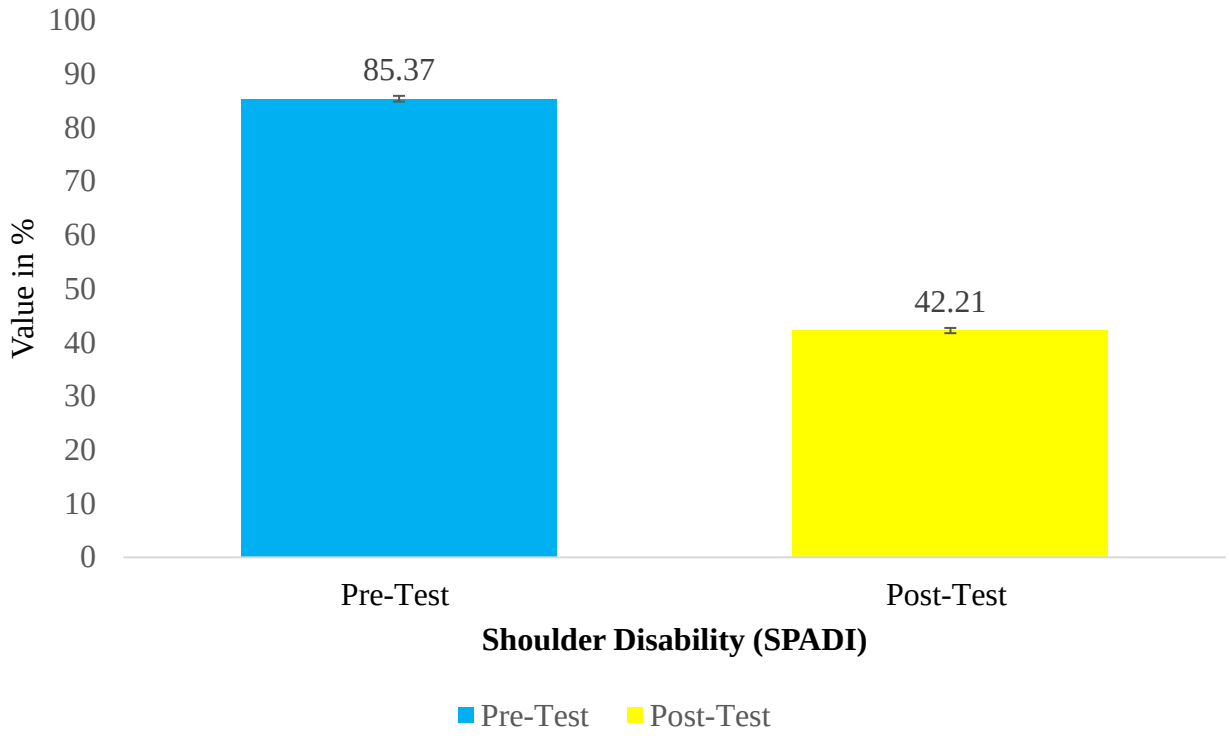

Figure 4.11 Mean and 95 % CI of pre and post-test readings of Shoulder Pain and Disability Index (SPADI) for the CPT group (Group-3).

4.2.3.4 Pressure Pain Threshold

Table 4.10 displays the comparison of PPT of pre- and post-intervention in group 3. It is evident that the post intervention PPT score of Supraspinatus muscle (1.91 ± 0.80) was significantly (t (26) = -4.21, $p \leq 0.05$) more than the pre-intervention score (1.4 ± 0.21). A similar trend was visible in Infraspinatus, Teres minor, Subscapularis, Deltoid, Pectoralis major, Teres major, Upper trapezius muscles. This indicates that the PPT of the muscles around the shoulder was significantly improved during post-intervention. The data is presented graphically in figure 4.12.

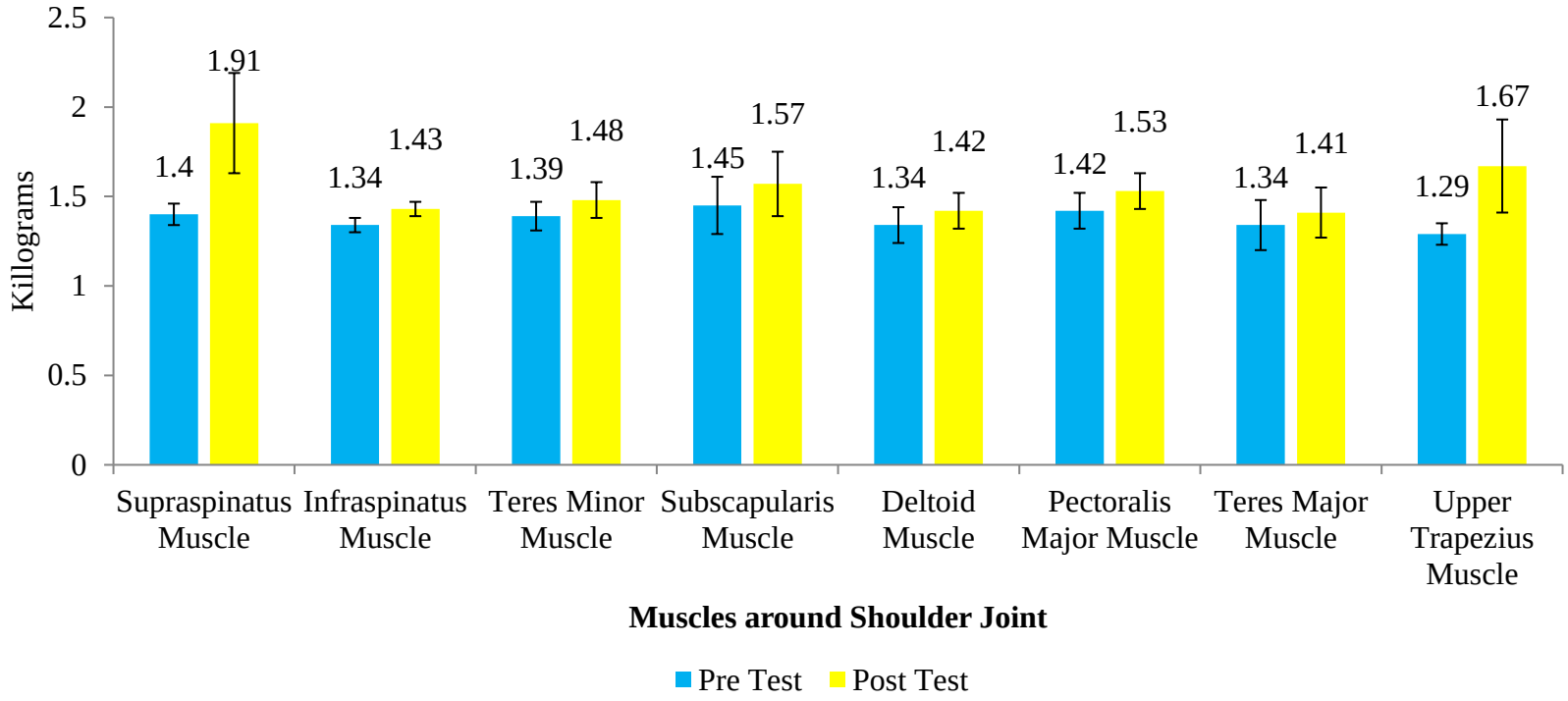

Figure 4.12 Mean and 95 % CI of pre and post-test readings of Pressure Pain Threshold (PPT) for the CPT group (Group-3).

Table 4. 9 Comparison of shoulder range of motions, pain (VAS) pre-test and post-test in the CPT group (Group-3) by paired t-test.

Outcome measures	Motion/ tools	Pre-Test		Post-Test			Cohen's
		M ± SD	SE	M ± SD	SE	t	d
Range of Motion	Flexion	101.1 ± 11.6	1.38	143.2 ± 8.6	1.03	-39.21*	4.16
	Extension	22.85 ± 6.1	0.73	39.57 ± 8.9	1.0	-26.34*	2.22
	Abduction	100.8 ± 13.5	1.6	147.7 ± 4.8	0.58	-27.22*	5.1
	Medial rotation	26.8 ± 5.5	0.66	51.2 ± 8.4	1.0	-38.67*	3.51
	Lateral rotation	29.7 ± 2.3	0.28	55.1 ± 5.8	0.69	-40.15*	6.27
Pain Intensity	Visual Analog Scale	7.9 ± 0.37	0.04	3.8 ± 0.62	0.07	49.80*	8.28

M- Mean, SD- Standard deviation, SE- Standard Error, * = $p \leq 0.05$

Table 4. 10 Comparison of shoulder disability (SPADI), Pressure pain threshold pre-test and post-test in the CPT group (Group-3) by paired t-test.

Outcome measures	Tools	Pre-Test		Post-Test			Cohen's
		M ± SD	SE	M ± SD	SE	t	d
Disability	SPADI	85.37 ± 4.4	0.53	42.21 ± 4.1	0.49	64.57*	10.1
Pressure pain threshold	Supraspinatus Muscle	1.40 ± 0.21	0.03	1.91 ± 0.80	0.14	-4.21*	1.0
	Infraspinatus Muscle	1.34 ± 0.10	0.02	1.43 ±0.12	0.02	-12.33*	0.81
	Teres Minor Muscle	1.39 ± 0.23	0.04	1.48 ± 0.24	0.05	-11.23*	0.39
	Subscapularis Muscle	1.45 ± 0.38	0.08	1.57 ± 0.39	0.09	-12.87*	0.31
	Deltoid Muscle	1.34 ± 0.21	0.05	1.42 ± 0.22	0.05	-11.71*	0.38
	Pectoralis Major Muscle	1.42 ± 0.20	0.05	1.53 ± 0.23	0.05	-10.56*	0.52
	Teres Major Muscle	1.34 ± 0.23	0.07	1.41 ± 0.23	0.07	-11.75*	0.30
	Upper Trapezius Muscle	1.29 ± 0.17	0.03	1.67 ± 0.68	0.13	-3.26*	0.90

M- Mean, SD- Standard deviation, SE- Standard Error, SPADI- Shoulder pain and disability index, * = $p \leq 0.05$

4.2.5 Effect of local myofascial trigger point dry needling without (Group 1) or with paraspinal dry needling (Group 2) and conventional physiotherapy (Group 3).

4.2.5.1 Shoulder range of motions

Table 4.11 displays that analysis of covariance (ANCOVA) was conducted to compare the effect of DN on shoulder ROMs in local MTrP-DN, local MTrP-DN along with PSDN and CPT conditions. There was a significant effect of DN on shoulder ROMs at the $p \leq 0.05$ level for the three conditions (Figure 4.13) in flexion [F (2, 207) = 3.39, $p \leq 0.05$]. A similar trend was visible in extension, medial rotation, and lateral rotation but there was not a significant effect of DN on shoulder abduction ROM [F (2, 207) = 1.37, $p \geq 0.05$]. Post hoc comparisons using the Fisher's least significant difference (LSD) test indicated that for flexion, extension, medial rotation, and lateral rotation ROMs, the mean score for the local MTrP-DN condition and local MTrP-DN along with PSDN condition was significantly different from the CPT condition. However, the local MTrP-DN condition did not significantly differ from the local MTrP-DN along with the PSDN condition. Inclusively, these results suggest that both local MTrP-DN and local MTrP-DN along with PSDN was equally effective in increasing shoulder flexion, extension, abduction, and medial rotation ROMs, but both were significantly effective in increasing shoulder ROMs in AC then the CPT alone, but all the three conditions were not significantly effective from each other in lateral rotation ROM.

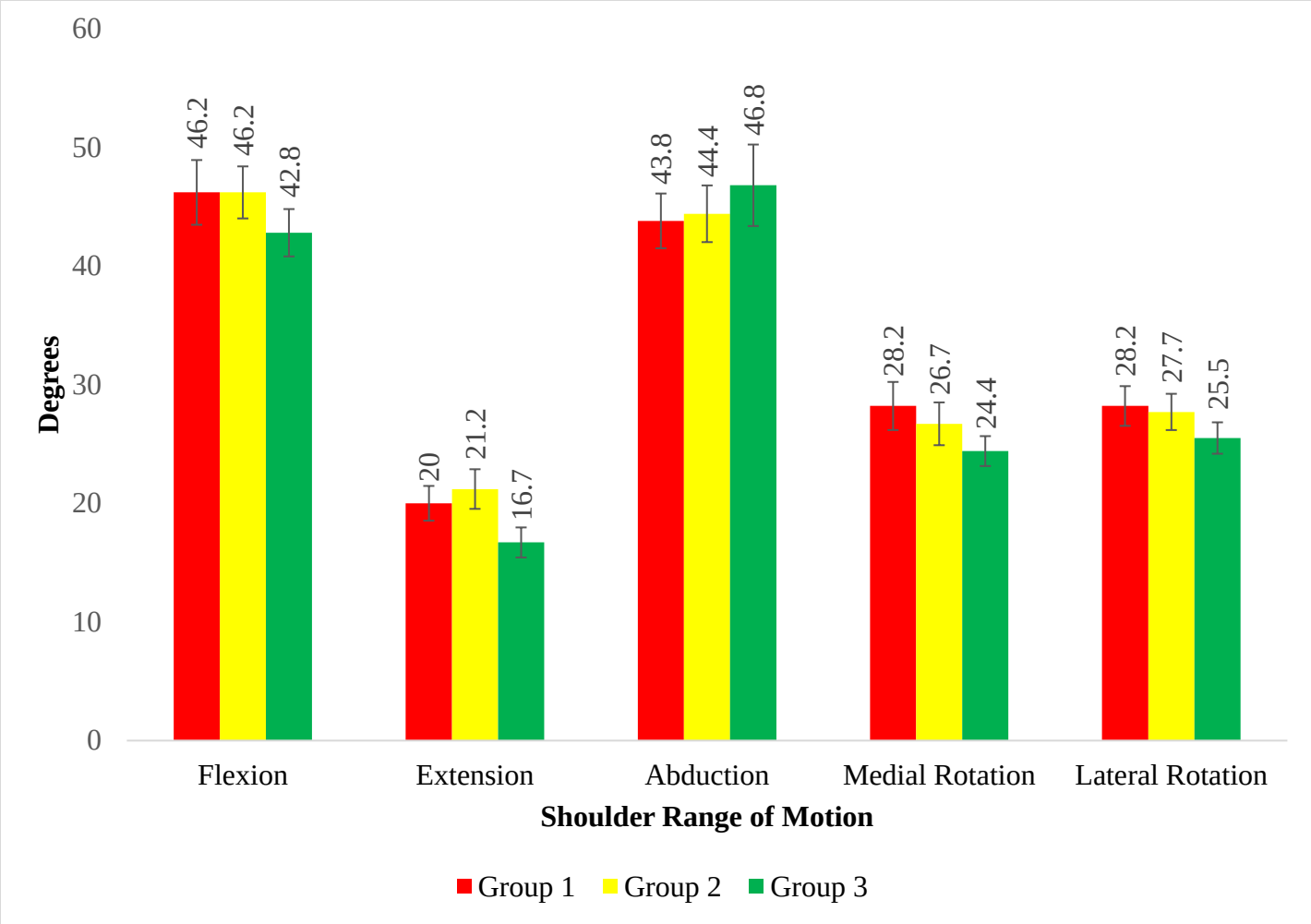

Figure 4.13 Shoulder active range of motions mean difference score in three different groups.

4.2.5.2 Pain Intensity

Table 4.11 shows that analysis of covariance (ANCOVA) was conducted to compare the effect of DN on shoulder pain (VAS) in local MTrP-DN, local MTrP-DN along with PSDN and CPT conditions. There was a significant effect of DN on shoulder pain at the $p \leq 0.05$ level for the three conditions (Figure 4.14) [F (2,207) = 92.63, $p \leq 0.05$], Post hoc comparisons using the Fisher's least significant difference (LSD) test indicated that the mean score for the local MTrP-DN condition and local MTrP-DN along with PSDN condition was significantly different than the CPT condition. However, the local MTrP-DN condition did not significantly differ from the local MTrP-DN along with PSDN condition.

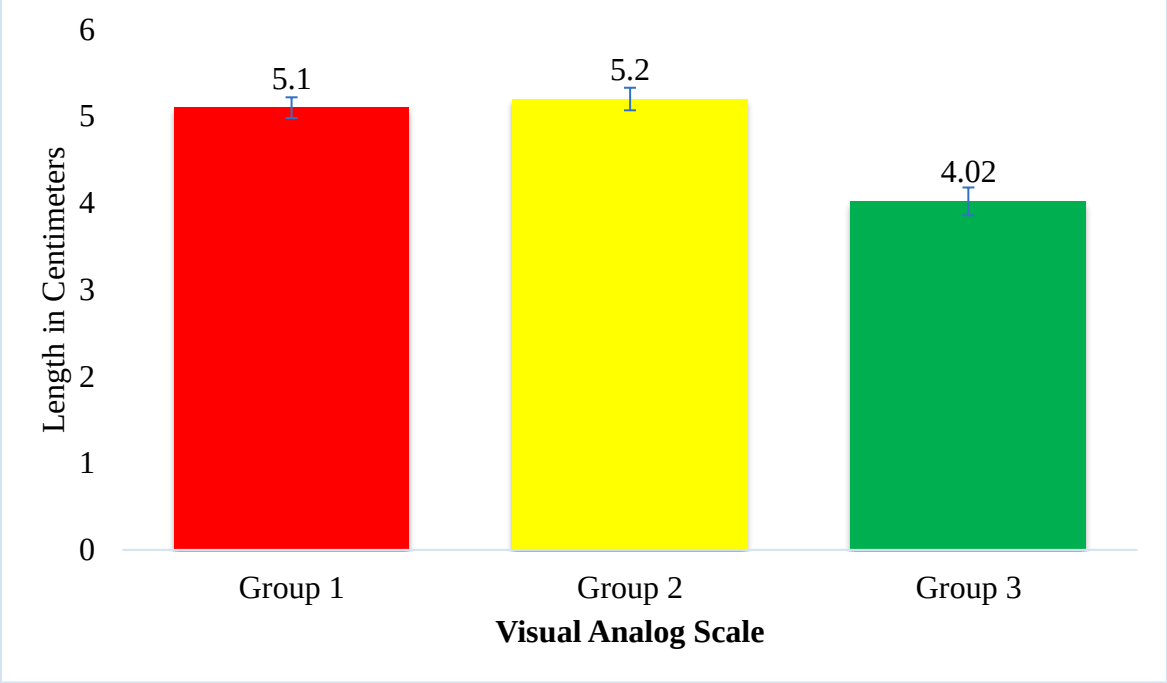

Figure 4.14 Visual Analog Scale mean difference scores in three different groups.

4.2.5.3 Shoulder Disability

Table 4.12 shows that analysis of covariance (ANCOVA) was conducted to compare the effect of DN on shoulder pain and disability index (SPADI) in local MTrP-DN, local MTrP-DN, along with PSDN and CPT conditions. There was a significant effect of DN on shoulder pain and disability index (SPADI) at the $p \leq 0.05$ level for the three conditions (Figure 4.15) [F (2, 207) = 139.5, $p \leq 0.05$], Post hoc comparisons using the Fisher's least significant difference (LSD) test indicated that the mean score for the local MTrP-DN condition and local MTrP-DN along with PSDN condition was significantly different than the CPT condition. However, the local MTrP-DN condition did not significantly differ from the local MTrP-DN along with PSDN condition.

