Research Paper

Hong Kong Physiotherapy Journal
Vol. 43, No. 2 (2023) 149–159
DOI: 10.1142/S1013702523500166

Hong Kong Physiotherapy Journal
https://www.worldscientific.com/worldscinet/hkpj

Comparison of Kaltenborn mobilization technique and muscle energy technique on range of motion, pain and function in subjects with chronic shoulder adhesive capsulitis

Sandeep Pattnaik*, Pravin Kumar, Bibhuti Sarkar and Anil Kumar Oraon

National Institute for Locomotor Disabilities (Divyangjan), Kolkata 700090, West Bengal, India

**sandypattnaik37@yahoo.com*

Received 30 March 2021; Accepted 9 May 2023; Published 21 June 2023

Background: Shoulder adhesive capsulitis (AC) is a common musculoskeletal condition causing pain, loss of range of motion (ROM) in the shoulder, and a decrease in its functionality, yet poorly defined and understood since its identification. Kaltenborn mobilization technique (KMT) and muscle energy technique (MET) are commonly used physiotherapeutic techniques for their treatment. To the best of our understanding, there was no study found to compare the effectiveness of one technique over another.
Objective: The objective of this study was to compare the effectiveness of KMT and MET on the ROM, pain and function in subjects with chronic shoulder AC.
Methods: In this single-centred, single-blinded quasi-experimental study with a pretest–posttest design 35 subjects were randomized into two groups: Group A ($n = 18$) received KMT and Group B ($n = 17$) received MET along with the moist hot pack (MHP), supervised exercises and home exercises common to both the groups. A total of 32 subjects completed the study with three dropouts. Subjects were evaluated before and after 10 treatment sessions for the outcomes, shoulder external rotation passive range of motion (ER-PROM) and abduction passive range of motion (ABD-PROM) using the universal goniometer, intensity of pain using the numeric pain rating scale (NPRS) and functional disability using the shoulder pain and disability index (SPADI).
Results: Analysis of 32 subjects showed that both groups were homogenous at baseline. The within-group analysis showed significant improvement ($p < 0.05$) in both groups related to all the outcomes. But when we compared the groups, Group B showed significant ($p < 0.05$) improvement in NPRS and SPADI in

*Corresponding author.

comparison to Group A. However, there was non-significant ($p > 0.05$) difference found in ER-PROM and ABD-PROM.
Conclusion: Both KMT and MET are effective in improving ROM, pain and function but MET showed a significant reduction of pain and improvement in function in subjects with chronic shoulder AC, thus supporting its use as a physiotherapeutic treatment technique.

Keywords: Adhesive capsulitis; frozen shoulder; Kaltenborn mobilization technique; muscle energy technique; shoulder pain.

Introduction

Adhesive capsulitis (AC) is a disabling self-limiting inflammatory process that affects the shoulder capsule, which is characterized by the gradual and painful loss of both active and passive range of motion (ROM) in all planes of the glenohumeral joint, resulting from progressive fibrosis and contracture of the joint capsule.[1] Naviesar in the year 1945 coined the term "adhesive capsulitis". Its synonyms include "peri-arthrite scapulo-humerale" and "frozen shoulder".[2] It has a prevalence of 7% among the general population and 17.9% among the diabetic population with the age of incidence between 35 and 65 years.[2,3] Based on the clinical presentation, Reeves (1975) categorized its clinical course into three stages, "freezing" (stage of pain), "frozen" (stage of significant stiffness) and "thawing" (stage of recovery) with an average course of 30 months.[4]

Physiotherapy along with medications is considered the first line of management for AC, which includes a wide variety of manual and electrotherapy interventions. However, the most effective treatment intervention remains an area of debate. Kaltenborn mobilization technique (KMT) and muscle energy technique (MET) are two commonly used manual techniques in physiotherapy.[5,6]

