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Effect of Scapular Movement Training on Pressure Pain Threshold, Pectoralis Minor Length, Scapular Dyskinesis and Shoulder Function in Adhesive Capsulitis: A Single Blind Randomized Controlled Trial

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Abstract:

- ***Background***

Adhesive capsulitis is a common painful shoulder condition. Scapular dyskinesis is commonly seen in patients with adhesive capsulitis. Studies suggest that the shortness of pectoralis minor muscle can be responsible for scapular dyskinesis. Scapular movement training is a movement based training system. It has been proved effective in reducing pain and improving function in patients with chronic shoulder pain. Hence, this study is trying to find out the effect of scapular movement training on pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis.

- ***Purpose***

To find out the effect of scapular movement training on pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis.

- ***Materials and Method***

The randomized controlled trial was conducted on twenty six subjects who were divided into two groups, control and intervention groups. Pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function were assessed using pressure pain algometer, pectoralis minor index, scapular dyskinesis test and shoulder pain and disability index, respectively. Intervention was started after the initial assessment. Both groups performed the intervention 3 times a week for 6 consecutive weeks. Pre scores were taken before the intervention, post scores after 6 weeks and a follow up score after 9 weeks.

- ***Results and Discussion***

The within group analysis for outcome measures were performed using paired t test for normally distributed data and Wilcoxon signed rank test for non normal data. Between group analysis for outcome measures were performed using independent t test for normally distributed data and Mann Whitney U test for non normal data. The results showed that there is significant effect of scapular movement training on all of the outcome measures ($p<0.001$, at 95% confidence interval), whereas there is significant long term follow up effect on these outcome measures ($p<0.05$, at 95% confidence

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interval) except for pressure pain threshold for levator scapulae and shoulder function. Patients with adhesive capsulitis exhibit improper activation and control of muscles and weakness, resulting in decreased pressure pain thresholds of shoulder muscles. Shortened pectoralis minor muscle is reported to increase scapular dyskinesis by increasing anterior scapular tilt. Both shortened pectoralis minor muscle and altered activation of scapular stabilizing muscles ultimately result in scapular dyskinesis. Scapular focused exercises concentrating on controlled exercise progressions with feedback can help to improve muscle control, re-educate neuromuscular activity, improve motor control and central processing and optimize internal feedback. These mechanisms might have altered the activation patterns and control of the affected muscles like middle deltoid, upper trapezius, levator scapulae, pectoralis minor and other scapular stabilising muscles, resulting in the improvement in pressure pain threshold, pectoralis minor length and scapular dyskinesis in subjects with adhesive capsulitis.

- ***Conclusion***

Scapular movement training is effective in improving pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor length, scapular dyskinesis and shoulder function, and this effect even persists in the follow up period except pressure pain threshold for levator scapulae and shoulder function in adhesive capsulitis.

Keywords: *Scapular Movement Training; Adhesive Capsulitis; Pressure Pain Threshold; Scapular Dyskinesis; Pectoralis Minor Length; Shoulder Function.*

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I. INTRODUCTION

Frozen shoulder or Adhesive Capsulitis (AC) is a shoulder pathology that starts by limiting shoulder abduction and shoulder external rotation, characterized by loss of shoulder motion and pain. biceps and supraspinatus tendonitis, recurrent or chronic injuries to the muscles in rotator cuff, shoulder instability, shoulder impingement syndrome, acromioclavicular arthritis, sternoclavicular arthritis and calcified tendonitis can result in adhesive capsulitis.[1] 2% to 5% of the population are affected by adhesive capsulitis, and people aged between 40-60 years are mostly affected.[2] Adhesive capsulitis affects overhead activities, daily work and life and impose financial burden on patients.[1,2]

The scapular and glenohumeral joints are the most affected in adhesive capsulitis. It causes changes in the movement sense and position of scapula.[2] Any changes in the scapular kinematics such as an abnormal motion pattern or alterations in the normal position of scapula while movements have been termed Scapular Dyskinesis (SD). The scapula has an important role for normal functioning of the shoulder. Proper movement and positioning of the scapula is important for effective muscle performance, stability, motion and shoulder position.[3]