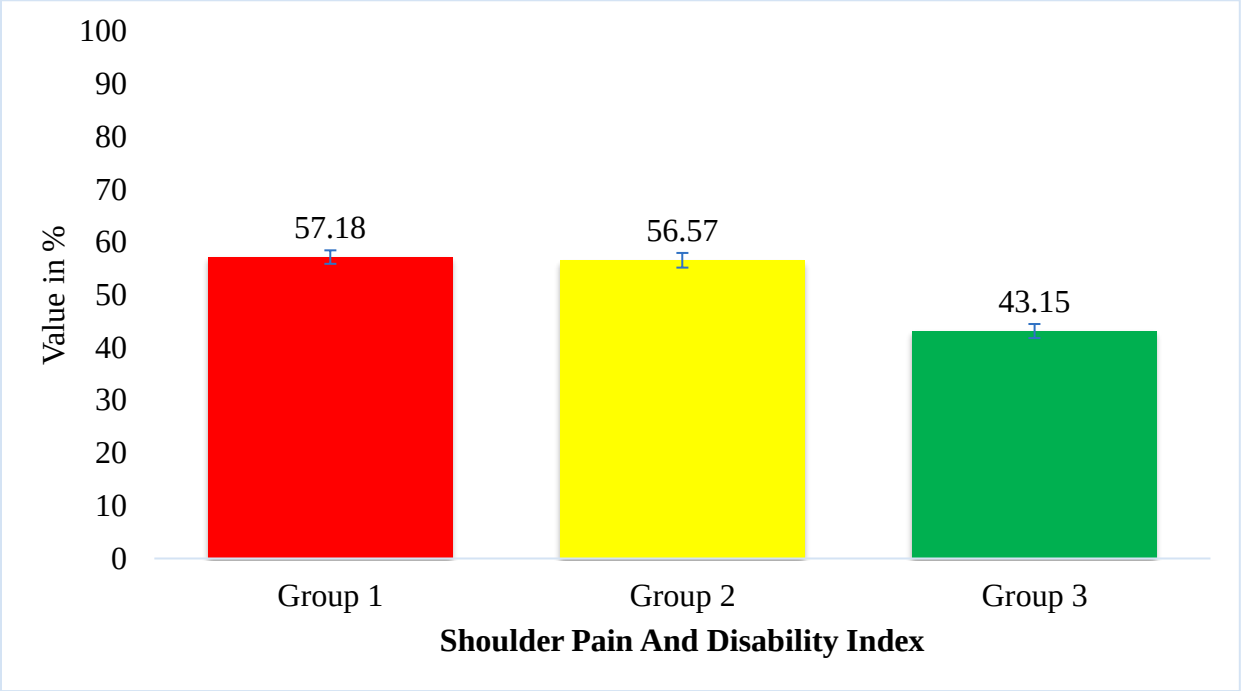

Figure 4.15 Shoulder Pain and Disability mean difference scores in three different groups.

4.2.5.4 Pressure Pain Threshold

Table 4.12 shows that Welch's ANOVA was conducted to compare the effect of DN on PPT in local MTrP-DN, local MTrP-DN, along with PSDN and CPT conditions. There was a significant effect of DN on PPT at the $p \leq 0.05$level for the three conditions (Figure 4.16) in supraspinatus muscle [F (2, 52.5) = 38.20, $p \leq 0.05$]. A similar trend was visible in infraspinatus muscle, teres minor muscle, subscapularis muscle, deltoid muscle, pectoralis major muscle, teres major and upper trapezius muscle. The post hoc comparisons showed that for all the tested muscles for PPT, the mean score for the local MTrP-DN and local MTrP-DN along with PSDN were significantly different from the CPT. However, the local MTrP-DN condition did not significantly differ from the local MTrP-DN along with the MTrP-DN condition.

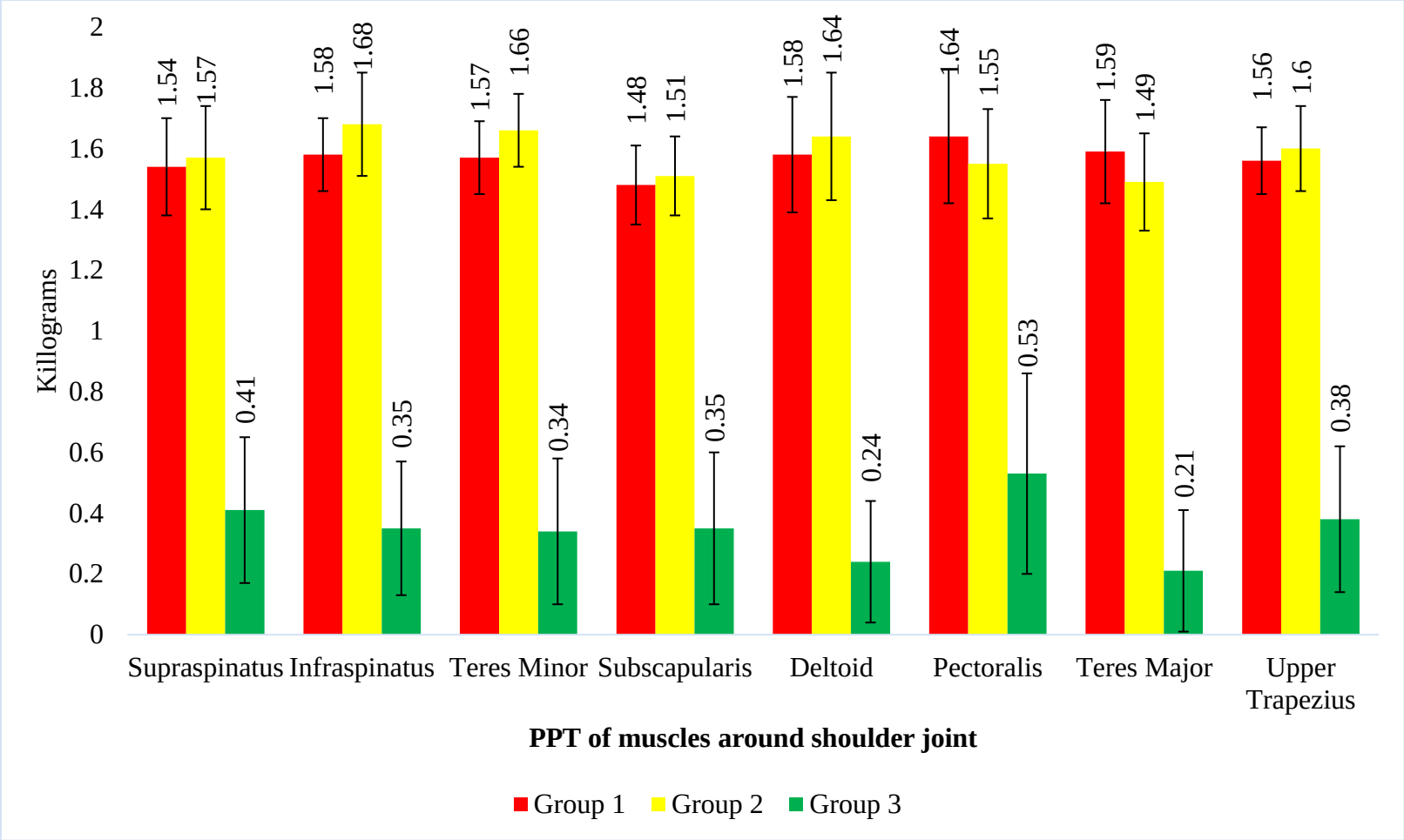

Figure 4.16 Pressure Pain Threshold scores in three different groups.

Table 4. 11 Analysis of Covariance (ANCOVA) shows the changes in the shoulder specific outcome measures over twelve days of dry needling-based intervention and post hoc analysis.

OM	Motions/tools	Group 1-2				Group 2-3			Group 1-3		
		F	MD	95% CI		MD	95% CI		MD	95% CI	
Range of motion	Flexion	3.93*	0.0	-3.3	3.3	4.14*	0.78	7.50	4.14*	0.78	7.50
	Extension	10.5*	-1.42	-3.5	0.64	4.71*	2.64	6.78	3.28*	1.21	5.35
	Abduction	1.378	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Medial Rotation	5.81*	1.0	-1.40	3.40	3.0*	0.59	5.40	4.0*	1.59	6.40
	Lateral Rotation	4.04*	0.42	-1.70	2.56	2.42*	0.29	4.56	2.85*	0.72	4.99
Pain	Visual Analog Scale	92.63*	-0.12	-0.31	0.07	1.23*	1.03	1.43	1.11*	0.91	1.31

Note. OM - Outcome measures, CI - Confidence interval, MD - Mean Difference, Group 1-2 - between local MTrP-DN group and Local MTrP-DN along with PSDN group, Group 2-3 - Between Local MTrP-DN along with PSDN group and CPT group, Group 1-3 – Local MTrP-DN group and CPT group, * - $p < 0.05$, NA- not applicable due to non-significant result.

Table 4. 12 Analysis of Covariance (ANCOVA) and Welch's ANOVA shows the changes in the shoulder specific outcome measures over twelve days of dry needling-based intervention and post hoc analysis.

OM	Tools	Group 1-2				Group 2-3			Group 1-3		
		F	MD	95% CI		MD	95% CI		MD	95% CI	
Disability	SPADI	139.5*	0.61	-1.25	2.48	13.4*	11.54	15.28	14.0*	12.15	15.89
Pressure pain threshold	Supraspinatus	38.20*	-0.03	-0.32	0.24	1.17*	0.82	1.52	1.13*	0.79	1.48
	Infraspinatus	439.5*	-0.10	-0.36	0.15	1.59*	1.37	1.80	1.48*	1.33	1.64
	Teres minor	594.7*	-0.07	-0.28	0.13	1.56*	1.39	1.73	1.48*	1.34	1.63
	Subscapularis	434.7*	-0.02	-0.25	0.19	1.39*	1.23	1.56	1.36*	1.20	1.53
	Deltoid	246.0*	-0.05	-0.39	0.28	1.56*	1.29	1.83	1.50*	1.26	1.74
	Pectoralis major	231.1*	0.09	-0.23	0.43	1.44*	1.21	1.67	1.54*	1.27	1.81
	Teres major	353.9*	0.10	-0.16	0.37	1.41*	1.22	1.61	1.51*	1.30	1.73
	Upper Trapezius	45.94*	-0.03	-0.24	0.18	1.22*	0.89	1.54	1.18*	0.87	1.50

Note. OM - Outcome measures, CI - Confidence interval, MD - Mean Difference, Group 1-2 - between local MTrP-DN group and Local MTrP-DN along with PSDN group, Group 2-3 - Between Local MTrP-DN along with PSDN group and CPT group, Group 1-3 – Local MTrP-DN group and CPT group, * - $p < 0.05$.

CHAPTER - V

DISCUSSION

This chapter is dedicated to discussing what our findings might mean, how valuable they are and why.

5.1 DISCUSSION

In this present study, we aimed to assess the efficacy of MTrP-DN & PSDN in subjects with AC and hypothesized that the MTrP-DN therapy for MTrPs may improve pain, ROM, disability, and PPT in subjects with AC. This study provided substantial evidence supporting the clinical applications of MTrP-DN in subjects with AC (Clewley et al., 2014; Sukumar & Lawrence, 2014) that pain is caused by MTrPs of glenohumeral girdle muscles, which could restrict ROM and contribute to the disability associated with AC. Although AC impacts the glenohumeral joint capsule, myofascial dysfunction can exacerbate discomfort, mobility restriction, and impairment in already inflamed shoulder capsules. Furthermore, these developed MTrPs may be partly responsible for the pain and reduced ROM, especially in the later phases of AC. Even after frequent physiotherapy management, subjects with AC have chronic pain, shoulder stiffness, and disability (Hand et al., 2008; Koh, 2016). Over 15 percent of AC subjects experienced irreversible functional impairment and symptoms (Koh, 2016). The addition of MTrP-DN to conventional rehabilitation may improve the clinical outcomes in subjects with AC.

While AC is a chronic inflammatory painful condition, the shoulder pain intensity was improved significantly in both Group 1 and Group 2 when compared with Group 3, even the effect size also shows that the DN was more effective in the reduction of shoulder pain intensity in both group 1 (Cohen's d -12.2) and group 2 (Cohen's d - 12.68) in comparison with CPT in group 3 (Cohen's d - 8.28) (Table 4.5, 4.7, 4.9). In addition, Tashjian et al (2009) found the Minimal detectable change (MDC) for VAS was 1.4 cm

(Tashjian et al., 2009) and the present study also reported the improvement in shoulder VAS greater than the MDC values that shows that the change were happened due to the beneficial effect of DN, but not due to intertrial variability or measurement error. The MTrP in the shoulder girdle muscles may be the source of pain. Biochemically, the release of acetylcholine due to abnormal sympathetic activity and local hypo-perfusion in the MTrPs results in hypoxia that causes a decrease in pH level releases bradykinin, potassium, substance P, and cytokines, which stimulate the free nerve ending in the muscle and causes pain (Gallego-Sendarrubias et al., 2020). Treating MTrPs using a dry needle induces micro-trauma and bleeding. Literature reported that the DN induced hyperemia, which could dilute the pain sensitizing substances and relieves the pain. In addition, Fernández et al. (2019) (Fernández-de-las-peñas et al., 2019) reported DN also releases endogenous opioids such as β-endorphin, which inhibit the release of the substance P. Despite there was no literature on the effectiveness of MTrP-DN on the AC population, there seems to be emerging evidence to demonstrate the clinical efficacy of MTrPs-DN in the treatment of myofascial pain syndrome (Fernández-de-las-peñas et al., 2019). Calvo-Lobo et al. (2017) reported a single DN session significantly reduced both local and distal pain in elderly adults with non-specific glenohumeral joint pain (Calvo-Lobo et al., 2017). Similarly, Passigli et al. (2016) observed immediate clinically significant pain relief after MTrPs-DN of the "infraspinatus", "teres minor", and "posterior deltoid" muscles in subjects with posterior glenohumeral joint stiffness (Passigli et al., 2016). Also, the results of the Calvo-Lobo et al. (2017) and Passigli et al. (2016) studies suggest an effect of local MTrPs-DN on shoulder pain, which is consistent with the results from this present study (Calvo-Lobo et al., 2017; Passigli et al., 2016).

On the other hand, Group 1 (Cohen's d -12.2) and Group 2 (Cohen's d - 12.68) were not having any significant differences between each other. That shows PSDN is not having any additional effect in reducing pain related to AC. Literature reported only one study done by Hyuk et al. (2007) to evaluate the effect of MTrP-DN with PSDN in myofascial pain syndrome in elderly subjects (Hyuk et al., 2007). They treated the subjects with local DN at upper trapezius muscle along with PSDN in multifidus muscles at C3-C5

levels of vertebrae, and they found a significant reduction in pain, which was not consistent with the present study because Hyuk et al. (2007) evaluated the upper trapezius muscle only, which is attached to spinal vertebrae, might be that is the reason of reduction in pain with PSDN in the upper trapezius muscle (Hyuk et al., 2007). Instead, the present study assessed the efficacy of PSDN on shoulder muscles, and all these muscles are not related to the vertebral column, might be that's why PSDN had not induced an additive effect in the reduction of pain around the shoulder muscles along with local MTrPs-DN.

In this study, the shoulder ROMs except shoulder abduction showed significant improvement in both Group 1 & Group 2 compared with Group 3 and Cohen's d also shows that MTrP-DN alone, MTrP-DN along with PSDN and CPT had large effect size to improve the shoulder ROMs (Table 4.5, 4.7, 4.9). In addition, Kolber et al (2011) found the Minimal detectable change (MDC) for shoulder flexion (8°), Abduction (4°), internal rotation (8°), and external rotation (9°) (Kolber et al., 2011) and the present study also gained ROM for all the shoulder ROMs greater than the MDC values that shows that the change were happened due to the beneficial effect of DN, but not due to intertrial variability or measurement error. It was postulated that the MTrPs, localized painful, hyperirritable sustained muscle fascicular contractions, could restrict the shoulder ROM (Page & Labbe, 2010). Treating the MTrPs in the shoulder girdle muscles with the dry needle could induce the twitch response and release the fascicular muscle contraction, thus improving the shoulder function. Literature only reported a few previous studies; those evaluated the effect of DN in subjects with AC. Sukumar and Lawrence (2014) did a single-blinded RCT to check the result of intramuscular manual therapy on improving shoulder abduction in AC. They were also given six treatment sessions of DN in two weeks, same as the present study, and their study results also supported the results of the present study as shoulder abduction ROM significantly improved after six treatment sessions compared to baseline (Sukumar & Lawrence, 2014). Clewley et al. (2014) studied the effect of DN on shoulder ROMs in a 54-year-old lady with AC in the second stage. They found that DN to the "upper trapezius", "levator scapula", "deltoid", and "infraspinatus" muscles resulted in fast improvement (Clewley et al., 2014). Hsieh et al. (2007) assessed the effect of DN on

shoulder internal rotation ROM and found significant improvement (Hsieh et al., 2007). The findings of Clewley et al. (2014) and Hsieh et al. (2007) studies imply that DN affects shoulder ROMs, which is consistent with the results of this current research project. However, DN of MTrPs of shoulder muscles did not show a significant improvement in the abduction ROM. This may be due to the pathological characteristic of the chronic inflammation and subsequent fibrosis of gleno-humeral joint capsule AC resulting in the typical abduction ROM restriction. On the other hand, Group 1 and Group 2 were not having any significant difference between each other. That shows PSDN is not having any additional effect in improving shoulder ROMs because PSDN was not able to reduce shoulder pain; that is why it had not induced any beneficial effect of shoulder ROMs.

The PPT shows significant improvement in both Group 1 and Group 2 as compared with Group 3, and the Cohen's d also shows the large effect size of local DN alone and local DN along with paraspinal DN to improve the PPT (Table 4.6, 4.8). The successful effect of the dry needle on PPT may be attributed to the mechanical pressure caused by the needle combined with its rotation polarizes the continuative tissue, which has an implicit piezoelectricity character. This mechanical pressure is converted into electrical energy, which enhances tissue reconstruction. When the needle is inserted, an axonal reflex strikes the terminal network of A-delta and C fibers, which are related to the liberation of many substances with vasoactive action (Cagnie et al., 2013; Dommerholt et al., 2006). They cause vasodilatation and inflation of local blood flow, which leads to decreasing the number of algogenic substances and decreasing the activity of nociceptors, resulting in resolution of peripheral sensitization (Sorour et al., 2020). The clinical studies reported that treating an MTrPs with DN would improve the PPT (Tesch et al., 2019) in upper trapezius (Ziaeifar et al., 2014) and Levator Scapulae (Garcia-de-Miguel et al., 2020) muscles. Tsai et al. (2010) also reported that PPT increased following DN for upper trapezius muscle (Tsai et al., 2010). Fernández-Carnero et al. (2010) also reported an increase in PPT following DN for masseter muscle (Fernández-Carnero et al., 2010). Other researchers also reported increased PPT after DN in stroke (Mendigutia-Gómez et al., 2016); even a single treatment session of DN increased the PPT in subjects with stroke

(Salom-Moreno et al., 2014). Koppenhaver et al. (2015) said that PPT increased in multifidus muscle in subjects with low back pain after one week of DN, but not immediately (Koppenhaver et al., 2015). Ceballos-Laita et al. (2020) reported that three sessions of DN were more effective for improving PPT than sham DN (Ceballos-Laita et al., 2020). Another study also said that DN with manual therapy was more effective in enhancing PPT than sham DN and manual therapy (Gallego-Sendarrubias et al., 2020). Wang-Price et al. (2020) said that deep DN with needle manipulation induced more improvement in PPT than DN without needle manipulation (Wang-Price et al., 2020).