KMT evaluates the motions on the articular surfaces and applies them to treatment according to MacConaill's classification of synovial joints to restore the reduced accessory glides and achieve painless physiological movements. KMT involves the application of a passive sustained joint play that can be graded from I to III based on the type and amount of force applied. Grade-I, "loosening" refers to small-amplitude joint distraction that produces an appreciable increase in joint separation without any stress on the capsule that equalizes the cohesive forces, muscle tension and atmospheric pressure acting on the joint. Grade-II, "tightening" refers to the distraction or glide movements applied to tighten the tissues around the joint, also known as "taking up the slack". Grade-III, "stretching" refers to the distraction or glide movement applied to stretch the joint capsule and surrounding periarticular structures, thus, increasing joint ROM.[7]

MET is a non-invasive manipulative technique designed to mobilize joints and lengthen muscle and fascia based on the principles of reciprocal inhibition, post isometric relaxation and joint mobilization.MET targets the soft tissues like muscles and fascia primarily, but it also makes a major contribution to the mobilization of joints.[8]

Several studies have individually investigated the efficacy of both the techniques and have proven their effectiveness as an intervention for chronic shoulder AC.[5,6,9,10] But few literature evidence shows the comparison of these two techniques in subjects with chronic shoulder AC. Therefore, the study was done with the purpose to compare the effectiveness of KMT and MET on ROM, pain and function of the shoulder in subjects with chronic shoulder AC as this study will add to the growing body of knowledge that if these two techniques yield comparable outcomes and if one technique is superior to the other, which should be the choice of therapy. It was conducted with the hypothesis that there is no statistical significant difference between KMT and MET on ROM, pain, and function in subjects with chronic shoulder AC.

Methods

Study design

This was a single-blinded single-centred quasi-experimental study of pretest–posttest design conducted at the Department of Physiotherapy, National Institute for Locomotor Disabilities (Divyangjan) (NILD), Kolkata within a period of 12 months between April 2019 to March 2020.

Approval of the Institute Ethical Committee (IEC) was taken before beginning the study with the review Paper No. IEC/1610/R&D/08/NIOH/758.

Subjects

In this study, all the subjects diagnosed with AC and referred to the department of physiotherapy, NILD for further rehabilitation by the orthopedists in the outpatient department of the institution were approached with the proposal of the study. The diagnosis was done based on clinical presentation, thorough radiological evaluation, and ruling out other shoulder conditions. A total of 113 subjects with chronic AC were evaluated for possible eligibility, out of which 35 subjects were selected as per the inclusion and exclusion criteria. 78 subjects were excluded and 10 were not willing to participate. Both male and female subjects of the age group between 35 and 50; having AC for more than 3 months or with 'frozen stage' AC, characterized by an increase in joint stiffness and moderate pain; more than 30% limitation of shoulder external rotation and abduction passive range of motion (PROM)[9,11] and pain intensity by numeric pain rating scale (NPRS) between 3 and 7[12,13] were included in the study. Subjects were excluded if they exhibited shoulder instability due to recurrent dislocation or rotator cuff tear; fracture and post-fracture stiffness around the shoulder; degenerative conditions (acromioclavicular or glenohumeral osteoarthritis); shoulder impingement syndrome, supraspinatus tendinitis, and painful arc syndrome; rheumatic diseases (rheumatoid arthritis, ankylosing spondylitis); infection or tumor around the shoulder; any history of shoulder surgery, manipulation under anesthesia, local corticosteroid or physiotherapy to the affected shoulder within last three months; shoulder functional defects accompanying neurological disorder (Parkinson's disease, stroke, reflex sympathetic dystrophy, cervical radiculopathy) and non-cooperative subjects. 35 subjects who met the inclusion criteria and agreed to participate were explained in detail about the study and written informed consent was taken in their preferred language before their enrolment in the study.

Randomization

The enrolled subjects were randomized into two groups by simple random sampling and chit-picking method. "Group A" consisted of total 18 subjects who were treated with KMT and "Group B" consisted of 17 subjects who were treated with MET along with moist hot pack (MHP), supervised exercises (stretching of shoulder internal rotators and adductors, active Codman's pendulum exercise) and home exercises common to both the groups Fig. 1. Subjects remained blinded to their allocated groups and the outcome assessments, whereas based on the nature of the study it was impossible to keep the assessor or the treating therapist blinded, hence a single-blinded study.