Shortening of soft tissue around the scapula is related to the occurrence of scapular dyskinesis.[4] These muscles are responsible for the dynamic stabilization and movement of scapula. Proper interaction of these muscles are essential to provide mobility and stability for scapula both during shoulder movements and at rest.[1] Scapular dyskinesis is also believed to occur due to the damage to spinal accessory, long thoracic or dorsal scapular nerves, alterations in the activation of scapular stabilizing muscles and shortened pectoralis minor muscle.[5] Short Upper Trapezius (UT) and pectoralis minor can limit the scapular movements, making the scapulae internally rotated, protracted and anteriorly tilted when lifting the arm.[3]

It has been observed that an increase in the scapular anterior tilt, lateral rotations elevation and upward rotations are associated with adhesive capsulitis.[2,6] Eventually, patients develop the “shrug sign” during shoulder elevation. They may also exhibit postural deviations like anterior shoulder.[7]

Current practiced conventional therapies for AC include joint cavity injections, acupuncture, surgery and non-steroidal medications.[8,9] Recent researches advice manipulation, needling techniques and cupping etc. as proven treatment strategies for AC.[10,11] Physiotherapy managements like posterior strengthening exercises, self-stretching exercises, side-lying external rotation, serratus punch, mobilisations etc. are being practiced conventionally.[1] Several recent physiotherapy techniques like scapular stabilisation exercise has also been proved effective in the treatment of AC.[12,13,14,15,16,17]

A kinesiopathologic model is being followed by the movement based classification system which studies deficits in relation to movement sequences that are consequence of or cause of patient’s dysfunction and pain.

Scapular Movement Training (SMT) which has been used for treating patients suffering from painful shoulder has exhibited a positive effect on scapular motion, function and pain in patients experiencing chronic pain of shoulder.[18] This research is trying to find the effects of scapular movement training on pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function in AC.

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II. MATERIALS AND METHOD

➢ *Study Design*

This study was a part of a single blind randomised controlled trial. Participants were divided into scapular movement training group (intervention group) and conventional training group (control group).

➢ *Study Setting*

Department of Physiotherapy, Little Flower Hospital and Research Centre, Angamaly. Community Health Centre, Kalloorkad.

➢ *Participants*

Subjects clinically diagnosed with adhesive capsulitis presenting with scapular dyskinesis.

➢ *Inclusion Criteria*

- Male subjects clinically diagnosed with unilateral adhesive capsulitis
- Subjects with type 1 and 2 scapular dyskinesia
- Visual analogue scale score greater than or equal to 5
- Age between 40-60 years
- Subjects with positive scapular dyskinesis test with value greater than 75mm
- Subjects with pectoralis minor index < 8.54 ± 0.88
- Subjects who can lift a weight of at least 1.4 kg bilaterally

➢ *Exclusion Criteria*

- Subjects under steroid therapy and pain medication
- Trauma or surgery of upper limb
- Body mass index > 29.9
- Debilitating neck pain
- Systemic inflammatory and degenerative musculoskeletal conditions of shoulder.
- Spinal pain and deformities
- Subjects not willing to participate
- Subjects who are not willing or cannot withdraw from pain medication
- Visual, auditory and tactile impairments

➢ *Procedure*

After getting approval from Ethical committee and the Institutional Review Board, subjects were selected for this study according to our inclusion criteria. Informed consent was obtained and subjects were allocated randomly in two groups, intervention treatment group and conventional treatment group by using the lottery method. Study was conducted for a duration of 6 months and outcome measures were assessed; before the study, after two weeks, after six weeks, and after nine weeks for both intervention and control groups. Comparison of both groups were done after the procedure (6 weeks) and after follow up (9 weeks).

➢ *Intervention Group*

Exercises for the intervention group were given in 3 phases;

- Pre-Intervention Phase (0-2 Weeks)
- Intervention Phase (2-6 Weeks)
- Post-Intervention Phase (6-9 Weeks)

- *Pre-Intervention Phase (0-2 Weeks):*

✓ Exercises were given daily for 2 weeks.
✓ Exercises include sub maximal isometrics against a wall for; abduction, lateral rotation and medial rotation.