Similarly, subjects demonstrated a significant reduction in shoulder disability in both Group 1 and Group 2 compared with Group 3 and the Cohen's d also shows the large effect size of local DN alone and local DN along with paraspinal DN to improve the shoulder disability (Table 4.6, 4.8). In addition, Angst et al (2007), Schmitt et al (2004) found the Minimal detectable change (MDC) for SPADI was 18 points (Angst et al., 2007; Schmitt., 2004) and the present study also reported the improvement in shoulder disability greater than the MDC values that shows that the change were happened due to the beneficial effect of DN, but not due to intertrial variability or measurement error. Neutralizing the MTrPs, the source of pain, and joint restriction improved disability following DN. Literature supports our findings that DN, along with exercise, found to be beneficial in reducing impairment and quality of life in subjects with shoulder myofascial pain (Griswold et al., 2019), chronic rotator cuff tendinopathy (Saylor-Pavkovich, 2016), and subacromial pain syndrome (Koppenhaver et al., 2016; Morgan et al., 2019). Clewley et al. (2014) did a case report to evaluate the effect of DN in subjects with AC, and they found that SPADI shows significant improvement following DN therapy (Clewley et al., 2014). Shariat et al. (2018) reported that one session of DN can reduce the disability in a golfer's elbow (Shariat et al., 2018). Liu et al. (2018) said that DN in combination with other therapies effectively reduced disability in low back pain, but its clinical superiority was not clear (Liu et al., 2018). Deep DN was more effective than superficial DN in reducing disability (Griswold et al., 2019).

Finally, the study results indicate that there was no substantial difference between the MTrP-DN and PSDN groups in shoulder pain severity, ROM, PPT, and disability. It implies that introducing the PSDN along with MTrP-DN does not have any clinical implications that fail to reflect on the outcome's measures in subjects with AC of the shoulder joint. Few studies claim that subjects treated with PSDN demonstrated substantial improvement in pain and joint function in acute facet joint dysfunction of the neck (Shanmugam & Mathias, 2017), myofascial pain syndrome of upper trapezius (Hyuk et al., 2007), and non-specific thoracic pain syndrome (Anandkumar & Manivasagam, 2017). It is noteworthy that in those conditions, the source of pain or restriction has a direct anatomical attachment with the spine; hence PSDN produced a substantial improvement. Besides, the other possible reason for the improvement in the joint function may be due to paraspinal muscle spasms itself being a source of pain and joint restriction in facet joint dysfunction and myofascial pain syndrome.

5.1.1 Limitations

(a) Present study evaluates only the short-term efficacy of DN in subjects with AC, and there was a lack of follow-up assessments for the long-term effect of DN. (b) Reeves (1975) described three sequential stages of AC (Reeves, 1975), but the present study included only subjects with the second stage of AC. (c) The present study is not registered in any clinical trial registry. (d) Blood glucose level was not assessed during pre-assessment and post-assessment. (e) The study was limited to a small geographical area.

5.1.2 Clinical Implication

From the previous decades, clinicians were treating AC subjects with CPT but now, as we know, MTrPs develop in muscles around the shoulder joint, leading to shoulder pain that ultimately leads to restricted ROMs and disability. The present study shows that local MTrP-DN along with CPT induced greater improvement in shoulder pain, ROMs, and disability. Clinicians can use local MTrP-DN along with CPT, which includes electrotherapy, joint mobilization, exercises to effectively treat subjects with AC in early stages.

5.2 RECOMMENDATIONS

(a) AC is a progressively developing condition of the shoulder capsule; future research should investigate the sustained “long-term” effect of MTrP-DN on pain severity, ROMs, and related disability in subjects with AC. (b) Future studies should evaluate the effect of DN in all three stages of AC.

CHAPTER - VI

CONCLUSION

The primary concern of this thesis is to examine the effectiveness of MTrP-DN with and without PSDN in improving shoulder pain, ROM, PPT, and physical disability among subjects with AC. Conventionally, chronic inflammation and tightness of joint capsules are considered the hallmark of AC; however, emerging evidence supports impaired myofascial kinetics, shoulder girdle muscle tightness, and MTrPs around the shoulder joint, and paraspinal muscle spasm may further restrict shoulder ROM. Therefore, it was proposed that MTrP-DN can resolve the MTrPS effectively around the shoulder muscles, and PSDN can also give additive benefits that lead to a improvement in shoulder pain, ROMs, disability, and PPT.

Within group comparison shows significant improvement in all the outcome measure such as pain intensity, PPT, ROMs and disability in all the three groups.

Between the group comparison shows that both local MTrP-DN (Group 1) and local MTrP-DN along with PSDN (Group 2) did not demonstrate differences in the clinical outcomes such as pain intensity, ROMs, PPT, and disability. Treating paraspinal muscles with PSDN does not have any additional effect in reducing pain related to AC.

When compared to the CPT (Group 3), both Group 1 and Group 2 demonstrated significant improvements in shoulder Pain, PPT, disability and ROM (except for shoulder abduction ROM). The shoulder abduction was not significantly improved by MTrPs-DN with and without PSDN. This could be attributed to the clinical feature of persistent inflammation and subsequent fibrosis of the glenohumeral joint capsule in AC, which leads to restriction in shoulder abduction. On the other hand, there were no significant differences between Group 1 and Group 2. This demonstrates that PSDN had no further benefit in improving shoulder pain, PPT, disability and ROMs.

Finally, the study findings confirm that there was no significant difference in shoulder pain severity, ROM, PPT, or impairment between the MTrP-DN and PSDN groups so that null hypothesis was accepted. Therefore, combining the PSDN with the MTrP-DN has no clinical significance that is not reflected in the outcomes of people with AC of the shoulder joint.

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APPENDIX – I

INFORMATION SHEET FOR PATIENTS - ENGLISH

This Informed Consent Form is for men and women whom we are inviting to participate in research on Adhesive Capsulitis. The title of our research project is "Efficacy of Trigger Point Dry Needling with and without Paraspinal Needling in patients with Adhesive Capsulitis. A Randomized Clinical Trial."

Introduction

I am Varun Kalia, a Student of the Physiotherapy department at Lovely Professional University. I am researching Adhesive Capsulitis, which is very common in this country. I am going to give you information and invite you to be a part of this research. You do not have to decide today whether or not you will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research. There may be some words that you do not understand. Please ask me to stop as we go through the information, and I will take time to explain. If you have questions later, you can ask them about me.

Purpose of the Research

As we all know, Adhesive Capsulitis is a prevalent problem, and physiotherapists are giving a conventional treatment for the problem. Some of the physiotherapists treat the patients by giving Therapeutic Ultrasound, Shoulder Joint Mobilization, Stretching Exercises, TENS, etc., but these conventional treatments give some relief to the patients, but they take a long time. Some of the researchers say 100 % recovery of Adhesive Capsulitis is not possible with conventional treatment. So, there is a strong need to find out some treatment modality that will give maximum relief in the short duration of the treatment period. Some of the researchers suggest that Myofascial Trigger Point formation is very prone in case of Adhesive Capsulitis, and this leads to severe pain and range of

motion restriction. So we are going to check the efficacy of Trigger Point Dry Needling with and without Paraspinal Needling in patients with Adhesive Capsulitis.

Type of Research Intervention

This research is a randomized clinical trial with six intervention sessions (alternative days). This research will involve a complete assessment taken and then followed by an allotment of the treatment group. Then we will take pre-test readings by using the Visual Analog Scale, Shoulder Pain and Disability Index (SPADI), Universal Goniometer, Pressure Algometer. After that, we will give treatment according to the allotted group for six treatment sessions and then will take post-test readings.

Participant selection

I am inviting patients who are having medically diagnosed Adhesive Capsulitis to participate in my research. Then I will select the subjects for my research work based on assessment.

Voluntary Participation

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. If you choose not to participate in this research project, you will offer the treatment that is generally offered for your disease, and we will tell you more about it later. You may change your opinion later and stop participating even if you agreed earlier.

Procedures and Protocol

This research will involve a complete assessment taken and then followed by an allotment of the treatment group. Then we will take pre-test readings by using the Visual Analog Scale, Shoulder Pain and Disability Index (SPADI), Universal Goniometer, Pressure Algometer. After that, we will give treatment according to the allotted group for six treatment sessions and then will take post-test readings.

Duration

This research is a randomized clinical trial with six intervention days (alternative days).

Side Effects

The whole research procedure is not having any side effects.

Risk

Participants do not have any risk. I will take care of and everything.

Benefits

You will come to know about your health status, the status of your vital sign at the time of research procedure, and treatment for your Adhesive Capsulitis problem.

Reimbursements

I will not give you any money or gift to take part in this research. You are voluntarily taking part in this research.

Confidentiality

The information collected from this research project will be kept confidential. Information about you that will be collected during the research will be put away from all those who are not having any concern with this research.

Sharing the Results

The knowledge gained from doing this research will be shared with you through community meetings before it is made widely available to the public. Confidential information will not be shared.

Right to Refuse or Withdraw

You do not have to take part in this research if you do not wish to do so. You may also stop participating in the research at any time you choose. It is your choice, and all of your rights will still be respected.

Whom to Contact

If you have any questions, you may ask me now or later, even after the study has been started. If you wish to ask questions later, you may contact me any time. Myself:

Varun Kalia, Ph.D. Scholar, Physiotherapy Department, Lovely Professional University.

Mobile Number: 083603-74990

E-mail: varunkalia935@gmail.com

APPENDIX – II

INFORMATION SHEET FOR PATIENTS - PUNJABI

ਸੂਚਿਤ ਸਹਿਮਤੀ ਫਾਰਮ

ਇਹ ਸੂਚਿਤ ਸਹਿਮਤੀ ਫਾਰਮ ਉਹਨਾਂ ਆਦਮੀਆਂ ਅਤੇ ਔਰਤਾਂ ਲਈ ਹੈ ਜਿਨ੍ਹਾਂ ਨੂੰ ਅਸੀਂ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ 'ਤੇ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਬੁਲਾ ਰਹੇ ਹਾਂ। ਸਾਡੇ ਖੋਜ ਪ੍ਰੋਜੈਕਟ ਦਾ ਸਿਰਲੇਖ ਹੈ "ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਚ ਟਰਿੱਗਰ ਪੁਆਇੰਟ ਡ੍ਰਾਈ ਨੀਡਲਿੰਗ ਦੀ ਪ੍ਰਭਾਵਕਤਾ ਪੈਰਾਸ੍ਪਾਇਨਲ ਡ੍ਰਾਈ ਨੀਡਲਿੰਗ ਦੇ ਨਾਲ ਅਤੇ ਇਸ ਤੋਂ ਬਿਨਾ" ਰੇਂਡਾਮਾਈਜਡ ਕਲੀਨਿਕਲ ਟ੍ਰਾਇਲ ।

ਜਾਣਕਾਰੀ ਸ਼ੀਟ

ਜਾਣ ਪਛਾਣ

ਮੈ ਲਵਲੀ ਪ੍ਰੋਫੇਸ਼ਨਲ ਯੂਨੀਵਰਸਿਟੀ ਵਿਚ ਫਿਜ਼ੀਓਥਰੈਪੀ ਵਿਭਾਗ ਦਾ ਵਿਦਿਆਰਥੀ ਵਰੁਣ ਕਾਲੀਆ ਹਾਂ । ਮੈਂ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਤੇ ਖੋਜ ਕਰ ਰਿਹਾ ਹਾਂ, ਜੋ ਕਿ ਇਸ ਦੇਸ਼ ਵਿੱਚ ਬਹੁਤ ਆਮ ਸਮੱਸਿਆ ਹੈ । ਮੈਂ ਤੁਹਾਨੂੰ ਜਾਣਕਾਰੀ ਦੇਣ ਜਾ ਰਿਹਾ ਹਾਂ ਅਤੇ ਤੁਹਾਨੂੰ ਇਸ ਖੋਜ ਦਾ ਹਿੱਸਾ ਬਣਨ ਲਈ ਸੱਦਾ ਦਿੰਦਾ ਹਾਂ । ਤੁਹਾਨੂੰ ਅੱਜ ਹੀ ਇਹ ਫੈਸਲਾ ਨਹੀਂ ਕਰਨਾ ਕਿ ਤੁਸੀਂ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲਓਗੇ ਜਾਂ ਨਹੀਂ । ਇਸ ਤੋਂ ਪਹਿਲਾਂ ਕਿ ਤੁਸੀਂ ਇਹ ਫੈਸਲਾ ਕਰੋ, ਤੁਸੀਂ ਕਿਸੇ ਵੀ ਵਿਅਕਤੀ ਨਾਲ ਗੱਲ ਕਰ ਸਕਦੇ ਹੋ ਜਿਸ ਨਾਲ ਤੁਸੀਂ ਸਹਿਜ ਮਹਿਸੂਸ ਕਰਦੇ ਹੋ । ਕੁਝ ਸ਼ਬਦ ਹੋ ਸਕਦੇ ਹਨ ਜੋ ਤੁਹਾਨੂੰ ਸਮਝ ਨਾ ਆਉਣ । ਕਿਰਪਾ ਕਰਕੇ ਮੈਨੂੰ ਰੁਕਣ ਲਈ ਕਹੋ ਅਤੇ ਮੈਂ ਤੁਹਾਨੂੰ ਸਭ ਕੁਝ ਸਮਝਾਉਗਾ । ਜੇ ਬਾਅਦ ਵਿੱਚ ਵੀ ਤੁਹਾਡੇ ਕੋਲ ਸਵਾਲ ਹੋਣ, ਤਾਂ ਤੁਸੀਂ ਮੈਨੂੰ ਪੁੱਛ ਸਕਦੇ ਹੋ ।

ਖੋਜ ਦਾ ਉਦੇਸ਼

ਜਿਵੇਂ ਕਿ ਅਸੀਂ ਸਾਰੇ ਜਾਣਦੇ ਹਾਂ ਕਿ, ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਬਹੁਤ ਆਮ ਸਮੱਸਿਆ ਹੈ ਅਤੇ ਫਿਜ਼ੀਓਥੈਰਾਪਿਸਟ ਸਮੱਸਿਆ ਦੇ ਲਈ ਇੱਕ ਰਵਾਇਤੀ ਇਲਾਜ ਦੇ ਰਹੇ ਹਨ । ਫਿਜ਼ੀਓਥੈਰੇਪਿਸਟ ਦੁਆਰਾ ਥੇਰਾਪਯੂਟਿਕ ਅਲਟਰਾਸਾਉਂਡ, ਮੋਢੇ ਦੇ ਜੁਆਇੰਟ ਮੋਬਿਲਾਇਜੇਸ਼ਨ, ਮਾਸਪੇਸ਼ੀ ਖਿੱਚਣ ਦੀ ਕਸਰਤ, ਟ੍ਰਾਂਸ ਕੁਟਾਨੇਓਸ ਇਲੇਕ੍ਟ੍ਰਿਕਲ ਨਰਵ ਸਟੀਮੁਲੇਸ਼ਨ ਆਦਿ ਨਾਲ ਇਲਾਜ ਕੀਤਾ ਜਾ ਰਿਹਾ ਹੈ । ਇਹ ਪਰੰਪਰਾਗਤ ਇਲਾਜ ਮਰੀਜ਼ ਨੂੰ ਕੁਝ ਰਾਹਤ ਦਿੰਦੇ ਹਨ ਪਰ ਇਸ ਨੂੰ ਬਹੁਤ ਸਮਾਂ ਲੱਗ ਜਾਂਦਾ ਹੈ । ਕੁੱਝ ਖੋਜਕਰਤਾਵਾਂ ਦਾ

ਕਹਿਣਾ ਹੈ ਕਿ ਪਰੰਪਰਾਗਤ ਇਲਾਜ ਦੇ ਨਾਲ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਦੀ 100% ਰਿਕਵਰੀ ਸੰਭਵ ਨਹੀਂ ਹੈ । ਇਸ ਲਈ ਇਲਾਜ ਦੇ ਕੁਝ ਢੰਗ ਲੱਭਣ ਦੀ ਬਹੁਤ ਲੋੜ ਹੈ ਜੋ ਇਲਾਜ ਦੀ ਮਿਆਦ ਦੇ ਥੋੜੇ ਸਮੇਂ ਵਿੱਚ ਵੱਧ ਤੋਂ ਵੱਧ ਰਾਹਤ ਦੇਵੇ । ਕੁਝ ਖੋਜਕਰਤਾਵਾਂ ਦਾ ਸੁਝਾਅ ਹੈ ਕਿ ਮਾਈਫਾਸਿਅਲ ਟਰਿਗਰ ਪੁਆਇੰਟ ਦਾ ਗਠਨ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਦੇ ਮਾਮਲੇ ਵਿੱਚ ਬਹੁਤ ਜ਼ਿਆਦਾ ਹੁੰਦਾ ਹੈ ਇਸ ਨਾਲ ਜੋੜ ਦੀ ਗਤੀ ਬੰਦਸ਼ ਵਿਚ ਆਉਂਦੀ ਹੈ ਅਤੇ ਗੰਭੀਰ ਦਰਦ ਹੁੰਦਾ ਹੈ । ਇਸ ਲਈ ਅਸੀਂ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਦੇ ਮਰੀਜ ‘ਚ ਟ੍ਰਿਗਰ ਪੁਆਇੰਟ ਡ੍ਰਾਈ ਨੀਡਲਿੰਗ ਦੀ ਕਾਰਗੁਜ਼ਾਰੀ ਦਾ ਪਤਾ ਪੈਰਾਸ੍ਪਾਇਨਲ ਡ੍ਰਾਈ ਨੀਡਲਿੰਗ ਦੇ ਨਾਲ ਅਤੇ ਇਸ ਤੋਂ ਬਿਨਾ ਲਗਾਉਣ ਜਾ ਰਹੇ ਹਾਂ ।

ਖੋਜ ਦਖਲ ਦੀ ਕਿਸਮ

ਇਹ ਖੋਜ 6 ਦਖਲ ਸੈਸ਼ਨਾਂ (ਬਦਲਵੇਂ ਦਿਨ) ਨਾਲ ਇੱਕ ਰੇਂਡਾਮਾਈਜਡ ਕਲੀਨਿਕਲ ਟ੍ਰਾਇਲ ਹੈ । ਇਸ ਖੋਜ ਵਿਚ ਸਹਿਭਾਗੀ ਦਾ ਪੂਰਾ ਮੁਲਾਂਕਣ ਕੀਤਾ ਜਾਵੇਗਾ, ਜਿਸ ਤੋਂ ਬਾਅਦ ਇਲਾਜ ਗਰੁੱਪ ਅਲਾਟਮੈਂਟ ਹੋਵੇਗੀ । ਫਿਰ ਅਸੀਂ ਵਿਜ਼ੂਅਲ ਐਨਲਾਗ ਸਕੇਲ, ਮੋਢੇ ਦਾ ਦਰਦ ਅਤੇ ਅਪਾਹਜਤਾ ਸੂਚਕਾਂਕ (SPADI), ਯੂਨੀਵਰਸਲ ਗੋਨੀਓਮੀਟਰ, ਪ੍ਰੈਸ਼ਰ ਅਲਗੋਮੀਟਰ ਦੀ ਵਰਤੋਂ ਕਰਕੇ ਪ੍ਰੀ-ਟੈੱਸਟ ਰੀਡਿੰਗ ਲਵਾਂਗੇ । ਫਿਰ ਅਸੀਂ 6 ਇਲਾਜ ਸੈਸ਼ਨਾਂ ਲਈ ਅਲਾਟ ਕੀਤੇ ਗਰੁੱਪ ਅਨੁਸਾਰ ਇਲਾਜ ਦੇਵਾਂਗੇ ਅਤੇ ਫਿਰ ਪੋਸਟ-ਟੈੱਸਟ ਰੀਡਿੰਗ ਲਵਾਂਗੇ ।

ਭਾਗ ਲੈਣ ਵਾਲੇ ਦੀ ਚੋਣ

ਮੈਂ ਉਨ੍ਹਾਂ ਮਰੀਜ਼ਾਂ ਨੂੰ ਸੱਦਾ ਦੇ ਰਿਹਾ ਹਾਂ ਜਿਹੜੇ ਮੈਡੀਕਲ ਤੌਰ ਤੇ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਨਾਲ ਪਹਿਚਾਣੇ ਗਏ ਹਨ । ਫਿਰ ਮੈਂ ਮੁਲਾਂਕਣ ਦੇ ਆਧਾਰ ਤੇ ਖੋਜ ਕਾਰਜ ਲਈ ਭਾਗ ਲੈਣ ਵਾਲਿਆਂ ਦੀ ਚੋਣ ਕਰਾਂਗਾ ।