Outcome measures

Outcome measures used in the study were shoulder external rotation and abduction PROM measured in degrees by half-arc metal universal goniometer; pain intensity at rest measured using NPRS and shoulder function measured in percentage by shoulder pain and disability index (SPADI). The values were taken at pre-intervention and the end of 10 treatment sessions.

The universal goniometer is a simple, reliable, and valid clinical tool most commonly used to measure shoulder PROM.[14,15] A single measurement was taken for the assessment of PROM.

The NPRS is a reliable and widely used measuring tool for the pain intensity in clinical practice whose responsiveness has been validated by several researchers.[16,17]

The SPADI is a self-administered questionnaire that can be used to assess pain level and the extent of difficulty with ADLs requiring the use of the shoulder. It has acceptable reliability, validity and sensitivity to changes in the case of shoulder pathologies like shoulder AC.[18,19] English version of SPADI was used for the study. However, in the case of Hindi or Bengali-speaking subjects, it was orally translated into their respective language by the assessing therapist.

Intervention

The interventions for both the groups in all the 10 sessions were provided by a single physiotherapist, who was trained in KMT as well as in MET.

Each treatment session in both groups started with the application of MHP over the affected shoulder with the subject in a relaxed sitting position for 15 min. Hot packs consisting of bentonite crystals enclosed in canvas cover and wrapped in terry vinyl cover and towel with three to four folds,

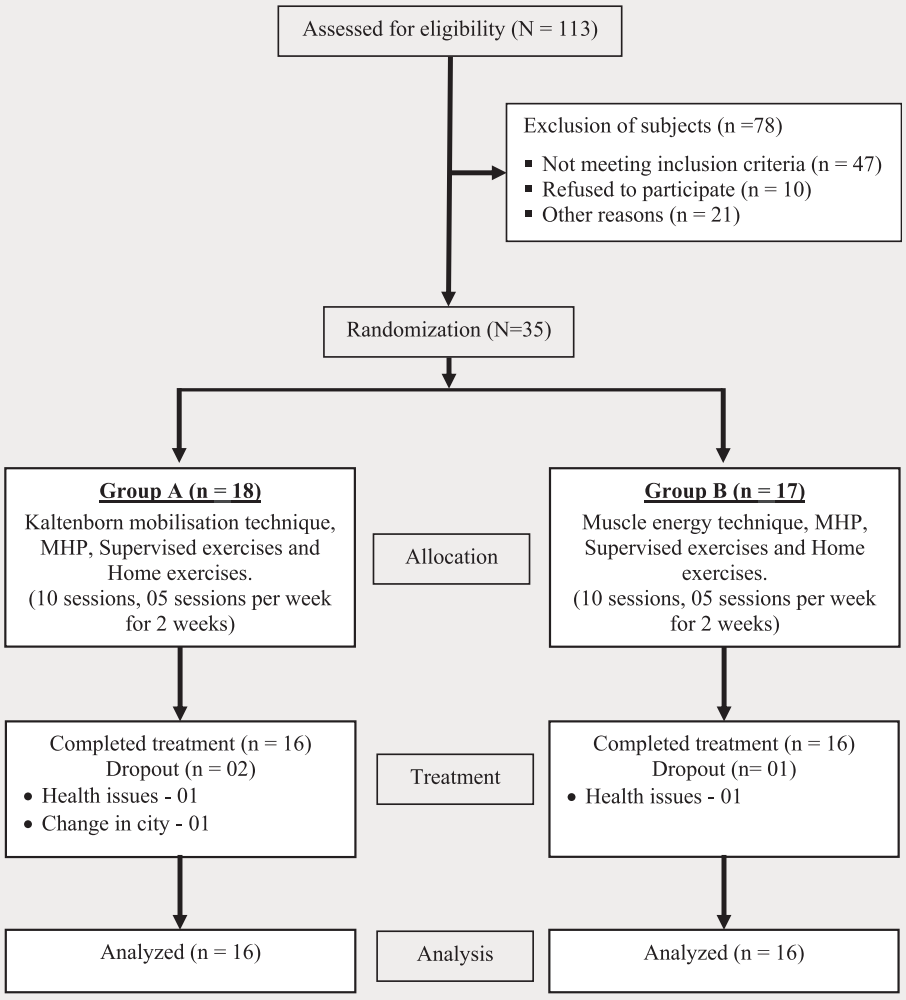


Fig. 1. Consort flow diagram.