- *Intervention Phase (2-6 Weeks):*

✓ Supervised exercises (Scapular Movement Training) were given 3 times a week for a duration of 4 weeks.

Table 1 Scapular Movement Training Exercise Protocol

Stage	Exercise	Final Position	Manual Feedback	Visual Feedback	Verbal Feedback
1	Passive arm elevation	Last position is held for 5 sec	*	*	*
2	Active assisted arm elevation	Last position is held for 5 sec	*	*	*
3	Active arm elevation	Last position is held for 5 sec	*	*	*
4	Active elevation			*	
5	Active elevation				
6	Active elevation with load				

✓ Visual feedback were given by performing the exercise in front of a mirror.
✓ Exercises were done in frontal, sagittal, and scapular planes.
✓ In each of the training stages, the range of movements were increased slowly with respect to the improvement in shoulder control until correct shoulder control is attained in each plane for full range of movements.
✓ As the subject became abled in performing one series of ten repetitions by correct control, we added more series until reaching series of 3. Subject is then progressed to next stage.
✓ Exercises were performed in the diagonal planes at the end the sessions. Subjects should touch the target in diagonal plane with the ROM they achieved in the vertical planes.
✓ Once 90^0 of abduction was correctly controlled, subjects performed external rotation of humerus with 90^0 abduction.
✓ Resistance exercise were begun.

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- ✓ Humeral lateral and medial rotation with shoulder in 0^0 abduction using weights, horizontal arm abduction with subject in supine with dumbbell and push ups starting with vertical wall to horizontal push up were the strengthening exercises performed.
- ✓ Repetitions were added from 1 to 3 series of ten.

- *Post Intervention Phase (6-9 Weeks)*

- ✓ At the termination of intervention phase, a home exercise program were given.
- ✓ Subject continued the exercises from intervention phase at home.
- ✓ The exercises and intensity of home exercise is determined by the level of strength and control of the shoulder at the end of intervention.

➢ *Control Group*

Subjects began with short duration (1–5 s) ROM exercises, in a pain-free range. Heat or ice pack were applied if needed before the exercises to reduce pain. Subjects performed the following exercises as tolerated; wand exercise: shoulder forward flexion and external rotation, pendulum exercises, scapular retraction exercises, posterior shoulder capsular stretch, isometric external rotation of shoulder and strengthening exercises.

III. RESULTS

In this study we aimed to find the effect of scapular movement training on pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis. Baseline normality was calculated using Shapiro-Wilk test. Wilcoxon signed rank test and paired t test were used for within group analysis for both intervention and control groups, whereas, independent t test and Mann Whitney U test were used for between the group analysis.

The pretest and posttest 1 values of PPT for middle deltoid and PMI were non normally distributed and analysed using Wilcoxon signed rank test for within group analysis in intervention group. The table value for Wilcoxon signed rank test was z = 1.96. At 95% confidence interval, the calculated values of z in intervention group for both PPT for middle deltoid and PMI were 3.51. The pretest and posttest 1 values for PPTs for levator scapulae and upper trapezius, SDT and SPADI were normally distributed. Hence, paired t test was used for within group analysis in intervention group. The calculated value of t for PPT for levator scapulae, PPT for upper trapezius, SDT and SPADI were 53.99, 65.24, 143.86 and 85.38, respectively and the table value of t for 12 degree of freedom and <0.051 significance level, for all of these outcome measures were 4.31. Since the calculated values of both Wilcoxon and paired t test are greater than the respective table values, there is statistically significant improvement in PPTs for middle deltoid, levator scapulae and upper trapezius, PMI, SDT and SPADI in the intervention group.

The posttest 1 and posttest 2 values of PPTs for middle deltoid and levator scapulae, PMI and SDT were non normally distributed and analysed using Wilcoxon signed rank test for within group analysis in intervention group. The table value for Wilcoxon signed rank test was z = 1.96. At 95% confidence interval, the calculated values of z in intervention group for PPTs for middle deltoid and levator scapulae, PMI and SDT are 3.52, 1.19, 2.43 and 3.51, respectively. The posttest 1 and posttest 2 values of PPT for upper trapezius and SPADI were normally distributed and analysed using paired t test in intervention group.