ਸਵੈਇੱਛਕ ਭਾਗੀਦਾਰੀ

ਇਸ ਖੋਜ ਵਿਚ ਤੁਹਾਡੀ ਸ਼ਮੂਲੀਅਤ ਪੂਰੀ ਤਰ੍ਹਾਂ ਸਵੈ-ਇੱਛਕ ਹੈ । ਇਹ ਤੁਹਾਡੀ ਪਸੰਦ ਹੈ ਕਿ ਤੁਸੀਂ ਹਿੱਸਾ ਲਵੋ ਜਾਂ ਨਾ । ਜੇ ਤੁਸੀਂ ਇਸ ਖੋਜ ਪ੍ਰੋਜੈਕਟ ਵਿਚ ਹਿੱਸਾ ਨਾ ਲੈਣ ਦਾ ਫੈਸਲਾ ਕਰਦੇ ਹੋ ਤਾਂ ਅਸੀਂ ਫਿਰ ਵੀ ਉਸ ਇਲਾਜ ਦੀ ਪੇਸ਼ਕਸ਼ ਕਰਾਂਗੇ ਜੋ ਤੁਹਾਡੀ ਬਿਮਾਰੀ ਲਈ ਨਿਯਮਤ ਤੌਰ ਤੇ ਦਿੱਤਾ ਜਾਂਦਾ ਹੈ । ਅਸੀਂ ਇਸ ਖੋਜ ਪ੍ਰੋਜੈਕਟ ਬਾਰੇ ਤੁਹਾਨੂੰ ਬਾਅਦ ਵਿਚ ਦੁਬਾਰਾ ਫਿਰ ਦੱਸਾਂਗੇ । ਤੁਸੀਂ ਬਾਅਦ ਵਿੱਚ ਵੀ ਆਪਣਾ ਮਨ ਬਦਲ ਸਕਦੇ ਹੋ ਅਤੇ ਹਿੱਸਾ ਲੈਣਾ ਬੰਦ ਕਰ ਸਕਦੇ ਹੋ ਭਾਵੇਂ ਤੁਸੀਂ ਪਹਿਲਾਂ ਸਹਿਮਤ ਹੋਏ ਹੋ ।

ਪ੍ਰਕਿਰਿਆਵਾਂ ਅਤੇ ਪ੍ਰੋਟੋਕੋਲ

ਇਸ ਖੋਜ ਵਿਚ ਪਹਿਲਾ ਪ੍ਰਤੀਭਾਗੀ ਦਾ ਮੁਲਾਂਕਣ ਕੀਤਾ ਜਾਵੇਗਾ, ਜਿਸ ਤੋਂ ਬਾਅਦ ਇਲਾਜ ਗਰੁੱਪ ਅਲਾਟਮੈਂਟ ਹੋਵੇਗੀ । ਫੇਰ ਅਸੀਂ ਵਿਜ਼ੂਅਲ ਐਨਲਾਗ ਸਕੇਲ, ਮੋਢੇ ਦਾ ਦਰਦ ਅਤੇ ਅਪਾਹਜਤਾ ਸੂਚਕਾਂਕ (SPADI), ਯੂਨੀਵਰਸਲ ਗੋਨੀਓਮੀਟਰ, ਪ੍ਰੈਸ਼ਰ ਅਲਗੋਮੀਟਰ ਦੀ ਵਰਤੋਂ ਕਰਕੇ ਪ੍ਰੀ-ਟੈੱਸਟ ਰੀਡਿੰਗ ਲਵਾਂਗੇ । ਫਿਰ ਅਸੀਂ 6 ਇਲਾਜ ਸੈਸ਼ਨਾਂ ਲਈ ਅਲਾਟ ਕੀਤੇ ਗਰੁੱਪ ਅਨੁਸਾਰ ਇਲਾਜ ਦੇਵਾਂਗੇ ਅਤੇ ਫਿਰ ਪੋਸਟ-ਟੈੱਸਟ ਰੀਡਿੰਗ ਲਵਾਂਗੇ ।

ਮਿਆਦ

ਇਹ ਖੋਜ 6 ਦਿਨਾਂ (ਬਦਲਵੇਂ ਦਿਨ) ਨਾਲ ਇੱਕ ਰੇਂਡਾਮਾਈਜਡ ਕਲੀਨਿਕਲ ਪਰੀਖਣ ਹੈ ।

ਬੁਰੇ ਪ੍ਰਭਾਵ

ਪੂਰੀ ਖੋਜ ਪ੍ਰਕਿਰਿਆ ਦਾ ਕੋਈ ਮਾੜਾ ਅਸਰ ਨਹੀਂ ਹੈ ।

ਖ਼ਤਰਾ

ਹਿੱਸਾ ਲੈਣ ਵਾਲਿਆਂ ਨੂੰ ਕੋਈ ਖਤਰਾ ਨਹੀਂ ਹੈ, ਮੈਂ ਹਰ ਇੱਕ ਵਿਅਕਤੀ ਅਤੇ ਉਸ ਪ੍ਰਤੀ ਹਰ ਚੀਜ਼ ਦਾ ਧਿਆਨ ਰੱਖਾਂਗਾ।

ਲਾਭ

ਤੁਹਾਨੂੰ ਆਪਣੇ ਸਿਹਤ ਦੇ ਰੁਤਬੇ, ਖੋਜ ਪ੍ਰਕਿਰਿਆ ਦੇ ਸਮੇਂ ਤੁਹਾਡੇ ਮਹੱਤਵਪੂਰਣ ਲੱਛਣਾਂ ਦੇ ਰੁਤਬੇ ਅਤੇ ਤੁਹਾਡੇ ਤੇ ਅਡਹੇਸੀਵ ਕੈਪਸੂਲੀਟਿਸ ਸਮੱਸਿਆ ਲਈ ਇਲਾਜ ਬਾਰੇ ਪਤਾ ਲੱਗ ਜਾਵੇਗਾ ।

ਅਦਾਇਗੀ

ਇਸ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈਂ ਤੁਹਾਨੂੰ ਕੋਈ ਪੈਸਾ ਜਾਂ ਤੋਹਫ਼ੇ ਨਹੀਂ ਦਿਆਂਗਾ. ਤੁਸੀਂ ਇਸ ਖੋਜ ਵਿਚ ਸਵੈ-ਇੱਛਾ ਨਾਲ ਹਿੱਸਾ ਲੈ ਰਹੇ ਹੋ ।

ਗੁਪਤਤਾ

ਅਸੀਂ ਇਸ ਖੋਜ ਪ੍ਰੋਜੈਕਟ ਤੋਂ ਜੋ ਵੀ ਜਾਣਕਾਰੀ ਇਕੱਠੀ ਕਰਾਂਗੇ ਉਸ ਨੂੰ ਗੁਪਤ ਰੱਖਾਂਗੇ। ਖੋਜ ਦੇ ਦੌਰਾਨ ਤੁਹਾਡੇ ਬਾਰੇ ਜੋ ਜਾਣਕਾਰੀ ਇਕੱਠੀ ਕੀਤੀ ਜਾਵੇਗੀ ਉਸ ਨੂੰ ਉਨ੍ਹਾਂ ਸਾਰੇ ਲੋਕਾਂ ਤੋਂ ਦੂਰ ਰੱਖਿਆ ਜਾਵੇਗਾ ਜਿਸ ਦਾ ਖੋਜ ਨਾਲ ਕੋਈ ਸਰੋਕਾਰ ਨਹੀਂ ਹੈ।

ਨਤੀਜੇ ਸਾਂਝੇ ਕਰਨ ਬਾਰੇ

ਜੋ ਨਤੀਜੇ ਅਸੀਂ ਇਹ ਖੋਜ ਕਰਨ ਤੇ ਪ੍ਰਾਪਤ ਕਰਾਂਗੇ, ਜਨਤਾ ਲਈ ਵਿਆਪਕ ਰੂਪ ਨਾਲ ਉਪਲੱਬਧ ਕਰਵਾਉਣ ਤੋਂ ਪਹਿਲਾਂ ਤੁਹਾਡੇ ਨਾਲ ਸਾਂਝਾ ਕੀਤੇ ਜਾਣਗੇ। ਗੁਪਤ ਜਾਣਕਾਰੀ ਸਾਂਝੀ ਨਹੀਂ ਕੀਤੀ ਜਾਵੇਗੀ।

ਇਨਕਾਰ ਕਰਨ ਜਾਂ ਫੈਂਸਲਾ ਵਾਪਸ ਲੈਣ ਦਾ ਅਧਿਕਾਰ

ਜੇ ਤੁਸੀਂ ਅਜਿਹਾ ਨਹੀਂ ਕਰਨਾ ਚਾਹੁੰਦੇ ਹੋ ਤਾਂ ਤੁਹਾਡਾ ਇਸ ਖੋਜ ਵਿੱਚ ਹਿੱਸਾ ਲੈਣਾ ਜਰੂਰੀ ਨਹੀਂ ਹੈ। ਤੁਸੀਂ ਕਿਸੇ ਵੀ ਸਮੇਂ ਖੋਜ ਵਿੱਚ ਹਿੱਸਾ ਲੈਣ ਤੋਂ ਮਨਾ ਕਰ ਸਕਦੇ ਹੋ। ਇਹ ਤੁਹਾਡੀ ਪਸੰਦ ਹੈ ਅਤੇ ਤੁਹਾਡੇ ਸਾਰੇ ਅਧਿਕਾਰਾਂ ਦਾ ਹਾਲੇ ਵੀ ਸਤਿਕਾਰ ਕੀਤਾ ਜਾਵੇਗਾ।

ਕਿਸ ਨਾਲ ਸੰਪਰਕ ਕਰਨਾ

ਜੇ ਤੁਹਾਡੇ ਕੋਈ ਸਵਾਲ ਹਨ ਤਾਂ ਤੁਸੀਂ ਹੁਣ ਜਾਂ ਬਾਅਦ ਵਿਚ ਮੈਨੂੰ ਪੁੱਛ ਸਕਦੇ ਹੋ, ਭਾਵੇਂ ਅਧਿਐਨ ਸ਼ੁਰੂ ਹੋਣ ਤੋਂ ਬਾਅਦ ਵੀ ਪੁੱਛ ਸਕਦੇ ਹੋ। ਜੇਕਰ ਤੁਸੀਂ ਬਾਅਦ ਵਿੱਚ ਪ੍ਰਸ਼ਨ ਪੁੱਛਣੇ ਚਾਹੁੰਦੇ ਹੋ ਤਾਂ ਤੁਸੀਂ ਕਿਸੇ ਵੀ ਸਮੇਂ ਮੇਰੇ ਨਾਲ ਸੰਪਰਕ ਕਰ ਸਕਦੇ ਹੋ।

ਵਰੁਣ ਕਾਲੀਆ, ਪੀਐਚਡੀ ਸਕਾਲਰ, ਫਿਜ਼ੀਓਥਰੈਪੀ ਵਿਭਾਗ, ਲਵਲੀ ਪ੍ਰੋਫੈਸ਼ਨਲ ਯੂਨੀਵਰਸਿਟੀ।
ਮੋਬਾਈਲ ਨੰਬਰ: 083603-74990
ਈ – ਮੇਲ: varunkalia935@gmail.com

APPENDIX – III

INFORMATION SHEET FOR PATIENTS - HINDI

सूचित सहमति पत्र

यह सूचित सहमति फॉर्म पुरुषों और महिलाओं के लिए है जिन को हम जमा हुआ कन्धा (Adhesive capsulitis) अनुसंधान में भाग लेने के लिए आमंत्रित कर रहे हैं । हमारे शोध परियोजना का शीर्षक है "जमे हुए कन्धे (Adhesive Capsulitis) में ड्राई नीडलिंग ट्रिगर प्वाइंट की प्रभावकारिता पेरास्पाइनल ड्राई नीडलिंग के साथ और इस के बिना" एक रेंडोमाइजड क्लिनिकल ट्रायल ।

सूचना पत्र

परिचय

मैं लवली प्रोफेशनल विश्वविद्यालय के फिजियोथेरेपी डिपार्टमेंट का छात्र वरुण कालिया हूँ । मैं विषय "जमा हुआ कन्धा" "(Adhesive Capsulitis)" पर शोध कर रहा हूँ, जो इस देश में बहुत आम बिमारी है। मैं आपको जानकारी देने जा रहा हूँ और इस शोध का हिस्सा बनने के लिए आमंत्रित कर रहा हूँ । आपको आज ही फैसला नहीं करना है कि क्या आप अनुसंधान में भाग लेंगे या नहीं। इससे पहले कि आप तय करें, आप अनुसंधान के बारे में किसी से भी बात कर सकते हैं जिस से आप सहज महसूस करते हैं। कुछ शब्द हो सकते हैं जिन की आपको समझ न आये। कृपया मुझे जानकारी के माध्यम से आगे जाने के लिए बंद करने के लिए कहें और मैं आप को सब कुछ समझाऊंगा। यदि बाद में भी आपके पास प्रश्न हो, तो आप मुझसे पूछ सकते हैं।

अनुसंधान का उद्देश्य

जैसा कि हम सभी जानते हैं, जमा हुआ कन्धा (Adhesive capsulitis) बहुत ही आम समस्या है और भौतिक चिकित्सक इस समस्या के लिए एक पारम्परिक उपचार दे रहे हैं। कुछ फिजियोथेरेपिस्ट इस का उपचार चिकित्सीय अल्ट्रासाउंड, शोल्डर जॉइंट मोबिलायज़ेशन, स्ट्रेचिंग एक्सरसाइजेज, ट्रांस्क्युटानियस इलेक्ट्रिकल नर्व स्टिमुलेशन आदि के द्वारा करते हैं, लेकिन इन पारम्परिक उपचारों से रोगी को कुछ हद तक राहत मिलती है और इस में बहुत समय लगता है। कुछ शोधों का कहना है कि पारम्परिक उपचार के साथ जमे हुए कन्धे का 100% स्वास्थ्य लाभ संभव नहीं है। इसलिए इलाज की कुछ ऐसी प्रक्रियाओं को खोजने की बहुत जरुरत है जो कम अवधि में अधिकतम राहत दें । कुछ शोधकर्ताओं का सुझाव है कि जमे हुए कन्धे के केस में मायोफैसिअल ट्रिगर पॉइंट का बनना बहुत आम बात है । यह दर्द को बढ़ाता है और जोड़ों की हरकत की सीमा को कम करता है। इसलिए अब हम जांचने जा रहे हैं “जमे हुए कन्धे (Adhesive capsulitis) में ड्राई नीडलिंग ट्रिगर प्वाइंट की प्रभावकारिता पेरास्पाइनल ड्राई नीडलिंग के साथ और इस के बिना” ।

अनुसंधान हस्तक्षेप का प्रकार

यह शोध 6 हस्तक्षेप सत्रों (वैकल्पिक दिन)के साथ एक रेंडोमाइजड क्लिनिकल ट्रायल है । इस शोध में उपचार समूह का पूरा मूल्यांकन किया जायेगा और अलग-अलग समूह में इस का आवंटन किया जायेगा । तब हम विज़ुअल एनालॉग स्केल, शोल्डर पेन एंड डिसेबिलिटी इंडेक्स, यूनिवर्सल गोनियोमीटर, प्रेशर अलगोमीटर का उपयोग करके पूर्व परीक्षण रीडिंग लेंगे । इसके बाद हम 6 उपचार सत्रों के लिए आवंटित समूह के अनुसार उपचार देंगे और फिर पोस्ट टेस्ट रीडिंग लेंगे।

प्रतिभागी चयन

मैं उन रोगियों को आमंत्रित कर रहा हूँ जो मेरे अनुसंधान में भाग लेने के लिए चिकित्सकीय रूप से जमे हुए कन्धे (Adhesive capsulitis) का निदान कर रहे हैं । फिर मैं मूल्यांकन के आधार पर अपने अनुसंधान कार्य के लिए रोगियों का चयन करूँगा ।

स्वैच्छिक भागीदारी

इस शोध में आपकी भागीदारी पूरी तरह से स्वैच्छिक है । यह आपकी पसंद है कि भाग लेना है या नहीं । यदि आप इस शोध परियोजना में भाग लेने के लिए इच्छुक नहीं हैं, तो

भी आपको आपकी बीमारी के लिए नियमित रूप से उपचार दिया जायेगा और हम आपको इसके बारे में बाद में और बताएंगे। आप बाद में अपना मन बदल सकते हैं और पहले सहमत होते हुए भी भाग लेना बंद कर सकते हैं।

प्रक्रियाएं और प्रोटोकॉल

इस शोध में उपचार समूह का पूरा मूल्यांकन किया जायेगा और बाद में ग्रुप आवंटन किया जायेगा। तब हम विज़ुअल एनालॉग स्केल, शोल्डर पेन एंड डिसेबिलिटी इंडेक्स, यूनिवर्सल गोनियोमीटर, प्रेशर अलगोमीटर का उपयोग करके पूर्व परीक्षण रीडिंग लेंगे। इसके बाद हम 6 उपचार सत्रों के लिए आवंटित समूह के अनुसार उपचार देंगे और फिर पोस्ट टेस्ट रीडिंग लेंगे।

अवधि

यह शोध 6 हस्तक्षेप दिवसों (वैकल्पिक दिनों) के साथ एक रेंडोमाइजड क्लिनिकल ट्रायल है।

दुष्प्रभाव

पूरी शोध प्रक्रिया में कोई दुष्प्रभाव नहीं है।

जोखिम

प्रतिभागियों के लिए कोई जोखिम नहीं है। मैं सभी सावधानियों का ख्याल रखूंगा।

लाभ

आप अपनी स्वास्थ्य स्थिति, अनुसंधान प्रक्रिया के समय आपके महत्वपूर्ण संकेत स्थिति और आपके जमे हुए कन्धे की समस्या का इलाज पाओगे।

पैसे की वापसी

इस शोध में भाग लेने के लिए मैं आपको कोई पैसा या उपहार नहीं दूँगा। आप इस शोध में स्वेच्छा से भाग ले रहे हैं।

गोपनीयता

इस शोध परियोजना से एकत्रित की जाने वाली जानकारी को गोपनीय रखा जाएगा। अनुसंधान के दौरान एकत्रित किए जाने वाली आपके बारे में जानकारी उन सभी लोगों से दूर रखी जाएगी जिनका इस शोध से कोई संबंध नहीं है।

परिणाम सांझा करना

इस शोध को करने से हम जो ज्ञान प्राप्त करेंगे, वह जनता के लिए व्यापक रूप से उपलब्ध होने से पहले आप के साथ सांझा किया जाएगा। गोपनीय जानकारी सांझी नहीं की जाएगी।

इनकार करने या वापस लेने का अधिकार

यदि आप की इस शोध में भाग लेने की इच्छा नहीं हैं तो आप का इस शोध में भाग लेना अनिवार्य नहीं है। आप किसी भी समय आपके द्वारा चुने गए शोध में भाग लेने से मना कर सकते हैं। आपके सभी अधिकारों का अभी भी सम्मान किया जाएगा।

किस से संपर्क करना

यदि आपके पास कोई सवाल है तो आप मुझे अभी या बाद में पूछ सकते हैं, यहां तक कि अध्ययन शुरू होने के बाद भी। यदि आप बाद में सवाल पूछना चाहते हैं, तो आप मुझसे कभी भी संपर्क कर सकते हैं।

वरुण कालिया, पीएचडी स्कॉलर, भौतिक चिकित्सा विभाग, लवली प्रोफेशनल यूनिवर्सिटी।
मोबाइल नंबर: 083603-74990
ईमेल: varunkalia935@gmail.com