that were preheated for 30 min to 75–80°C in the hydrocollator unit of Biowave health care (Biowave health care, New Delhi, India) were used for the treatment.[20] Subsequently, they were treated by assigned manual therapy along with supervised exercises for 10 sessions (five sessions per week for two weeks).

In the first session, each subject was prescribed home exercises that included shoulder anterior capsule self-stretching and wall-ladder exercise. Subjects were asked to hold the stretch of anterior shoulder capsule for 15–20 s and repeat it five times. Whereas the wall-ladder exercise was to be repeated 10 times per session at home regularly.[21] Regularity of practice was checked by inquiry on the following day.

KMT group A

Following the application of MHP, subjects in the KMT Group A were treated with 15 sets each of glenohumeral traction, ventral glide and caudal glide of the glenohumeral joint in the above-stated sequence with each set of 30 s hold and 10 s rest-time in between for a total period of 10 min (Fig. 2).

For glenohumeral traction, each subject was in supine lying with the scapula fixed, affected shoulder in resting position and elbow flexed to 90°. The therapist was standing by the affected side gripping both the ends of the affected arm. A mobilization belt was placed around the proximal humerus and the therapist's body. KMT Grade-I traction was then applied to the glenohumeral joint by pulling the belt along with the therapist leaning backward.[7] An 8 feet long and 2 in wide adjustable black-colored VPK mobilization belt made of nylon was used to apply glenohumeral traction that can be adjusted to change the length of the belt according to the convenience of use.

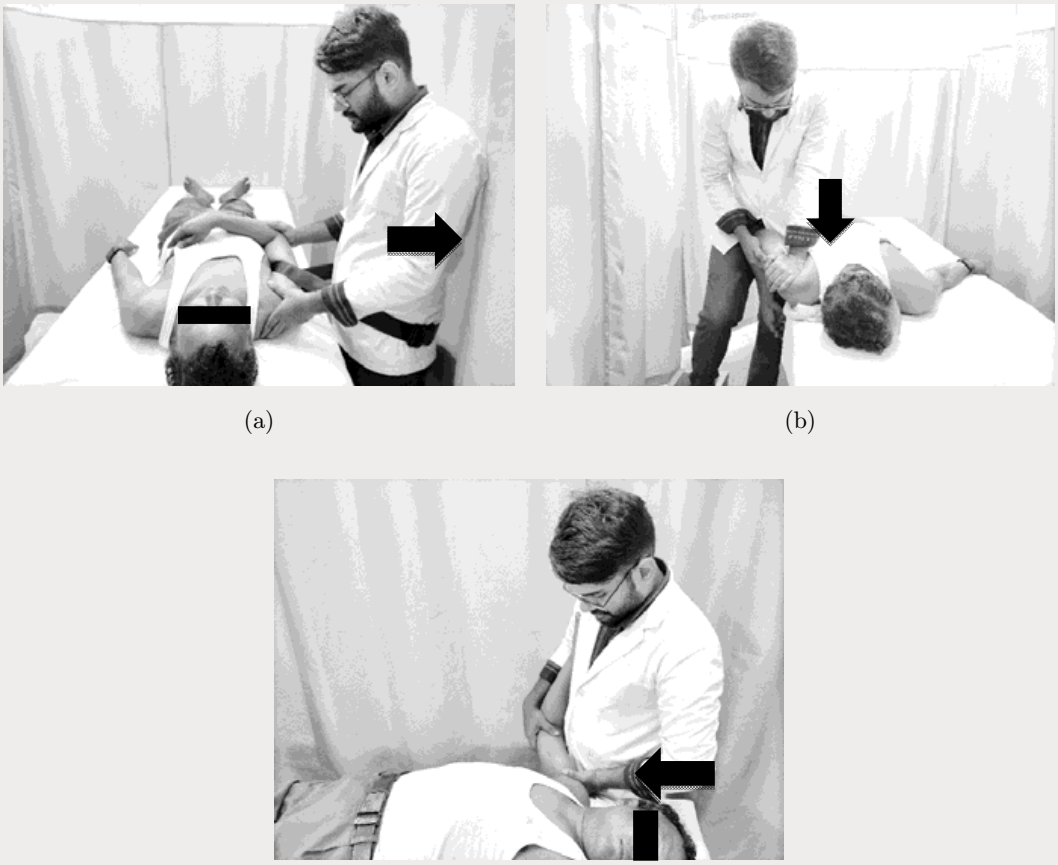
Subsequently, for ventral glide, each subject was in prone lying with the scapula fixed and the affected shoulder positioned at its available pain-free end range of extension and external rotation. The scapula was fixed with a towel wedged under the coracoid process to avoid excessive protraction of the scapula resulting from the ventral pressure by the therapist. The therapist was standing by the side, holding the anterior aspect of the distal humerus against his own body with one hand and with the other was pushing the head of the humerus anteriorly from its posterior aspect to apply KMT Grade-III sustained stretching ventral glide.[7]

Lastly for caudal glide, each subject was in supine lying with the scapula fixed and affected shoulder at its end range of abduction. Therapist was standing by the affected side at the cranial end and with one hand was supporting the subject's arm and with the other hand was pushing the humeral head caudally from its cranial end to apply KMT Grade-III sustained stretching caudal glide.[7]

MET group B

Group B was treated with MET for shoulder external rotation and abduction following MHP application. MET for shoulder external rotation and abduction was given for five repetitions per set for three sets each (Fig. 3).

For shoulder external rotation the subject was in supine lying with arm abducted to 90°, elbow flexed to 90° and the therapist was by the same side. In subjects with shoulder abduction PROM less than 90°, the shoulder was placed in available pain-free abduction end-range with the elbow flexed to 90°, and subsequently with the progression of treatment when the 90° shoulder abduction PROM was achieved, it was placed in 90° of abduction. The shoulder was positioned at its physiological barrier for external rotation by the therapist and subjects were asked to statically contract muscles towards their freedom of motion that is internal rotation (away from the barrier(s) of restriction) and the therapist was resisting any movement of the part. The contraction was held



(a) (b) (c)

Fig. 2. KMT (clockwise): (a) glenohumeral traction; (b) ventral glide; (c) caudal glide.

for about 10 s. The subjects were then asked to relax for 5 s or so, between the contraction efforts, at which time the therapist could re-engage the joint at its new motion barrier.[5,8]

For shoulder abduction, the subject was in supine lying with the shoulder positioned at its physiological barrier for abduction. The therapist was by the side stabilizing the lateral border of the scapula with one hand and with the other resisting the statical muscle contraction of the subject towards their freedom of motion that is adduction (away from the barrier(s) of restriction). The contraction was held for about 10 s. The subjects were then asked to relax for 5 s between the contraction efforts, at which time the therapist could re-engage the joint at its new motion barrier.[5,8]

Following the treatment of subjects with the assigned manual therapy, each subject in both the groups was treated with supervised exercises at the department itself, which included stretching of shoulder internal rotators and adductors along with Codman's pendular exercise. In each session, shoulder internal rotators and adductors were stretched for 15–20 s and were repeated five times each. Codman's pendular exercise was done for both flexion-extension and abduction-adduction, 10 times each per session.[22]