APPENDIX – IV

CERTIFICATE OF CONSENT - ENGLISH

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it, and any question that I have asked has been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Name of Participant_____

Signature of Participant _____

Date _____

Day/month/year

If illiterate

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Name of witness_____ AND Thumb print of participant

Signature of witness _____

Date _____

Day/month/year

Investigator: Varun Kalia

Ph.D. Scholar

Date:

Signature:

APPENDIX – V

CERTIFICATE OF CONSENT - PUNJABI

ਸਹਿਮਤੀ ਦਾ ਸਰਟੀਫਿਕੇਟ

ਮੈਂ ਅੱਗੇ ਦਿੱਤੀ ਜਾਣਕਾਰੀ ਪੜ੍ਹੀ ਹੈ ਜਾਂ ਇਹ ਮੇਰੇ ਲਈ ਪੜ੍ਹੀ ਗਈ ਹੈ। ਮੈਨੂੰ ਇਸ ਬਾਰੇ ਪ੍ਰਸ਼ਨ ਪੁੱਛਣ ਦਾ ਮੌਕਾ ਮਿਲਿਆ ਹੈ ਅਤੇ ਜੋ ਵੀ ਸਵਾਲ ਮੈਂ ਪੁੱਛੇ ਹਨ, ਉਨ੍ਹਾਂ ਬਾਰੇ ਮੈਨੂੰ ਤਸੱਲੀ ਬਖ਼ਸ਼ ਜਵਾਬ ਦਿੱਤਾ ਗਿਆ ਹੈ। ਮੈਂ ਇਸ ਰਿਸਰਚ ਵਿੱਚ ਇੱਕ ਭਾਗੀਦਾਰ ਦੇ ਰੂਪ ਵਿੱਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਸਹਿਮਤ ਹੋਇਆ ਹਾਂ।

ਭਾਗੀਦਾਰ ਦਾ ਨਾਮ.....
ਭਾਗ ਲੈਣ ਵਾਲੇ ਦੇ ਹਸਤਾਖਰ.....
ਮਿੱਤੀ .....
ਦਿਨ / ਮਹੀਨਾ / ਸਾਲ

ਜੇ ਅਨਪੜ੍ਹ ਹੋਵੇ ਤਾਂ
ਮੈਂ ਸੰਭਾਵੀ ਭਾਗੀਦਾਰ ਨੂੰ ਸਹਿਮਤੀ ਫਾਰਮ ਦੀ ਸਹੀ ਜਾਣਕਾਰੀ ਮਿਲਦੀ ਹੋਈ ਦੇਖੀ ਹੈ ਅਤੇ ਵਿਅਕਤੀ ਨੂੰ ਸਵਾਲ ਪੁੱਛਣ ਦਾ ਮੌਕਾ ਮਿਲਿਆ ਹੈ। ਮੈਂ ਪੁਸ਼ਟੀ ਕਰਦਾ ਹਾਂ ਕਿ ਵਿਅਕਤੀ ਨੇ ਸਹਿਜ ਮਨਜ਼ੂਰੀ ਦਿੱਤੀ ਹੈ।

ਗਵਾਹ ਦਾ ਨਾਮ.....
ਗਵਾਹ ਦੇ ਦਸਤਖਤ.....
ਮਿੱਤੀ .....
ਦਿਨ / ਮਹੀਨਾ / ਸਾਲ

ਭਾਗੀਦਾਰ ਦਾ ਅੰਗੂਠੇ ਦਾ ਨਿਸ਼ਾਨ

ਪੜਤਾਲਕਾਰ: ਵਰੁਣ ਕਾਲੀਆ
ਪੀਐਚਡੀ ਸਕਾਲਰ
ਮਿਤੀ:
ਦਸਤਖਤ:

APPENDIX – VI

CERTIFICATE OF CONSENT - HINDI

सहमति का प्रमाण पत्र

मैंने पूर्वगामी जानकारी पढ़ी है, या यह मेरे लिए पढ़ी गई है। मुझे इस बारे में सवाल पूछने का अवसर मिला है और मैंने जो प्रश्न पूछे हैं उससे मेरी संतुष्टि के उत्तर दिए गए हैं। मैं इस शोध में प्रतिभागी के रूप में भाग लेने के लिए स्वेच्छा से सहमति देता/ देती हूं।

प्रतिभागी का नाम.....

प्रतिभागी के हस्ताक्षर.....

तारीख.....

दिन/महीने/साल

अगर निरक्षर है

मैंने संभावित भागीदार को सहमति फार्म सटीक पढ़ाते देखा है और व्यक्ति को सवाल पूछने का अवसर मिला है। मैं पुष्टि करता हूं कि व्यक्ति ने स्वतंत्र रूप से सहमति दी है।

गवाह का नाम..... तथा प्रतिभागी के अंगूठे का निशान

गवाह के हस्ताक्षर.....

तारीख.....

दिन/महीने/साल

जांचकर्ता: वरुण कालिया

पीएचडी स्कॉलर

तारीख:

हस्ताक्षर:

APPENDIX – VII

PATIENT ASSESSMENT FORM

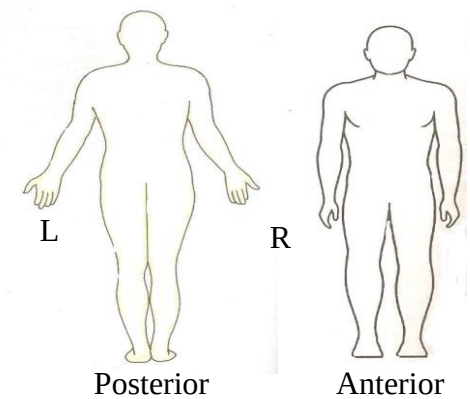
Group…… Identification No…… Date……....

Name……Age/Gender……Study Setting……

Address……..

Occupation…… Contact no……...

Chief complaint**:**



HISTORY OF PRESENT ILLNESS:

Past medical history of a patient? ☐ Cardiopulmonary Disease ☐ Diabetes

☐ Parkinson's Disease ☐ Rotator Cuff Pathologies ☐ Humerus Fracture

☐ AC Joint Arthritis ☐ Calcific Tendonitis ☐ Biceps Tendonitis

☐ Other…….……

FAMILY HISTORY:

PERSONAL HISTORY:

- Do you use Tobacco products? …….YES, …….NO
- Beer, Wine, or other Alcoholic beverages? ……...YES, ……NO
- Do you exercise regularly? ……..YES, ….....NO

- If Yes, then which type? …….
- From how much time? …….....

PAST SURGICAL HISTORY:…….

DRUG HISTORY: Do you take any prescription medication? ……YES, …….NO

……

PAIN HISTORY: Site ……..Shoulder Joint/……. Other Joint/ ……

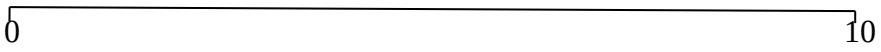
Side …….Right/ …….Left

Onset……Sudden……Gradual

Duration…….....

Type…….

Intensity…….Continuous / ……..…… Intermittent



Visual Analog Scale

Aggravating factors of pain? ……..

Relieving factors of pain? ……...

Sleep Disturbance? ……YES, ……NO.

GENERAL EXAMINATION

Height …….

Weight……..

Blood pressure……..

Pulse Rate……..

Respiratory Rate…….

Temperature……

Segmental temperature: ……Warmth/ ……Cold

OBSERVATION

Specific Body part……

Edema? ..……YES/ ..…….NO. If yes then, Type……

Redness? ..…….YES/...…….NO

Scar? ……..YES/...…….NO

Scapular Winging ……..YES/ ……..NO

PALPATION

- Site……....
- ……Warmth/…..…… Cold
- Edema ……Yes/ ……No
- Trigger Point……Present/ ……Absent if present then in which muscle

Muscles	**Pressure Pain Sensitivity with Algometer**			
	Reading 1st	2nd	3rd	Average
☐ Supraspinatus Muscle ……				
☐ Infraspinatus Muscle ……				
☐ Teres Minor Muscle ……				
☐ Subscapularis Muscle ……				
☐ Deltoid Muscle ……				
☐ Pectoralis Major Muscle……				
☐ Teres Major Muscle ……				
☐ Upper Trapezius ……..……				

SENSORY EXAMINATION

Touch - Fine touch…….

Crude touch……...

Pain sensation? ……..Normal / ……..Abnormal

MOTOR EXAMINATION

RANGE OF MOTION

JOINTS	MOTIONs	Rt(Active)	Rt(Passive)	Lt(Active)	Lt(Passive)
SHOULDER	Flexion Extension Abduction Adduction Internal rotation External rotation				
CERVICAL	Flexion Extension				
	Side Flexion Rotation				
ELBOW	Flexion Extension				

MUSCLE POWER:

MUSCLE POWER	MUSCLES	RIGHT	LEFT
SHOULDER	Flexors Extensors Abductors Adductors Internal rotators External rotators		
Cervical	Flexion Extension		
	Side Flexion Rotation		
ELBOW	Flexors Extensors		

REFLEXES

DEEP REFLEXES

JERKS	RIGHT	LEFT
Biceps(C5)		
Brachioradialis(C5-C6)		
Triceps(C7)		

DIFFERENTIAL DIAGNOSIS:

PROVISIONAL DIAGNOSIS:

APPENDIX – VIII

SHOULDER PAIN AND DISABILITY INDEX (SPADI)

Patient Name _____ Date _____

Please read carefully:

Instructions: Please circle the number that best describes the question being asked.

Pain scale:

No pain at all 0 1 2 3 4 5 6 7 8 9 10 Worst pain Imaginable

How severe is your pain?

1. At its worst?

   0 1 2 3 4 5 6 7 8 9 10

2. When lying on the involved side?

   0 1 2 3 4 5 6 7 8 9 10

3. Reaching for something on a high shelf?

   0 1 2 3 4 5 6 7 8 9 10

4. Touching the back of your neck?

   0 1 2 3 4 5 6 7 8 9 10

5. Pushing with the involved arm?

   0 1 2 3 4 5 6 7 8 9 10

Disability scale:

No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult it requires help

How much difficulty do you have?

1. Washing your hair?

   0 1 2 3 4 5 6 7 8 9 10

2. Washing your back?

0 1 2 3 4 5 6 7 8 9 10

3. Putting on an undershirt or pullover sweater?

0 1 2 3 4 5 6 7 8 9 10

4. Putting on a shirt that buttons down the front?

0 1 2 3 4 5 6 7 8 9 10

5. Putting on your pants?

0 1 2 3 4 5 6 7 8 9 10

6. Placing an object on a high shelf?

0 1 2 3 4 5 6 7 8 9 10

7. Carrying a heavy object of 10 pounds?

0 1 2 3 4 5 6 7 8 9 10

8. Removing something from your back pocket?

0 1 2 3 4 5 6 7 8 9 10

OTHER COMMENTS:

_____

_____

Examiner:

_____

APPENDIX – IX

VISUAL ANALOGUE SCALE (VAS) FOR PAIN

Name _____ **Date** _____

Place a mark on the line below to indicate the current level of pain.

No Pain

Pain as bad as it could possibly be

APPENDIX – X

DATA COLLECTION FORM

Group…… **Identification No……** **Study Setting**…….

Name …… **Age/Gender**……

RANGE OF MOTION **DATE**:…… **DATE**:……

		PRE TEST READINGS				POST TEST READINGS			
JOINTS	**MOTIONs**	**Right (A)**	**Right (P)**	**Left (A)**	**Left (P)**	**Right (A)**	**Right (P)**	**Left (A)**	**Left (P)**
SHOULDER	Flexion Extension Abduction Adduction Internal rotation External rotation								
CERVICAL	Flexion Extension Side Flexion Rotation								
ELBOW	Flexion Extension								

	PRE-TEST READING	**POST-TEST READING**
VAS Score		

	PRE-TEST READING	POST-TEST READING
SPADI Score		

PRESSURE PAIN SENSITIVITY WITH ALGOMETER								
Muscles	**PRE-TEST READING**				**POST-TEST READING**			
	1st	**2nd**	**3rd**	**Average**	**1st**	**2nd**	**3rd**	**Average**
Supraspinatus Muscle								
Infraspinatus Muscle								
Teres Minor Muscle								
Subscapularis Muscle								
Deltoid Muscle								
Pectoralis Major Muscle								
Teres Major Muscle								
Upper Trapezius								

APPENDIX – XI

ETHICAL COMMITTEE CLEARANCE CERTIFICATE

INSTITUTIONAL ETHICS COMMITTEE
Lovely Professional University, Punjab
Ph: +91-1824-444039; E-mail: ao_pharma.lit@lpu.co.in

Chairperson: **Dr. H. S. Gill** **Deputy Chairman:** **Dr. Monica Gulati** **Members:** **Dr. Shivani Tandon** **Dr. Naresh Kundra** **Dr. N. K. Gupta** **Dr. Meenu Chopra** **Mr. Dharminder Singh Dhillon** **Dr. Sasmita Kaur** **Sardar Nagina Singh** **Member Secretary:** **Dr. Navneet Khurana**	LPU/IEC/2018/01/04 Date: June 06, 2018 To Varun Kalia Department of Physiotherapy, St. Soldier Co-Ed College, Jalandhar (Punjab) Dear Sir/Madam, The Ethics committee has studied the research proposal submitted by Mr./Ms./Dr. **Varun Kalia** on research topic **EFFICACY OF MYOFASCIAL TRIGGER POINT DRY NEEDLING WITH AND WITHOUT PARASPINAL NEEDLING IN PATIENTS WITH ADHESIVE CAPSULITIS : A RANDOMIZED CLINICAL TRIAL** It has been decided to accord **approval** to this study protocol. Thanking You. Your sincerely (Chairperson) (Deputy Chairman) (Member Secretary)

APPENDIX – XII

LIST OF PAPER PUBLICATIONS AND CONFERENCE PRESENTATIONS

Paper Publications					
Sr. No	**Topic**	**Journal**	**Year of Publication**	**SJR**	**Indexing**
1.	Physiotherapy interventions for Adhesive capsulitis of shoulder: A quick review	Journal of Emerging Technologies and Innovative Research	May 2019	5.87	UGC
2.	Short-term Effect of Myofascial Trigger Point Dry-Needling in Patients with Adhesive Capsulitis	Journal of Bodywork and Movement Therapies	October 2020	0.452	Scopus, Pubmed
3.	Dry needling with and without paraspinal needling in patients with Adhesive capsulitis. A randomized clinical trial.	International Journal of Physiotherapy	Accepted		Web of Science (ESCI)

Conference Presentations					
Sr. No	**Topic**	**Conference Name**	**Place**	**Date**	**Mode**
1.	Dry needling in the frozen shoulder: A special perspective	3rd National conference synapse 2017	Chitkara University	26th - 27th October 2017	Regular
2.	Short-term effect of myofascial trigger points dry needling in patients with adhesive capsulitis.	International Conference of Pharmacy (ICP-2019)	Lovely Professional University	13th-14th September 2019	Regular
3.	Effect of myofascial trigger point dry needling in patients with adhesive capsulitis.	E-Physiocon International Physio online consortium	Online	16th April-9th May 2020	Online

PHYSIOTHERAPY INTERVENTIONS FOR ADHESIVE CAPSULITIS OF SHOULDER: A QUICK REVIEW

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Abstract: Adhesive Capsulitis is a prevalent disease but its management is challenging. In contrast, the current best scientific data about the use of physical therapy intervention is reviewed in this quick review. Furthermore, this article is intended to offer a brief overview of physiotherapy treatments for adhesive capsulitis. There are a number of physiotherapy interventions that have been proposed such as therapeutic exercises, interferential therapy and joint mobilizations are advised to reduce pain, increase range of motion (ROM) and function in adhesive capsulitis subjects. Low Level Laser Therapy was highly recommended for relieving pain but fairly recommended for function enhancement and not recommended for range enhancement. Microwave diathermy, therapeutic ultrasound was not recommended for relieving pain, enhancing ROM and function. Deep heat, Joint mobilization, Kaltenborn mobilization and Mobilization under anaesthesia can be used to ease pain and enhancing ROM. Efficacy of iontophoresis is still needed to check. Dry needling may relief the pain and increase ROM but there is need to check the efficacy of dry needling in adhesive capsulitis with large sample sized randomized control trial. In this situation, there is little consensus on the most effective treatment to decrease pain, improve ROM and shoulder function.

Key Words- Adhesive Capsulitis, Dry Needling, Mobilization, Electrotherapy, Stretching Exercise.

INTRODUCTION

Adhesive Capsulitis (AC) is a musculoskeletal condition also known as frozen shoulder and is characterized by functional restriction of both active and passive shoulder motions.(Zuckerman & Rokito, 2011) Moreover there is no definite etiology or underlying pathology associated with AC. Lundberg(Lundberg, 1969) (1969) was the first author who classified the AC into two types such as Primary and Secondary. Primary AC developed idiopathically and secondary develops with trauma. In fact, the primary idiopathic cases are the extremely familiar and the slightly understood.(Walker, K. L., Gabard, D. L., Bietsch, E., Masek-VanArsdale, D. M. & Robinson, 1997)

It was reported around 2 to 5.3 percent of the general population was affected with AC globally.(Kelley et al., 2013) The incidence of secondary AC linked to diabetes mellitus and thyroid disease are 4.3 percent and 38 percent respectively.(Kelley et al., 2013) Approximately 70 percent of AC subjects are women between the ages of 40 and 60(Page & Labbe, 2010); however, males with AC are at substantial risk of prolonged rehabilitation and severe impairment(Page & Labbe, 2010) because its management is very challenging. Furthermore this article is intended to offer a brief overview of physiotherapy treatments for AC.

PHYSICAL THERAPY INTERVENTIONS

a. Electro Physical Agents for AC

Electro Physical Agents (EPA) are used in physical therapy interventions (PTI) of AC that are focus to decrease pain and enhance function via an increase of different type of energies into the body.(Watson, 2010) In addition, several EPA exists and we can classify them as (a) Electrical stimulation agents include Transcutaneous Electrical Nerve Stimulation (TENS) and Interferential Therapy (IFT). (b) Thermal agents include Shortwave Diathermy (SWD), Microwave Diathermy (MWD) and Therapeutic Ultrasound (UST). (c) Non Thermal Agents include Low-Level Laser Therapy (LLLT).

TENS delivers electrical stimulation to activate the underlying nerves by means of electrodes mounted over the intact skin adjacent to the pain source.(Jones & Johnson, 2009) In AC, Dewan and Sharma(Dewan & Rohit, 2011) checked the efficacy of TENS and IFT and concluded that both TENS and IFT are effective in treating AC. IFT is more effective in decreasing pain severity and restoring function in the shoulder for people with AC.(Dewan & Rohit, 2011) IFT includes the interaction of two medium-frequency currents, resulting in a low-frequency 'beating' response in deep tissues.(Beatti, Rayner, Souvlis, & Chipchase, 2010) Literature suggested that it is effective in pain relief, function and ROM improvement.(Cheing, So, & Chao, 2008) Continuous SWD is the transmission of a continuous stream of electromagnetic short wave radiations to achieve deep heating effect in soft tissues.(Allen, 2006) Recently , deep diathermic heating along with stretching proved more effective than superficial heating to treat AC.(Leung & Cheing, 2008) MWD uses microwaves to heat superficial tissues than SWD. It is mainly used for heating up superficial muscles and joints such as the shoulder.(Steven, Mila, Lynn, James, & Allison, 2009) Literature showed that MWD along with physical exercises is not efficient in reducing pain and disability as compared to UST along with physical exercise programme.(Haque, Rahman, Yousuf, & Hasan, 2015) Using a crystal sound head, UST delivers energy to deep tissue sites through ultrasonic waves (at a frequency of 1 or 3 MHz and intensities between 0.1 watts / cm2 and 3 watts / cm2). Treatment can be given in two ways, continuous and pulsed.(Allen, 2006) Literature did not recommend the further use of UST to lessen pain, increase ROM and function in AC.(Dogru, Basaran, & Sarpel, 2008) LLLT produces a light beam with the potential to transmit light energy to tissue depths under the dermis.(Peplow, Chung, & Baxter, 2010) Literature reported that by using LLLT, pro-inflammatory cytokines are decreasing and anti-inflammatory growth factors along with cytokines are enhancing that contributes to pain cessation.(Peplow et al., 2010) LLLT is a viable choice for the conservative management of shoulder pain caused by AC in the elderly, with a favorable clinical outcome of more than 90 percent and clinical effectiveness in both the short and medium term(David & Nga-Yue, 2015) since literature reported that LLLT on AC did not reliably achieve an increased range of motion.(van Breugel & Bär, 1992)

b. Iontophoresis for AC

In physical therapy, this technique was used to administer ionic medicines through the skin, mainly for a local effect.(Costello & Jeske, 1995) Jewell et al. and Ewald reported that iontophoresis (IP) has lower the probability of beneficial results which suggest to stop the use of this modality.(Ewald, 2011; Jewell, Riddle, & Thacker, 2009) In 2013, one study had compared the effectiveness of IP with calcium chloride plus SWD, IP with sodium chloride plus SWD and SWD alone and they found that IP with calcium chloride plus SWD and IP with sodium chloride plus SWD are effective in reducing pain in AC as compared to SWD alone.(Yigiter & Kerem, 2013) In this situation, high quality study is required to confirm the effectiveness of IP in AC.

c. Joint mobilization for AC

Many researchers have tested the efficacy of joint mobilization in AC. Although there is evidence that this could be of value, there is little evidence to support greater efficiency over other approaches.(Vermeulen et al., 2000; Vermeulen, Rozing, Obermann, Cessie, & Vlieland, 2006) Some authors reported successful mobilizations alongside home exercise program(Vermeulen et al., 2000, 2006) whereas few did not find it effective for controlling pain.(Chan, Hill, & Kerr, 2010) Similarly, some studies have indicated that mobilization along with exercises is successful for short- and long-term improvement of ROMs.(Johnson,

Godges, Zimmerman, & Ounanian, 2007; Vermeulen et al., 2000, 2006) However, Chan et al.(Chan et al., 2010) found no significant difference in ROM after mobilization, whereas with shoulder function, few studies found no significant change in mobilization efficiency,(Chan et al., 2010) while other studies suggested mobilization was effective.(Vermeulen et al., 2000, 2006)

d. Kaltenborn mobilization for AC

Kaltenborn proposed different degrees of mobilization such as mid-range and end-range mobilizations to enhance joint mobility and minimize pain.(Hammad et al., 2019) Jing-lan Yang et al stated that in AC, Kaltenborn Mobilization (KM) and Mulligan Mobilization with Movement (MWM) seemed more successful than Maitland Mobilization (MM).(Yang, Chang, Chen, Wang, & Lin, 2007) Vermeulen HM et al stated that KM (end range) was more helpful in enhancing the mobility of glenohumeral joint in AC.(Vermeulen et al., 2000) A research comparing Maitland and KM techniques for reducing pain in the shoulder and enhancing ROM in AC found that both groups experienced substantial reductions in post-intervention pain. The internal and external rotation ROMs in both groups increased significantly after intervention. However, there was no substantial difference in pain improvement or ROM between the groups.(Moon, Lim, Kim, & Kim, 2015) One recent study found that KM with thermotherapy was more effective than KM alone in AC.(Hammad et al., 2019)

e. Manipulation under anaesthesia for AC

Manipulation under anesthesia (MUA) requires the use of manual joint manipulation combined with general anesthetics.(West, Mathews, Miller, & Kent, 1999) Janda and Hawkins (1993) said that anaesthetic manipulation has no effect on the course of AC.(Janda, Hawkins, & Frcs, 1993) The effect of anesthetic treatment on the primary AC showed that initially subjects were substantially improved in ROMs but 59 percent of subjectss were listed as having no or mild disability only during follow-up at 3 months, 28.2 percent as having moderate disability and 12.8 percent as having extreme disability.(Dodenhoff, Orth, Levy, Wilson, & Copeland, 2000) Although, MUA is effective in terms of joint mobilization but literature reported many complications related to it as hemarthrosis, localized synovitis, disseminated synovitis, superior joint capsule rupture, anterior capsule rupture up to the infraglenoid pole, posterior capsule lesion, iatrogenic superior labrum anterior-posterior lesion, partial tears of the subscapularis tendon and anterior labral detachments.(Loew, Heichel, & Lehner, 2005)

f. Therapeutic exercises for AC

Therapeutic exercises has traditionally been a cornerstone of treatment for AC.(Ewald, 2011) Literature reported that studies utilized therapeutic exercises to treat AC subjects of different stages from I to III and these exercises are beneficial for pain relief and improved function at all stages.(Griggs, Anthony, & Andrew, 2000; Pajareya et al., 2004) Aggressive PTI can exacerbate pain and reduce adherence to the treatment regimen; therefore, care should be taken in subjects with a high degree of pain and stiffness.(Ewald, 2011) On the other hand, most of the exercises found to be effective in improving shoulder function(Griggs et al., 2000; Pajareya et al., 2004) but Diercks and Stevens reported supervised neglect to be superior than PTI in enhancing function in AC.(Diercks & Stevens, 2004)

g. Mirror Therapy for AC

Mirror therapy (MT) is a simple, inexpensive and most importantly, patient-centric type of treatment used to improve mobility in upper extremity disorders.(Baskaya, Erçalik, Kir, Erçalik, & Tuncer, 2018) Literature reported many studies related to MT for different neurological and musculoskeletal conditions.(Cacchio, De Blasis, De Blasis, Santilli, & Spacca, 2009) Cacchio et al. reported substantial post-treatment pain relief and improvement of upper extremity motor functions with MT in a randomized controlled study of 48 subjects s with post-stroke of the upper limbs.(Cacchio et al., 2009) In a subject with an absent active wrist extension following a distal radius fracture, Altschuler and Hu observed improvement of wrist movements and functions after MT.(Altschuler & Hu, 2008) Moreover for AC, only one prospective randomized controlled study is available and that study concluded that MT applied to AC in combination with standard physical therapy methods can lessen pain and improve ROM, functions and quality of life in short term. This study was done with small sample size. Therefore, in order to confirm whether MT can contribute further to the

improvement of AC in combination with PTI; more studies with larger sample sizes, structured application techniques, well-defined optimal application time and mode and long-term follow-up are required in which MT 's effectiveness is supported by neuroimaging techniques.(Baskaya et al., 2018)

h. Dry Needling for AC

Dry needling (DN) is an invasive technique but it comes under the scope of physiotherapy.(Dommerholt, 2004) Literature reported only two published studies that investigated the use of DN for AC.(Clewley, 2014; Sukumar & Lawrence, 2014) In a case study of AC, Clewley et al, started DN on the third intervention session for trigger points in the upper trapezius muscle and elicit a localized twitch response with the goal of decreasing pain associated with them. Instantly after the first DN session, end range pain decreased from a 4/10 to a 0/10. By the fifth DN session, Quick DASH reported improvement in disability from 68 to 23 points.(Clewley, 2014) Sukumar and Mathias done a single blinded randomized controlled trial (RCT) with AC subjects. Outcome measures were Shoulder pain and disability and shoulder abduction ROM and they concluded that intramuscular manual therapy was more effective than PTI and it can be used as a primary intervention tool in treating AC. But there is need to conduct a RCT with large sample size and must include all shoulder ROMs.(Sukumar & Lawrence, 2014)

CONCLUSION

Numerous therapies have been proposed for AC such as PTI, SWD, IFT, KM, MUA and joint mobilizations that are advised to reduce pain, increase ROM and function in AC. MWD and UST were not recommended for relieving pain, enhancing ROM and function. DN, LLLT and Iontophoresis may relief the pain and increase ROM but there is need to check the efficacy with large sample sized RCTs. In this situation, there is still little consensus on the most appropriate treatment to decrease pain and enhance the ROM in AC.

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Myofascial Pain and Treatment

Short-term effect of myofascial trigger point dry-needling in patients with Adhesive Capsulitis

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ABSTRACT

Background: Adhesive Capsulitis (AC) is a common disabling musculoskeletal pain condition of unknown etiology related to the shoulder joint. Literature reported the restricted range of motion (ROM) and pain could be the result of myofascial trigger points (MTrPs) in the muscles of the shoulder girdle. Hence, the objective of this study was to assess the short-term effectiveness of MTrP dry needling (DN) in improving ROM, pain, pressure pain threshold (PPT), and physical disability among patients having AC.

Methods: In a single group pre-post experimental study design, a total of 70 clinically diagnosed patients (both male & female, age group between 40 and 65 years) with AC were recruited from three multi-specialty hospitals. The informed consent forms were received from each patient before participating in the study. Each patient received DN for the MTrPs of shoulder girdle muscles for alternative six days. In addition to DN, each patient had received conventional physiotherapy for continuous twelve days which includes electrotherapy modalities and exercises. The pain intensity (visual analog scale), shoulder ROM (Goniometer), disability (shoulder pain and disability index) and PPT (Algometer) were the outcome measures assessed at the baseline and twelfth day of the intervention.

Results: There was a statistically significant ($p < 0.05$) improvement in shoulder ROM, pain intensity, shoulder disability, and PPT at the end of the twelve days of intervention as compared to baseline assessment.

Conclusion: MTrPs-DN techniques may improve the pain, ROM, disability and PPT along with conventional physiotherapy management among patients with AC.

1. Introduction

Adhesive capsulitis (AC) is a common musculoskeletal disorder of shoulder joint characterized by pain, restricted range of motion (ROM) and tightness of the gleno-humeral joint that negatively influence the whole upper extremity functions. Patients usually report that starting of pain in the shoulder joint pursued by a restricted ROM (Kingston et al., 2018). The AC may be either primary (idiopathic) or secondary (Ravikanth and Kamalasekar, 2019). Primary AC occurs as a result of a long-lasting inflammatory reaction with fibroblastic proliferation which may be an unusual response from the immune system (Akbar et al., 2019) whereas secondary AC takes place in case of a shoulder injury or after surgery and can occur with other conditions like diabetes, stroke, cardiovascular disease, rotator cuff injury that may enlarge recovery time and limit outcomes (Ravikanth and Kamalasekar, 2019). It was reported that around 2%–5.3% of the general population was affected with AC globally. The prevalence of secondary AC is reported to be between 4.3% and 38% related to diabetes mellitus and thyroid disease respectively (Chiaramonte et al., 2020). However, the etiology of AC has not been identified yet (Neviaser and Hannafin, 2010) but it affects approximately 70% women; whereas, men with AC are at more serious risk for prolonged recovery and significant disability. Among four clinical stages of AC, the second stage, also known as “painful” or “freezing stage” that lasts for 3–9 months associated with marked gradual loss of all shoulder ROMs and pain (Neviaser and Hannafin, 2010).

The AC is commonly identified with the fibrosis and shortening of the joint capsule, ligaments around the gleno-humeral joint. Nevasier (1945) had done a histological study and reported that the

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gleno-humeral joint capsule becomes dense and contracted along with inflammatory changes (Neviaser, 1945). The volume of the joint capsule decreases because of the contracture of the shoulder joint ligaments that leads to limited joint ROM. Not only capsular and ligamentous tightness around the shoulder joints are responsible for restriction in ROM and the pain related to AC but also fascial and muscular tightness and trigger points within the muscles are also part of it (Ughreja et al., 2019). Physiotherapists are addressing AC with a variety of treatment procedures but the most successful treatment for this common disease is still under discussion and no standard treatment has been validated yet (Jason et al., 2015). Various treatment options have been suggested such as Ultrasound Therapy (UST), Phonophoresis, Massage Therapy, Iontophoresis, Low-Level Laser Therapy (LLLT), Transcutaneous Electrical Nerve Stimulation (TENS), Continuous Passive Motion (CPM), Short Wave Diathermy (SWD), Dynamic Splinting, Total End Range Time (TERT) and Joint Mobilization (Jason et al., 2015) but the recovery of the patients is limited. Several studies have exhibited long-term pain, shoulder joint stiffness and disability even after conservative treatment. Prolong disability has been revealed in 15%, permanent functional loss in 7–15% and persistent symptoms in 40% of patients with AC (Hand et al., 2007; Koh, 2016).

As discussed earlier, myofascial trigger points (MTrPs) may be present around the shoulder joint muscles in AC patients as focal areas of increased tension. Sukumar and his colleagues (2014) reported that MTrPs formation in muscles around the shoulder joint is one of the reasons for pain and reduction in the ROM in AC (Sukumar and Lawrence, 2014). Literature is showing emerging support for the clinical effectiveness of DN in the treatment of many musculoskeletal pain diseases (Puentedura et al., 2017; Rahou-El-Bachiri et al., 2020; Tabatabaiee et al., 2019). DN includes the insertion of solid monofilament needles into areas of muscle that are distinguished to have motor malfunctions (i.e., taut bands, trigger points) in an attempt to reduce pain and re-establish normal muscle function (Ball et al., 2019). In addition, Travel and Simons reported limitations in the shoulder elevation and external rotation due to the presence of trigger points in the subscapularis muscle (Simons et al., 1999). Clewley et al. (2014) suggested that DN for MTrPs can be used as an adjunct therapy for a patient with AC of the shoulder (Clewley et al., 2014). Therefore, the purpose of this study was to evaluate the short-term effectiveness of MTrPs DN in improving pain, ROM, PPT and physical disability among patients with AC.

2. Methods

2.1. Study design & participants

Using a single group pre-post experimental study design, a total of 79 patients (9 dropped out) with diagnosed AC from three multi-specialty hospitals were recruited between May 2017 to March 2019 for this study. All of these patients were diagnosed by an orthopedic surgeon based on the medical history, orthopedic physical examination and imaging if necessary and referred to the physiotherapy department for therapy.

In this study, patients who were (a) medically diagnosed with AC, (b) aged between 40 and 65 years, (c) both male or female, (d) presented with shoulder pain and restricted shoulder ROM for more than three months with tender, taut, palpable band or nodule within muscles around the shoulder joint and (e) having normal cognitive function were included. Additionally, the patients who had (a) skin disorder over the neck and shoulder region, (b) history of neck surgery, (c) taken antiplatelet therapy within the past three days of the study, (e) history of cancer-pain related to shoulder and pectoral region within past six months of the study, (f) received steroid injections to shoulder joint within past three months of the study, (g) extreme fear of needles and (h) uncooperative behavior were excluded from the study. The institutional ethical committee (LPU/IEC/2018/01/04) has approved this study.

2.2. Outcome measures

2.2.1. Primary outcome measures

Shoulder Pain and Disability Index (SPADI) is internationally accepted for self-reporting pain and disability by using 13-items which includes a 5-item subscale to measure pain and 8-item subscale that measures disability. In different patient populations, SPADI has good reliability coefficients of ICC $\geq$0.89 and good internal consistency with Cronbach α of 0.90 (Breckenridge and Mcauley, 2011). SPADI shows high construct validity and is related to other region-specific shoulder questionnaires (Hill et al., 2011; Sudarshan et al., 2019).

The Pressure Pain Threshold (PPT) was assessed by using a pressure algometer. A pressure algometer is a device that identifies the force that eliciting a PPT. These devices are having high reliability and validity (Kinser et al., 2009) and also showing acceptable intra-examiner reliability of pressure rate application. The between-session PPT across multiple sessions was reliable and without differences (Nussbaum and Downes, 1998).

2.2.2. Secondary outcome measures

Visual Analog Scale (VAS) related to Pain is a self-reporting scale which consists of a horizontal 100 mm line with ratings starting from score 0 on the left side showing “no pain” and ending with a score 100 on the right side showing “worst pain” (Pulik et al., 2020).

Shoulder ROM was assessed by universal goniometer and it has excellent intra-rater reliability (Intraclass Correlation Coefficients (ICC- 3,k) for goniometry $\geq$ 0.94) (Mullaney et al., 2010).

2.2.3. Intervention

In this study, the following interventions were administered.

2.2.4. Dry needling

The MTrPs were identified during detailed physiotherapy assessment and the trigger point if found was treated with the acupuncture needle (Suzhou Tianxie) of 0.25 mm gauge using a needle of size 25 mm or 40 mm according to the muscle and size of the patients. The entire DN procedure was performed by a physiotherapist having experience for more than five years in DN techniques. Under the aseptic techniques, dry needle was put into the muscle belly with a tender nodule of the taut band. Fast in/out movement technique was used in a cone pattern by physiotherapists to target many sensitive loci as feasible within the tender nodule of the taut band of muscle as to look for twitch response. The needle was left in the affected muscle for 10 min. At the end of 10 min, the needle was taken out and the condition of hemostasis was maintained. The needle was discarded into a sharps container (Table 1).

2.2.5. Electrotherapeutic intervention

In addition to DN, the affected shoulder joint was also received electrotherapeutic interventions with SWD and TENS. The SWD (27.12 MHz) was applied in using the contra-planner method with eightfold towel wide spacing for 20 min. The intensity was adjusted and maintained based on the patient's feedback to produce comfortable warmth. For TENS, the electrodes were placed on bellies of deltoid muscle and trapezius and treated with the parameters (frequency 100 Hz, 0.05 ms duration, modulation pulse shape, 9 V) (Pantaleão et al., 2011) aimed to stimulate A-delta fiber for 20 min to relieve pain. The intensity of the current was

Table 1
Details of dry needling techniques include patient & shoulder position, palpation technique & Direction of needle insertion.

Sr.No	Muscle	Patient position	Shoulder position	Palpation Technique	The direction of needle insertion
1	Supraspinatus Muscle	Prone lying	Neutral	Flat palpation	Longitudinal to the frontal plane
2	Infraspinatus Muscle	Prone lying	Neutral	Flat palpation	Directed towards scapula
3	Teres minor Muscle	Prone lying	90° Abduction	Flat palpation	Directed towards the lateral border of the scapula
4	Subscapularis Muscle	Supine lying	90° abduction & 90° ER	Pincer palpation	Directed parallel to the ribcage
5	Deltoid Muscle	Anterior fiber- Supine Middle fiber- Side-lying Posterior fiber- Prone lying	Slight Abduction	Flat palpation	Directed perpendicularly
6	Pectoralis major Muscle	Supine lying	Slight Abduction	Flat palpation	Directed towards shoulder
7	Teres major Muscle	Prone lying	Slight Abduction	Pincer palpation	The ventral and lateral direction

increased to the point until no observation contractions were produced but with a light tingling sensation, while making sure the patient was comfortable (Pantaleão et al., 2011).

2.2.6. Shoulder mobilization and exercises

The affected gleno-humoral joint was treated with the passive oscillatory glides which include caudal glide, caudal glide progression, postero-anterior glide and antero-posterior glide at the rate of 2–3 glides per second and total for 30 s in a set. Each glide was given for 5 sets with 30 s intervals between each set. Additionally, the conventional passive stretching of shoulder girdle muscles was also demonstrated and encouraged to perform by patients at home. Each stretch was maintained for 30 s and repeated three times with 15 s rest between them (Kumar et al., 2012) and patients were also instructed to do active-assisted shoulder exercises using a towel for 5 min at home (Pajareya et al., 2004).

2.2.7. Procedure

The researcher explained the study procedure and obtained informed consent from each patient at the commencement of the study. Consequently, patients underwent pre-intervention assessment which includes pain intensity (VAS), shoulder ROM (Goniometer), disability (SPADI)) and PPT (Algometer). After a detailed explanation of the dry needling procedure, the patients had received local MTrPs-DN treatment for affected muscle from Upper Trapezius, Infraspinatus, Teres major, Supraspinatus, Teres minor, Pectoralis major, Subscapularis and Deltoid muscle for alternate six days along with conventional electrotherapeutic intervention (SWD, UST, & TENS) and Maitland Mobilization for continuous twelve days. In addition, each patient was encouraged to perform shoulder exercises at home. On the twelfth day, the post-intervention assessment was taken in the same manner as the pre-intervention assessment.