Statistical Analysis

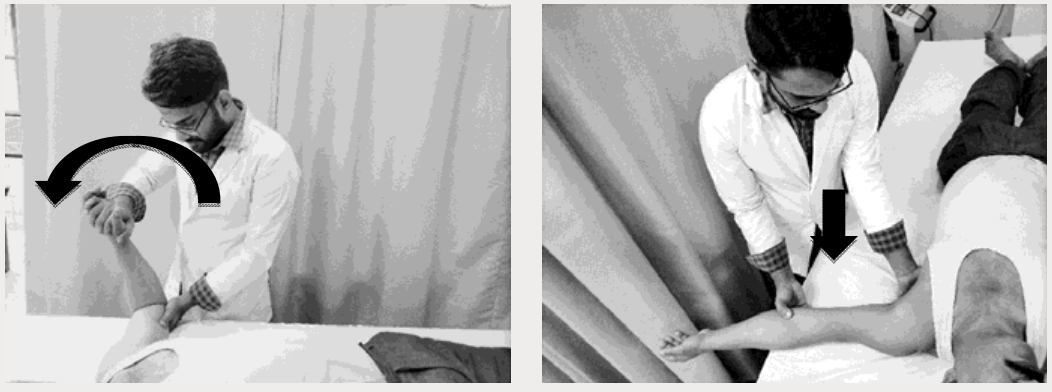
Statistical analysis was performed using IBM Statistical Package for Social Science (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Amongst the demographic data, categorical data were analyzed using the chi-square test and the ordinal, interval or ratio level data were analyzed using the independent sample t-test. Given the total sample size ≥ 30, the central limit theorem applies.[23,24] Thus, the within-group difference was analyzed using the paired sample t-test and between-group differences, both at baseline and after treatment was analyzed using the independent sample t-test for all the outcomes. Assuming the effect size of 0.5 (Cohen's d), all the tests were applied at a 95% confidence interval on the α value set at 0.05 and 80% power. The level of significance was set at $p \leq 0.05$.

Results

Figure 1 depicts the study profile. Of the recruited 35 subjects, only 32 subjects distributed over two groups fulfilled the treatment protocol of the assigned group. A total of three subjects dropped out (two from Group A and one from Group B) for not completing the total treatment sessions. These data were not included for analysis. The intention to treat analysis was not used. Instead, the per-protocol analysis was used.

Table 1 represents the demographics and baseline characteristics of both groups. There were statistically non-significant ($p > 0.05$) differences between the two groups in terms of demographic characteristics and baseline variables before treatment thus indicative of homogeneity between the groups.

Table 2 represents within-group and between-group comparisons. Within-group comparison following 10 sessions of interventions, were suggestive of statistically significant differences ($p < 0.05$) concerning shoulder external rotation and abduction PROM, pain intensity (NPRS) and function (SPADI) in both Group A and Group B.



(a) (b)

Fig. 3. MET (left to right): (a) for shoulder external rotation; (b) for shoulder abduction.

Table 1. Demographics & pre-intervention data.

Variables	Group A	Group B	*t*-value	*p*-value
Age (Years)	47.31 ± 4.40	48.87 ± 5.93	−0.84	0.404
Male/Female*	11:05	08:08		0.280
Duration of Symptoms (Months)	7.00 ± 4.91	5.19 ± 3.82	1.164	0.254
ER-PROM$_0$	24.13 ± 9.26	25.56 ± 9.60	−0.43	0.669
ABD-PROM$_0$	78.19 ± 8.92	75.31 ± 10.27	0.85	0.404
NPRS$_0$	6.25 ± 0.86	5.88 ± 0.81	1.275	0.212
SPADI$_0$	64.85 ± 8.14	62.27 ± 11.52	0.73	0.471

Notes:

- ABD-PROM$_0$ = Abduction passive range of motion at pre-intervention.
- ER-PROM$_0$ = External rotation passive range of motion at pre-intervention.
- NPRS$_0$ = Numeric pain rating scale at pre-intervention.
- SPADI$_0$ = Shoulder pain and disability index at pre-intervention.
- Quantitative variables are presented as mean ± SD and categorical variables (*) as the number.

Whereas in between-group comparison, Group B showed statistically significant improvement over Group A in pain intensity and function ($p < 0.05$), but there were non-significant differences between the groups for shoulder external rotation and abduction PROM ($p > 0.05$) after 10 sessions of intervention.

Discussion

This study aimed to compare the effectiveness of KMT and MET on ROM, pain and function in subjects with chronic shoulder AC. During the intervention in both the groups, there was no report of any adverse reactions, i.e., increase in pain, discomfort, etc., or aggravation of symptoms.

ROM

Consistent with previous literature, the result of this study shows that the shoulder PROM increased significantly with both the KMT and MET when applied along with pre-determined supervised and home exercise protocols for 10 sessions.[6,9,22,25]

The effectiveness of KMT could be based on the characteristics of creep which indicates an increase in deformation of viscoelastic structures under constant load. Based on this property when the shoulder joint was subjected and maintained to its maximum arthrokinematic motion at its end-range then it resulted in stretching and deformation of the periarticular structures, thus, generating maximum elongation of the anterior and inferior joint capsule and helping in realigning the humeral head with the glenoid cavity.[26,27] Before the application of glides, glenohumeral traction was also applied which may have caused passive elongation of periarticular components and minimized the joint contact zones thus helping with the movement within the articulating surfaces.[7]

On the other hand, the increased shoulder external rotation and abduction PROM following MET could be explained by the osteoligamentous system mobilization that is, during its application when the targeted shoulder internal rotators and adductors were isometrically contracted against the therapist's force stabilizing the humerus on which those muscles are inserted, then the pull of

Table 2. Intra-group & inter-group comparison.

	Group A			Group B			Inter-group
	Pre-intervention	Post-intervention	*p*-value	Pre-intervention	Post-intervention	*p*-value	*p*-value
ER-PROM	24.13 ± 9.26	50.69 ± 15.90	0.000	25.56 ± 9.60	53.75 ± 19.88	0.000	0.634
ABD-PROM	78.19 ± 8.92	122.31 ± 20.01	0.000	75.31 ± 10.27	124.81 ± 24.73	0.000	0.756
NPRS	6.25 ± 0.86	3.00 ± 1.63	0.000	5.88 ± 0.81	1.75 ± 1.61	0.000	0.037*
SPADI	64.85 ± 8.14	38.60 ± 9.26	0.000	62.27 ± 11.52	30.01 ± 13.72	0.000	0.048*

Notes:

- ABD-PROM = Abduction passive range of motion.
- ER-PROM = External rotation passive range of motion.
- NPRS = Numeric pain rating scale at pre-intervention.
- SPADI = Shoulder pain and disability index.
- Quantitative variables are presented as mean ± SD.
- (*) = *p*-value < 0.05, Group B statistically significant over Group A.

those muscles results in the desired accessory motion at the joint, that is anterior and inferior glide, respectively, thus stretching the shoulder capsule, rotator interval and ligaments along with it and mobilize the joint.[21] Elongation of the periarticular structures based on the viscoelastic properties of creep may have also contributed to improving the ROM following the application of MET.[5]

The adjunct therapy of MHP and passive stretching of the shoulder adductor and internal rotator may have also helped in increasing the ROM by reducing muscle viscosity and inducing neuromuscular-mediated relaxation.[28,29] Thus, the improvement in PROM in both the groups could be due to the individual effect of the assigned intervention or could be due to the cumulative effect of respective interventions along with MHP and passive stretching exercises. So the real cause of improvement in both the groups remains a matter of discussion and requires further research.

Pain

In this study, both the KMT and MET groups showed a decrease in pain intensity post-intervention and both the technique exhibited a hypoalgesic effect. But on the comparison between the groups, the effect of MET was more statistically significant in reducing pain.

The most accepted mechanisms that could be responsible for the reduction of pain intensity in both the groups encompassing the two physiotherapeutic techniques are its neurophysiological effects by the stimulation of type-II mechanoreceptors while inhibiting type-IV nociceptors[30] and the muscle relaxation mediated by increased afferent input from the Golgi-tendon organs at the end of both KMT and MET that results in a decrease in joint concentric activation, muscle tension in the periarticular tissues thus alleviating pain.[31]