2.2.8. Statistical analysis

The Statistical Package for the Social Sciences (SPSS, v21) was used for statistical analysis. Demographic data such as age, gender and BMI were analyzed descriptively. Based on the Shapiro-Wilk test, skewness, kurtosis and box-plots, the normality of the data was resolved. A paired 't' test was employed to compare the effectiveness of DN at baseline and the end of twelve days. The probability value of 0.05 was considered statistically significant.

3. Results

Among 79 patients with AC recruited, 9 of them dropped out of the study. The final 70 patients, (male = 33 (47.14%) & female = 37 (52.85%)) with the mean and standard deviation of height was 1.68 ± 0.31 m; weight was 67.5 ± 6.69 kg; and body mass index (BMI) was 24.52 ± 1.32 kg/m^2. Based on the kurtosis and skewness statistics, the data were approximately normally distributed. The post-intervention results showed statistical significant ($p = < 0.05$) improvement in shoulder ROM: Flexion (154.2 ± 10.97), Extension (42.14 ± 8.14), Abduction (154.42 ± 9.42), Medial rotation (55.71 ± 9.71), Lateral rotation (57.42 ± 7.15) and VAS (2.80 ± 0.44), SPADI (27.52 ± 3.85) and PPT of Supraspinatus = 3.0 ± 0.39, Infraspinatus = 2.99 ± 0.44, Teres minor (3.0 ± 0.31), Subscapularis (2.95 ± 0.40), Deltoid (2.99 ± 0.33), Pectoralis major (1.54 ± 0.37) and Teres major (1.41 ± 0.37) muscles at the end of the twelve days of intervention as compared with baseline assessment: Flexion (108 ± 14.40), Extension (22.14 ± 6.78), Abduction (110.57 ± 13.92), Medial rotation (27.57 ± 6.9) and Lateral rotation (29.42 ± 3.35), VAS (7.94 ± 0.39), SPADI (84.71 ± 4.46) and PPT of Supraspinatus (1.46 ± 0.26), Infraspinatus (1.40 ± 0.26), Teres minor (1.43 ± 0.27), Subscapularis (1.46 ± 0.22), Deltoid (1.40 ± 0.29), Pectoralis major (3.19 ± 0.48) and Teres major (3.0 ± 0.43) muscles (Table 2).

4. Discussion

This study aimed to find the effectiveness of DN in patients with AC and hypothesized that the DN therapy for MTrPs might improve pain, ROM, PPT and disability associated with AC. This study added substantial evidence to support the potential clinical effect of DN among patients with AC (Clewley et al., 2014; Sukumar and Lawrence, 2014) that the pain arising from the trigger points of shoulder girdle muscles could restrict the ROM and impose a further burden on the disability associated with AC. Although AC was thought to be initially a disorder affecting the shoulder joint capsule, myofascial dysfunction may superimpose more pain, movement restriction and disability on already inflamed shoulder capsules. In addition, the development of trigger points within the muscles around the shoulder joint might be responsible for the pain and associated ROM restriction. Several studies had demonstrated that patients with AC experienced long-term pain, shoulder stiffness and disability even after regular physiotherapy management. Over 15% of AC patients suffered permanent functional disability and persistent symptoms (Hand et al., 2007; Koh, 2016). Integration of DN along with regular therapy could enhance the overall clinical outcomes among patients with AC.

Clinically, the AC had been considered to be the inflammatory sequela of the shoulder capsule and resulted in pain in various upper limb activities (Le et al., 2017). However, literature reported that the MTrPs in the shoulder girdle muscles could be a potential source of pain and impair movement (Sukumar and Lawrence, 2014) In this study, DN of trigger points demonstrated a significant reduction in pain intensity (2.80 ± 0.44) as compared with baseline pain score (7.94 ± 0.39). Although DN was considered to be effective for the management of MTrPs, the scarcity of literature existed the efficacy of DN in AC. Calvo-Lobo et al. (2018) investigated the efficacy of DN among patients with non-specific shoulder pain and treated with a single session of conventional

Table 2
Details of pre- and post-intervention changes in the outcome measures following dry needling.

Outcome Measure	Motions/Muscle	Pre test (Mean ± SD)	Post test (Mean ± SD)
Range of Motion (Universal Goniometer)	Flexion	108 ± 14.40	154.2 ± 10.97*
	Extension	22.14 ± 6.78	42.14 ± 8.14*
	Abduction	110.57 ± 13.92	154.42 ± 9.42*
	Medial Rotation	27.57 ± 6.9	55.71 ± 9.71*
	Lateral Rotation	29.42 ± 3.35	57.42 ± 7.15*
Pain intensity (Visual Analog Scale)		7.94 ± 0.39	2.80 ± 0.44*
Disability (SPADI)		84.71 ± 4.46	27.52 ± 3.85*
Pressure Pain Threshold (Pressure Algometer)	Supraspinatus	1.46 ± .263	3.0 ± .392*
	Infraspinatus	1.40 ± .265	2.99 ± .441*
	Teres Minor	1.43 ± .256	3.0 ± .3111*
	Subscapularis	1.46 ± .221	2.95 ± .40*
	Deltoid	1.40 ± .296	2.99 ± .330*
	Pectoralis Major	1.54 ± .373	3.19 ± .480*
	Teres Major	1.41 ± .377	3.0 ± .432*

SPADI= Shoulder Pain and Disability Index; SD= Standard Deviation, * = $p < 0.05$.

physiotherapy with DN for an active and latent MTrPs in infraspinatus muscle. A short-term reduction in pain intensity and PPT among treated patients as compared with the control group was reported (Calvo-Lobo et al., 2017). Similarly, in a single case report study, Passigli et al. (2016) reported immediate clinical measurable improvement in pain and shoulder ROM following DN for MTrPs of Infraspinatus, Teres minor and posterior Deltoid muscles in patients with posterior shoulder tightness (Passigli et al., 2016). DN attributed the reduction in the non-capsular origin shoulder pain by improving hemodynamics or pain-modulation via pain-gate theory (Baldry et al., 2001). Hence, the significant reduction in non-shoulder capsular pain could improve shoulder ROM among patients with AC.

Restricted shoulder ROM was the common clinical presentation in AC. According to the study results, there was a significant improvement in ROM after twelve days of intervention. This indicated that effective treatment of MTrPs improved the pain and myofascial dynamics, thus improved joint functions. In a case series, Clewley et al. (2014) reported that adding the DN along with conventional physiotherapy significantly improved pain and ROM. The authors incorporated DN in patient's treatment protocol and treated upper Trapezius, Levator Scapulae, Deltoid and Infraspinatus muscles when they observed improvement in the shoulder ROM in patients with AC (Clewley et al., 2014). Similarly, a single-blind randomized clinical trial reported significant improvement in shoulder abduction ROM following 2–3 sessions per week of DN in a patient with idiopathic AC. In this study, the MTrPs were treated for alternative days using DN and found significant improvement in all the ROMs of the shoulder joint (Sukumar and Lawrence, 2014). The aforementioned results clearly stated that the DN could improve the pain and joint ROMs associated with AC.

The patients with AC often experienced physical disability and activity limitations for many months due to pain and progressive loss of shoulder joint movements in all directions. The restricted ROM of shoulder flexion, abduction and rotations were significantly associated with a physical disability (Anwer et al., 2018). Hence, the physiotherapeutic intervention should not be limited to just alleviate pain and improve ROM but also aimed to restore the patients as effective social well-being. The results from the current study showed that effective management of MTrPs using DN had significantly improved physical disability (27.52 ± 3.85) as compared with baseline disability status (84.71 ± 4.46). Earlier published literature supported similar results as compared with the current study. Literature reported a significant improvement in the post-test reading of SPADI (10.76 ± 3.13) as compared to pre-test reading (110.08 ± 7.44) (Sukumar and Lawrence, 2014) following DN for MTrPs among patients with AC. Furthermore, A case report also reported 50 points significant reduction in SPADI post-test score (5) as compared to baseline score (55) following 13 sessions of DN treatment along with conventional physiotherapy (Clewley et al., 2014). Therefore, integration of DN as an adjunct protocol in the conventional physiotherapy treatment protocol might improve pain, joint functions, PPT and disabilities associated with AC.

4.1. Strength and limitation

This study has included a sufficient sample of 70 patients with AC whereas earlier studies reported single case series and an RCT with a small sample size. However, the lack of a control group in the current study makes it difficult to generalize the results to general populations. In addition, since the AC is a slowly progressive disorder of shoulder capsule; it is recommended that future studies should focus on the long-term effect of DN in improving pain, ROM, PPT and associated disability in AC patients.

5. Conclusion

DN treatment is an effective treatment technique along with conventional physiotherapy intervention in patients with AC. The outcomes presenting significant improvement in shoulder ROMs, pain, PPT and function following DN treatment suggest a possible benefit of DN treatment in patients with AC.

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CRediT authorship contribution statement

Varun Kalia: Formal analysis, was involved in study conceptualization, making study design, data analysis, interpretation of data and preparation of the manuscript. **Suresh Mani:** Writing - original draft, contributed to data compilation, table preparation, manuscript writing, and finalizing the manuscript. **Senthil Paramasivam Kumar:** Writing - review & editing, assisted in getting approval and ethical clearance. He also contributed to writing and editing the final manuscript.

Declaration of competing interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

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DRY NEEDLING WITH AND WITHOUT PARASPINAL NEEDLING IN PATIENTS WITH ADHESIVE CAPSULITIS. A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Background: Adhesive Capsulitis (AC) of the shoulder joint is a chronic disabling musculoskeletal condition affecting 2% to 5.3% of the world's general population. It results in pain, restricted ROM, impaired myofascial kinetics due to fibrosis of capsules and ligaments. Myofascial trigger points (MTrPs) that could further restrict shoulder movements by inducing girdle muscle tightness. MTrP dry needling (MDN) intervention and other conservative therapies in subjects with AC of the shoulder would enhance the clinical outcome. However, insufficient evidence available to support the local MDN with paraspinal dry needling (PSDN) for the AC management. The study's objective is to evaluate the efficacy of local MDN with and without PSDN in AC patients.

Methods: A total of 210 (98 male, 112 female) clinically diagnosed subjects with AC were recruited from a multi-specialty hospital and then randomly assigned to one of three groups. G1: Local MDN group (n=70) G2: Local MDN with PSDN group (n=70) G3: Conventional physiotherapy group (n=70). The outcome measures included pain intensity (VAS), shoulder ROMs (Goniometer), disability (SPADI), and pressure pain threshold (pressure algometer) were assessed at baseline and 12th day of the intervention.

Results: The statistically significant ($p < 0.05$) improvement in all shoulder ROMs (except lateral rotation), pain intensity, SPADI, and PPT in "G1" and "G2" compared to "G3" but no significant difference in between "G1" and "G2".

Conclusion: Local MDN is an effective treatment technique and conventional physiotherapy intervention, but PSDN does not have an additive effect on outcome measures in AC subjects.

Keywords: Adhesive Capsulitis, Physiotherapy, Pain, Disability, Impairment.

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INTRODUCTION

Adhesive Capsulitis (AC) is a chronic disabling musculoskeletal condition of the shoulder joint affecting 2% to 5.3% of the general population globally [1,2]. The beginning of shoulder pain accompanied by a diminished range of motion (ROM) is predominantly expressed by subjects with AC. The AC might either be primary (idiopathic) or secondary. There is no definite etiology or underlying pathology associated with primary AC. Primary AC occurs spontaneously, and they are least understood but the most common; on the other hand, secondary AC results from trauma [3]. Over 3.8% & 4.3% of secondary AC reported were linked to thyroid disease and diabetes mellitus, respectively [2,4]. Women are more affected by AC (approximately 70%) than men, but there is more risk for a longer recovery period and more significant disability in men [5].

While AC can impose a significant disability on individuals, it would also substantially burden healthcare expenditure. Literature reported that $7,000 and $8,000 are the estimated cost of annual health care and non–health care of AC per episode, and the societal cost was estimated at $55 per session (6). $53 per hour was the cost of home nursing care after hospitalization to treat AC with manipulation under anesthesia and acromioplasty. Home care services also cost $30 per hour [7]. So the evaluated significant burden on the subject, and the community suggested to achieve speed up healing, effective early management of AC is warranted [6].

While chronic inflammation-induced fibrosis of shoulder capsules and coraco-humeral ligaments [8] could have restricted shoulder ROM, the recent evidence elucidates impaired myofascial kinetics, shoulder girdle muscle tightness, and myofascial trigger points (MTrPs) that could further restrict shoulder movement [9]. In regular clinical practice, AC with restricted ROM has been managing various treatment approaches; however, the most successful treatment for this chronic disability condition remains debatable, and no specific treatment protocol has yet been developed [10]. Furthermore, the literature reported several treatment options such as electrotherapy modalities, dynamic splinting, continuous passive motion, total end range time, joint mobilization (10). Still, complete recovery was not attained with existing treatment protocols. Several studies have shown that the patient experiences long-term pain, stiffness, and disability despite regular conservative treatment [11,12]. It was reported 15% of AC subjects were still reported long-term disability, 7 to 15% permanent functional loss, and persistent symptoms in 40% following conservative interventions [12]. Therefore, there is a need for effective early treatment strategies that can help in the early recovery of AC subjects.

MTrP in the shoulder girdle muscles may be a possible non-articular source of pain and restricted ROM in AC [13]. The MTrPs are focal, hyperirritable areas of increased tension within a muscle. Recently, there is growing evidence to support the clinical efficacy of MDN for MTrP for the effective treatment of various musculoskeletal pain conditions [14]. In the process of dry needling, a solid monofilament needle is inserted into the muscle area with motor anomalies (i.e., taut bands) to decrease discomfort and promote expected muscle functions [15]. Page and Labbe (2010) reported that MTrPs in the subscapularis muscle induced a restricted flexion and external shoulder joint rotations [9]. In another study, Clewley et al. (2014) concluded in a case series that the introduction of MTrP dry needling intervention and other conservative therapies in subjects with AC of the shoulder would enhance the clinical outcomes [16]. Besides, Hyuk et al. (2007) have recommended myofascial dry needling (MDN) of MTrP along with paraspinal dry needling (PSDN), which improves pain, depression, and cervical ROM in elderly subjects with upper trapezius MTrP [17]. However, there is insufficient evidence to recommend the clinical efficacy of local MDN and PSDN for the management of subjects with AC. Therefore, the purpose of this study was to evaluate the efficacy of MDN with and without PSDN in AC subjects.

MATERIAL AND METHODS

Study Design and ethical approval

This study was a single-blinded, randomized controlled, three-arm parallel-group clinical trial accepted by the Clinical Research Ethical Committee of Lovely Professional University of Applied Medical Sciences (LPU/IEC/2018/01/04). In this clinical trial presentation, Consolidated Standards of Reporting Trials (CONSORT) guidelines were used.

Participants

The participants were recruited via the physician referral from an OPD of three multi-specialty hospitals. Subjects who were (a) medically diagnosed patients of AC based on the medical history, physical examination, and imaging if necessary (b) aged between 40-65 years (c) male or female (d) having pain and restriction in the shoulder for three months or more along with tender, taut, palpable band or nodule within muscles around the shoulder joint and (e) having normal cognitive function were taken into study. Additionally, the participants who had (a) skin disease around shoulder and neck (b) surgical history around the neck (c) taken anticoagulant medication within three days before study recruitment (e) history of malignancy-related pain within six months prior study (f) received injections in the trigger points to be punctured within three months prior study (g) extreme fear of needles (h) uncooperative behavior were eliminated from the study. Prior to the study, each subject was informed about the study procedure and received written informed consent. The sample size was determined using the clinical superiority design formula with minimal detectible change (MDC 95%) as 18 points on a SPADI with a standard deviation of 19 points from previous studies [18,19]. Assuming a 95 percent confidence interval and 80 percent of power, the calculated sample size was 70 subjects per group, with 210 subjects [20,21].

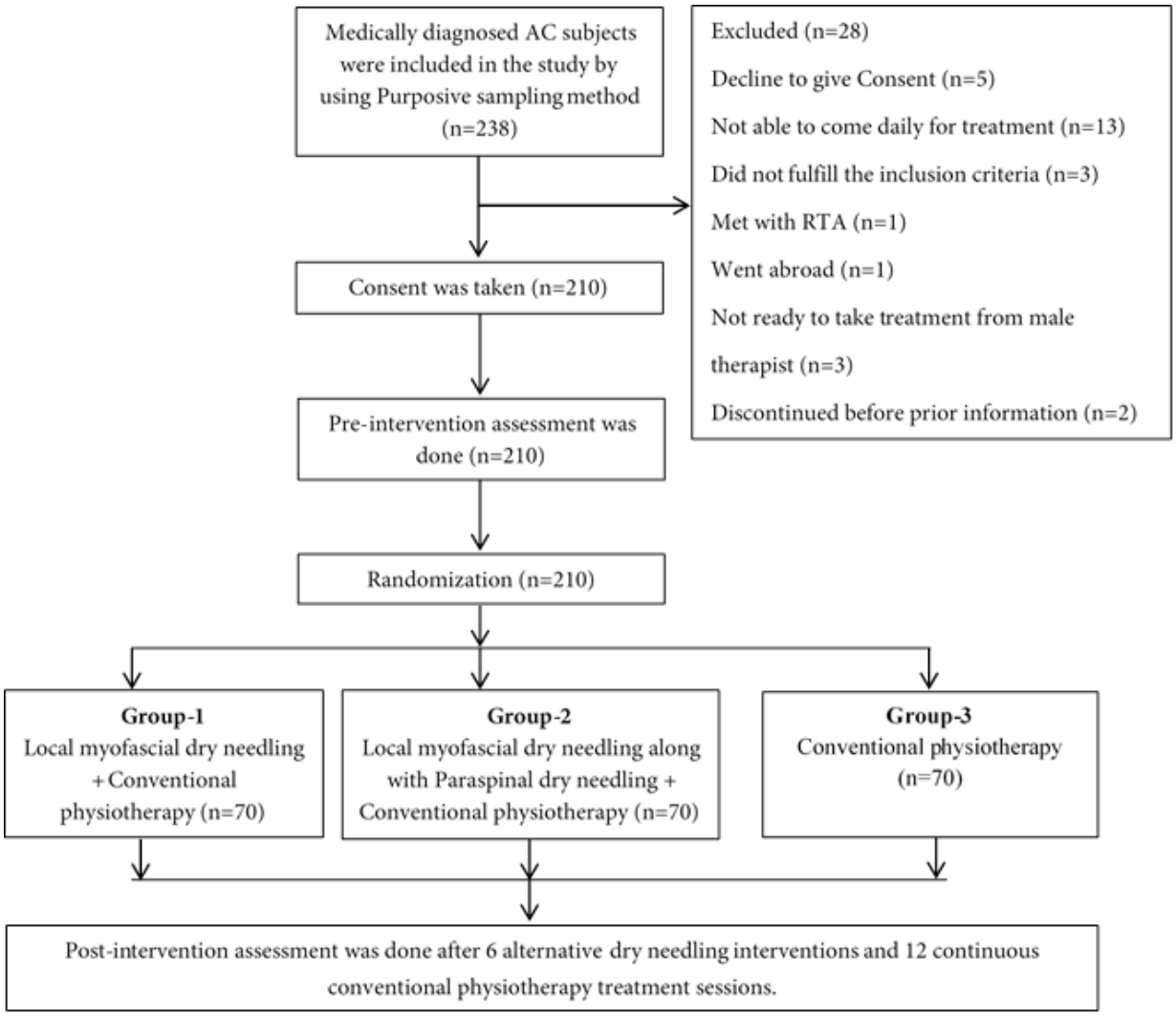
Randomization

Participants were allocated to one of the three groups using a simple randomization process.; local MDN group (G1), local MDN along with PSDN group (G2), or conventional physiotherapy group (G3).