Along with the assigned interventions each subject was also treated with MHP. MHP has a central effect of non-noxious skin warming on increased activation of the thalamus and posterior insula of the brain and innocuous tactile stimulation of the skin activates the thalamus and S2 region of the cerebral cortex which may alleviate the sensation of pain thus helping in reduction of pain. It also facilitates blood flow to the area and helps with the healing.[32] It may have an additional effect on the reduction of pain intensity. Application of MHP before other interventions also helped in preparing the joint for intervention, by reducing the muscle guarding and increasing the extensibility of the periarticular structures.[29]

During shoulder movements, the abnormal translation of humerus within the glenohumeral cavity with shoulder AC causes the nerves to be entangled and bow-string around the joint. Those usually get irritated with the joint mobilization or gliding techniques, which results in some residual pain even after the treatment of the cause. This may have been the reason, why KMT was found to be less efficient in reducing pain intensity as compared to the MET.[33]

The psychological aspect of MET, that is subjects feeling more involved with the technique as it involves active contraction of muscles against therapists resistance instead of passive mobilization of the joint in the case of KMT may have also influenced the result.[34]

But there are very few literature works that can explain and support these findings, so it requires further research in this regard.

Function

Shoulder pain and limitation in multi-directional movement reduced the functionality in subjects with shoulder AC. Following the intervention, as the pain reduced and there occurred an increase in ROM, it resulted in an overall improvement in shoulder function.

Other than the increase in ROM and reduction in pain, both the techniques induce rheological changes in synovial fluid, increase the exchange of fluid between synovial tissue and the cartilage matrix, enhanced synovial fluid turnover and increase the supply of nutrition, and help in progressing in a proper process of healing, thereby improving the shoulder functionality in both groups.[35]

The significant improvement concerning the shoulder function in Group B as compared to Group A could be explained by the improvements in the subgroups. The subjects in Group B showed marked improvement in terms of pain as compared to Group A while the improvement in terms of ROM was statistically similar to both the groups, thus giving an advantage to Group B over Group A in improving functionality.[36,37]

In this study MET was found to be a significantly better therapeutic intervention as compared to KMT in improving shoulder function but it

lacks any literature to support the result, thus requiring further research on this context.

Limitations

Some of the limitations associated with the studies are that this study was single-centered and evaluated only short-term results without any follow-ups in a condition in which flare-ups are common, requiring a long-term follow-up period. It also did not have any control group to compare the relative effectiveness of the treatment procedure, as the improvement in both the groups could be due to the adjunct therapy or it could be self-limiting, considering its tendency of natural recovery. Due to the nature of the study, it was also impossible to blind the treating physiotherapist. Lastly, the irritable effect of joint mobilization was not taken into consideration before its application, which may have affected the result on the intensity of pain.

We recognize that general AC population-based multi-centered experimental studies with a control group and long-term post-intervention follow-up are needed to allow a more generalized interpretation of these results. Regarding this topic, our sample consisted of subjects with chronic shoulder AC, in the frozen stage. So the treatment protocol can be generalized for the population in the frozen stage of the shoulder AC and may not be generalizable to the population with acute shoulder AC or in the later course of the disease.

Conclusion

The result of this study demonstrated that both KMT and MET were effective in improving ER-PROM and ABD-PROM; decreasing the intensity of pain and improving function but when we compared the groups, MET showed a significant reduction in pain and improvement in function whereas there was non-significant difference found between both groups for ER-PROM and ABD-PROM in subjects with chronic AC.

Clinical Implication

The result suggests that the MET along with therapeutic exercises can be used as an alternative in subjects with chronic shoulder AC, especially to reduce pain and improve functionality.

Conflict of Interest

The authors declare that there is no conflict of interest relevant to the study.

Funding/Support

The authors declare that there is no funding for this study.

Author Contributions

The authors indicated in parentheses made substantial contributions to the following tasks of research: Initial conception and design (S. Pattnaik, P. Kumar, B. Sarkar and A. K. Oraon); treatment of patient (S. Pattnaik); Collection of data (S. Pattnaik); Analysis and interpretation of data (S. Pattnaik and A. K. Oraon); writing and revision of paper (S. Pattnaik, P. Kumar and A. K. Oraon).

Acknowledgments

The authors would like to thank all of the subjects in this study for their attendance and participation, which are greatly appreciated.

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