Procedure

Each subject underwent a pre-intervention assessment of pain intensity, joint ROM, disability, and PPT trigger points of the muscles shoulder girdle (Supraspinatus, Subscapularis, Teres minor, Infraspinatus, Pectoralis major, Teres major, Deltoid and Upper trapezius muscles). Consequently, participants were randomly allocated to one of the three groups (a) G1 (n=70 (33 male, 37 female)), subjects received MTrP MDN for ten minutes in a session for the affected muscles for six alternative days and conventional physiotherapy treatment for twelve days. (b) G2 (n=70 (35 male, 35 female)), subjects received local MDN for ten minutes in a session for the affected muscles along with PSDN group of multifidus muscles at the nerve root levels of affected muscles around the shoulder joint for six alternative days and conventional physiotherapy treatment for continuous twelve days, (c) G3 (n=70 (30 male, 40 female)), subjects received conventional physiotherapy treatment includes SWD (one session of 20 minutes per day), therapeutic Ultrasound (one session of 10 minutes per day), TENS (one session of 20 minutes per day), joint mobilization (three sets of 10 repetitions with a rest interval of 30 seconds between each set), passive stretching exercises and active exercise (one session of 10 minutes per day) for continuous twelve days. The post-intervention assessment was measured at the end of two weeks.

Figure 1: Consort flowchart diagram



Dry needling procedure

The MTrPs were identified during a detailed physiotherapy assessment. If found, the trigger point was treated with the acupuncture needles (Suzhou Tianxie) of a 0.25 mm gauge of either 25 mm or 40 mm long targeted muscle and size of the subjects [22]. Table.1 describes the positions of the patient and joint and needle insertion techniques for different muscles of the shoulder girdle. Fast-in/out movement technique of needle in a conical form employed to target various sensitive loci and looked for the local twitch response. The needle remained in the affected muscle for ten minutes. After ten minutes, the needle was taken out, and the hemostasis was maintained. The needle was discarded into a sharps container (Table 1) [23].

Table 1: Details of dry needling techniques includes patient & shoulder position, palpation technique & Direction of needle insertion

Sl. No	Muscle Name	Patient position	Shoulder position	Palpation Technique	Direction of needle insertion
1	Supraspinatus	Prone lying	Neutral	Flat palpation	Longitudinal to frontal plane
2	Infraspinatus	Prone lying	Neutral	Flat palpation	Directed toward scapula
3	Teres minor	Prone lying	90° Abduction	Flat palpation	Directed toward lateral border of scapula
4	Subscapularis	Supine lying	90° abduction & 90° ER	Pincer palpation	Directed parallel to the ribcage
5	Deltoid	Anterior fiber- Supine Middle fiber- Side lying Posterior fiber- Prone lying	Slight Abduction	Flat palpation	Directed perpendicularly
6	Pectoralis major	Supine lying	Slight Abduction	Flat palpation	Directed toward shoulder
7	Teres major	Prone lying	Slight Abduction	Pincer palpation	Ventral and lateral direction

Electrotherapeutic Intervention

In addition to DN, electrotherapeutic interventions with Shortwave diathermy (SWD) Therapeutic Ultrasound and Transcutaneous electrical nerve stimulation (TENS) were also administered on the affected shoulder joint. The SWD (27.12 MHz) was applied using a contra-planner method with eightfold towel wide spacing for 20 minutes. According to the subject's feedback, the intensity was adjusted to produce comfortable warmth. Pulsed Ultrasound was applied with 1:4 pulse ration and 1.5 W/cm2 of intensity for ten minutes [24]. For TENS, the electrodes were placed on deltoid muscle and trapezius bellies and treated with the parameters (frequency 100 Hz, 0.05ms duration, modulation pulse shape, 9 volts) (25) aimed to stimulate A-delta fiber for 20 minutes to relieve pain. The current intensity was boosted until the subject reported light tingling sensation without any observational muscle contraction [25].

Mobilization Exercises

The affected gleno-humoral joint was treated with the passive oscillatory glides, including posteroanterior, anteroposterior, caudal, and caudal progression glides. Each glide was given for 30 seconds at the speed of 2-3 glides every second. Each glide was given for five sets with 30 seconds intervals between each set. Additionally, the conventional passive stretching of shoulder girdle muscles was also demonstrated and encouraged to perform at home. Each stretch should be held three times for 30 seconds, with 15 seconds of the interval between stretches [26] and active exercises using a towel for 5 minutes [27].

Outcome Measures

The Shoulder Pain and Disability Index (SPADI)

SPADI is a self-assessed questionnaire that consists of two subscales, i.e., pain and disability. SPADI has ICC ≥ 0.89, which shows it's a reliable tool with high internal consistency (Cronbach α typically greater than 0.90) and construct validity [28].

Pressure Pain Threshold (PPT)

A handheld pressure algometer examined PPT. A pressure algometer is a device with a 1 cm^2 metallic probe area that measures the force that eliciting a pressure pain threshold. The algometer was positioned in a vertical direction over a muscle's trigger point region and then pushed against the tester muscle with a steady rate of 1 kg / cm2 while increasing compressive pressure. Subjects were told to say "pain" when only minimal abnormal discomfort was felt. This process has been repeated three times with 5-minute rest in between each repetition [29]. This device has high validity [30] and good intra and inter-rater reliability of pressure rate application [31].

Pain intensity

Visual Analog Scale (VAS) was used to examine pain intensity. It is described as a 100-mm horizontal line where two extreme points represent "no pain at all" & "worst pain imaginable." Thus, it is a simple, reliable & valid optimal method that describes severe or intense pain with its ratio scale properties [32].

Range of motion (ROM)

A universal goniometer was used to assess shoulder ROM, as in the earlier published study [33]. The goniometric shoulder joint ROM assessment has excellent intra-rater reliability ($ICC_{3,1} \geq 0.94$) [34].

Statistical analysis

The Statistical Program for Social Sciences (SPSS, v21) was used to evaluate the collected data. Demographic data such as age, gender, and BMI were analyzed descriptively. Based on Shapiro-Wilk, skewness, and kurtosis statistics, the data's normality was determined, and all the parameters' data shows the normal distribution. Homogeneity of the data was determined using Levene's test, and all the shoulder ROMs, VAS, and SPADI showed homogeneity, but PPT did not have homogeneity. For between-group comparisons of all shoulder ROMs, VAS, and SPADI, analysis of covariance (ANCOVA) was used. In statistically significant ANCOVA outcomes, post hoc comparisons were performed using the Fisher least significant difference (LSD) test. Because of non-homogenous but normally distributed PPT data, Welch's ANOVA was used for between-group comparison. Post hoc comparisons were made using the Games-Howell test in statistically significant results. A probability value of less than 0.05 was considered significant.

RESULTS

Out of 238 subjects screened for eligibility, a total of 210 (98 male, 112 female) subjects with AC were recruited. The baseline demographic characteristics of all three groups were displayed in Table 2 and demonstrated the homogeneity.

Table 2: Baseline Demographic characteristics and Homogeneity of study subjects

Measure	Group – 1 n=70	Group – 2 n=70	Group – 3 n=70	*p- value*
	M ± SD	*M ± SD*	*M ± SD*	
Gender	Male= 33 (47.1%) Female = 37 (52.9%)	Male = 35 (50.0%) Female = 35 (50.0%)	Male = 30 (42.9%) Female = 40 (57.1%)	
Age (Years)	54.4 ± 5.67	54.5 ± 5.50	54.5 ± 5.64	0.99**
Height (Feet)	5.51 ± 0.31	5.53 ± 0.29	5.49 ± 0.33	0.80**
Weight (Kg)	67.5 ± 6.69	67.1 ± 6.67	67.2 ± 6.94	0.70**
BMI (kg/m^2)	24.52 ± 1.32	24.01 ± 1.37	24.38 ± 1.58	0.15**

Note. *SD* – Standard deviation, Group = 1 represents Local myofascial dry needling group (G1), Group- 2 represents Local myofascial dry needling along with paraspinal dry needling group (G2), Group – 3 represents Conventional physiotherapy group (G3). *BMI* – Body Mass Index, ***p* > 0.05.

There was a significant effect of MDN on shoulder ROMs in flexion [F(2, 206) = 18.01, p = 0.000], extension [F(2, 206) = 9.35, p = 0.000], abduction [F(2, 206) = 5.60, p = 0.004] medial rotation [F(2, 206) = 5.49, p = 0.005], Shoulder pain (VAS) [F(2,206) = 112.7, p = 0.000] and SPADI [F(2, 206) = 309.1, p = 0.000], but not a significant ROM for lateral rotation [F(2, 206) = 2.03, p = 0.13] for the three conditions. Post hoc comparisons using the Fisher's least significant difference (LSD) test showed that for flexion, extension, medial rotation, abduction range of motions, VAS and SPADI; the mean score for the local MDN condition and local MDN along with PSDN condition was significantly different than the conventional physiotherapy condition. However, the local MDN condition did not significantly differ from the local myofascial DN along with PSDN condition (Table 3).

Analysis using Welch's ANOVA showed that there was a significant effect of MDN on PPT for the three groups in supraspinatus muscle [F(2, 52.5) = 38.20, p = 0.000], infraspinatus muscle [F(2, 29.33) = 439.5, p = 0.000], teres minor muscle [F(2, 23.04) = 594.7, p = 0.000], subscapularis muscle [F(2, 29.11) = 434.7, p = 0.000], deltoid muscle [F(2, 16.79) = 246.0, p = 0.000], pectoralis major muscle [F(2, 20.43) = 231.19, p = 0.000], teres major [F(2, 14.37) = 353.9, p = 0.000] and upper trapezius muscle [F(2,45.41) = 45.94, p = 0.000]. The post hoc comparisons showed that all the tested muscles for PPT, the mean score for the local myofascial DN and local myofascial DN along with PSDN were significantly different than the conventional physiotherapy. However, the local MDN condition did not significantly differ from the local MDN along with PSDN condition (Table 3).

Table 3: *Analysis of Covariance (ANCOVA) and Welch's ANOVA show the changes in the shoulder specific outcome measures over twelve days of dry needling based intervention and post hoc analysis*

			Group 1-2			Group 2-3			Group 1-3		
	OM	F	MD	95% CI		MD	95% CI		MD	95% CI	
AR OM^	Flexion	18.01*	1.53	-1.03	4.11	5.97*	3.40	8.54	7.51*	4.89	10.1
	Extension	9.35*	-1.18	-3.22	0.85	4.33*	2.29	6.38	3.15*	1.11	5.18
	Abduction	5.60*	1.57	-0.59	3.74	2.24*	0.03	4.45	3.81*	1.56	6.07
	Medial rotation	5.49*	1.74	-0.66	4.15	2.29	-0.11	4.70	4.04*	1.62	6.45
	Lateral rotation	2.03	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pa in^	VAS	112.7*	0.10	-0.07	0.27	-1.1*	-1.35	-1.01	-1.0*	-1.25	-0.9
Disability^	SPADI	309.1*	-0.60	-1.91	0.70	-14.0*	-15.3	-12.7	-14.6*	-15.9	-13.3
	SSP	38.20*	-0.03	-0.32	0.24	1.17*	0.82	1.52	1.13*	0.79	1.48
	IS.	439.5*	-0.10	-0.36	0.15	1.59*	1.37	1.80	1.48*	1.33	1.64
	TMin	594.7*	-0.07	-0.28	0.13	1.56*	1.39	1.73	1.48*	1.34	1.63
PP T^^	SSC	434.7*	-0.02	-0.25	0.19	1.39*	1.23	1.56	1.36*	1.20	1.53
	Delt	246.0*	-0.05	-0.39	0.28	1.56*	1.29	1.83	1.50*	1.26	1.74
	PM	231.1*	0.09	-0.23	0.43	1.44*	1.21	1.67	1.54*	1.27	1.81
	TMaj	353.9*	0.10	-0.16	0.37	1.41*	1.22	1.61	1.51*	1.30	1.73
	UTpz	45.94*	-0.03	-0.24	0.18	1.22*	0.89	1.54	1.18*	0.87	1.50

Note. OM = Outcome measure, AROM = Active range of motion, CI = Confidence interval, MD = Mean Difference, Group 1-2 = between Local myofascial dry needling group and Local myofascial dry needling along with paraspinal dry needling group, Group 2-3 = Between Local myofascial dry needling along with paraspinal dry needling group and Conventional physiotherapy group, Group 1-3 = Local myofascial dry needling group and Conventional physiotherapy group, SSP = Supraspinatus muscle, IS = Infraspinatus muscle, TMin = Teres minor muscle, SSC = Subscapularis muscle, Delt = Deltoid muscle, PM = Pectoralis major muscle, TMaj = Teres major muscle, UTpz = Upper trapezius muscle, VAS = Visual Analog Scale, ^ = Parameter analyzed using ANCOVA test, ^^ = Parameter analyzed using Welch's ANOVA, * = p <0.05.

DISCUSSION

This study aimed to evaluate the effect of MDN & PSDN in subjects with AC and hypothesized that the MDN therapy for MTrP might improve pain, ROM, disability, and pressure pain threshold of MTrP associated with AC. This study added substantial evidence to support the potential clinical effect of MDN among subjects with AC [13,16] that the pain arising from the MTrPs of shoulder girdle muscles could restrict the ROM and impose a further burden on the disability associated with AC. Although AC is a disorder that affects the shoulder joint's capsule, myofascial dysfunction may superimpose more pain, movement restriction, and disability on already inflamed shoulder capsules. Besides, the pain and restricted ROM may be partly due to these developed MTrPs, mainly in

later AC stages. Several studies have demonstrated that subjects with AC experience long-term pain, shoulder stiffness, and disability even after regular physiotherapy management [11,12]. Over 15% of AC subjects suffered permanent functional disability, and persistent symptoms [12]/ Integration of MDN and regular therapy could enhance the overall clinical outcomes among subjects with AC.

While AC is a chronic inflammatory painful condition, the shoulder pain intensity was improved significantly in both G1 and G2 compared with G3. The MTrP in the shoulder girdle muscles may be the source of pain. Biochemically, the release of acetylcholine due to abnormal sympathetic activity and local hypo-perfusion in the MTrPs results in hypoxia that causes a decrease in pH level releases bradykinin, potassium, substance P, and cytokines, which stimulate the free nerve ending in the muscle, and causes pain [35]. Treating MTrPs using a dry needle induces a micro-trauma and bleeding. Literature reported that the dry needling induced hyperemia could dilute the pain sensitizing substances and relieves the pain. Also, Fernández et al. (2019) [36] reported dry needing also releases the endogenous opioids such as β-endorphin, which inhibit the release of the substance P. Despite there was no literature on the efficacy of MDN on the AC population, there is emerging evidence to demonstrate the clinical efficacy of MDN for the management of myofascial pain syndrome [36]. Calvo-Lobo et al. (2018) [37] reported a single dry needling session significantly reduced both local and distal pain in elderly adults with non-specific shoulder pain.

In this study, the shoulder ROM except shoulder lateral rotation showed significant improvement in both G1 & G2 compared with the conventional physiotherapy group (G3). It was postulated that the MTrPs, localized, painful, hyperirritable sustained muscle fascicular contractions could restrict the shoulder ROM [9]. Treating the MTrPs in the shoulder girdle muscle with the dry needle could induce the twitch response and release the muscle fascicular contraction, thus improved the shoulder function. However, dry needling of MTrPs of shoulder muscles did not show a significant improvement in the external rotation. This may be due to the pathological characteristic of the chronic inflammation and subsequent fibrosis of glenohumeral joint capsule AC resulting in the typical external rotation restriction.

The PPT shows significant improvement in both G1 and G2 as compared with the G3. The successful effect of the dry needle on PPT may be attributed to the mechanical pressure caused by the needle combined with its rotation polarizes the continuative tissue, which has an implicit piezoelectricity character. This mechanical pressure is converted into electrical energy, which enhances tissue reconstruction. When the needle is inserted, an axonal reflex strikes the terminal network of A-delta and C fibers related to the liberation of many substances with vasoactive action [38,39]. They cause vasodilatation and inflation of local blood flow, which decreases the number of algogenic substances and decreases the activity of nociceptors, resulting in resolution of peripheral sensitization [40]. The clinical studies reported treating an MTrPs with DN would improve the PPT [41] in upper trapezius [42] and Levator Scapulae [43] muscles.

Similarly, patients have demonstrated a significant reduction in shoulder disability in both G1 and G2 compared with G3. Neutralizing the MTrPs, the source of pain, and joint restriction resulted in improvement in disability following DN. Literature supports our findings that DN, along with exercise found to be beneficial in reducing impairment and quality of life in subjects with shoulder myofascial pain [44], chronic rotator cuff tendinopathy [45], and subacromial pain syndrome [46,47].

Finally, the study results indicate no substantial difference between the MDN and PSDN groups in shoulder pain severity, ROM, PPT, and disability. It implies that introducing the PSDN and MDN does not have any clinical implications that fail to reflect on the outcomes measures in patients with AC of the shoulder joint. Few studies claim that subjects treated with PSDN demonstrated substantial improvement in pain and joint function in acute facet joint dysfunction of the neck, [48] myofascial pain syndrome of upper trapezius [17] and non-specific thoracic pain syndrome [49]. It is noteworthy that in those conditions, the source of pain or restriction has a direct anatomical attachment with the spine; hence PSDN produced a substantial improvement. The other possible reason for the improvement in the joint function may be due to paraspinal muscle spasms themselves being a source of pain and joint restriction in facet joint dysfunction and myofascial pain syndrome.

Strength and limitation

This study has included a sufficient sample of 210 subjects with AC, whereas earlier studies reported single case series and an RCT with small sample size. The present study is not having long-term follow-up. AC is a slowly progressive disorder of the shoulder capsule; it is recommended that future studies evaluate DN's long-term effect in improving pain, ROM, and associated disability in AC subjects.

CONCLUSION

Local MDN treatment is an effective treatment technique along with conventional physiotherapy intervention in subjects with AC. The outcomes showing significant improvement in shoulder ROMs (except shoulder lateral rotation ROM), pain intensity, disability, and PPT after local MDN management indicate a potential benefit of DN intervention in subjects with AC. Still, PSDN is not having an additive effect on outcome measures.

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For this study, no funding sources or conflicts of interest were reported.

CRediT authorship contribution statement

VK: Investigation, Resources, data curation, Writing -

original draft. **SM**: Conceptualization, Methodology, Formal analysis, Writing - review & editing, Visualization, Supervision.

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Conference Presentation- I

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TO WHOM SO EVER IT MAY CONCERN

This is to certify that Dr. Varun Kalia, PT, HOD, St. Soldiers College of Physiotherapy, Jalandhar has delivered a talk on **"DRY NEEDLING IN FROZEN SHOULDER: A SPECIAL PERSPECTIVE"** in 3rd National Conference SYNAPSE-2017 held on 26th & 27th Oct. 2017.

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Conference Presentation- II

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Certificate of Participation

This is to certify that Prof./Dr./Mr./Ms. Varun Kalia

has **Presented E-poster/Oral presentation on** Short-term Effect of Myofascial Trigger Point-Dry-Needling in Patients with Adhesive Capsulitis.

presentation in International Conference of Pharmacy (ICP-2019) on the theme of " Pharmacy: Realigning the focus on health" held on 13-14th September 2019 organized by School of Pharmaceutical Sciences, Lovely Professional University, Punjab in a collabration with Indian Pharmacy Graduates' Assocaition (IPGA) Phagwara chapter.

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Conference Presentation- III

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2020-2021

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This is to certify that

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presented E-Paper at

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16th April - 9th May 2020

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09/05/2020

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