Calculated value of t for PPT for upper trapezius is 24.11 and the calculated value of t for SPADI is 19.24. The table value for 12 degree of freedom and <0.051 significance level for both of these outcomes are 4.31. Since, the calculated values of PPT for levator scapulae is less than the table value, there is no statistically significant long term follow up effect of SMT in for PPT for levator scapulae. Since, the calculated value of PPT for middle deltoid and upper trapezius and SDT are greater than the table value, there is statistically significant long term follow up effect of SMT in intervention group.

Even though, PMI and SPADI showed significant difference in posttest 1 and posttest 2 comparison in the intervention group, these values exhibited a significant decrease, indicating a deterioration in subject's improvement. So, in order to determine its effect, pretest and posttest 2 test within group comparison was done for both PMI and SPADI in the intervention group. Wilcoxon signed rank test was used to determine PMI as the values did not follow normal distribution and paired t test was used for SPADI as the values followed normal distribution. For pretest and posttest 2 comparison of PMI, the calculated z value was 3.51 and the table value was 1.96. For pretest and posttest 2 comparison of SPADI the calculated value was 71.28 and table value for 12 degree of freedom and <0.051 significance level was 4.31. Even if PMI exhibit a significant decrease between posttest 1 and posttest 2 comparison, the change is still within the normal range (8.54 ± 0.88.). Since, the calculated values for PMI is greater than the table value, there is statistically significant long term improvement in the intervention group for PMI. Since, the calculated values for SPADI is greater than the table value of t, there is statistically significant improvement of SPADI between pretest and posttest 2, but there is deterioration in shoulder function at long term follow up.

The pretest and posttest 1 values of PPT for middle deltoid and PMI were non normally distributed and analysed using Wilcoxon signed rank test for within group analysis in conventional group. The table value for Wilcoxon signed rank test was; z = 1.96. At 95% confidence interval, the calculated values of z in conventional group for both PPT for middle deltoid and PMI were 3.51. The pretest and posttest 1 values for PPTs for leavator scapulae and upper trapezius, SDT and SPADI were normally distributed. Hence, paired t test was used for within group analysis in intervention group. The calculated value of t for PPT for levator scapulae, PPT for upper trapezius, SDT and SPADI were 94.21, 45.27, 16.22 and 62.39, respectively and the table value of t for 12 degree of freedom and <0.051 significance level for all of these outcome measures were 4.31. Since the calculated

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values of both Wilcoxon and paired t test are greater than the respective table values, there is statistically significant improvement in PPTs for middle deltoid, levator scapulae and upper trapezius, PMI, SDT and SPADI in the conventional group.

The posttest 1 and posttest 2 values of PPTs for middle deltoid and levator scapulae, PMI and SDT were non normally distributed and analysed using Wilcoxon signed rank test for within group analysis in conventional group. The table value for Wilcoxon signed rank test was z = 1.96. At 95% confidence interval, the calculated values of z in conventional group for PPTs for middle deltoid and levator scapulae, PMI and SDT were 1.81, 0.44, 2.46 and 1.39, respectively. The posttest 1 and posttest 2 values of PPT for upper trapezius and SPADI were normally distributed and analysed using paired t test in conventional group. The calculated value of t for PPT for upper trapezius and SPADI are 0.16 and 0.90, respectively and the table value of t for PPT for upper trapezius for 0.86 significance level is 0.18 and that of SPADI with a significance level of 0.38 is 0.90 for 12 degrees of freedom. Here, the calculated values of PPTs for middle deltoid, levator scapulae and upper trapezius and SDT are less than the table value and the calculated value of SPADI is equal to the table value. So, there is no statistically significant long term follow up effect in PPTs for middle deltoid, levator scapulae and upper trapezius, SDT and SAPDI in conventional group.

Even though posttest 1 and posttest 2 comparison of PMI showed significant difference in conventional group, the values exhibited a significant decrease, indicating a deterioration in subject's improvement. So, in order to determine its effect, pretest and posttest 2 within group comparison was done for PMI in conventional group. Wilcoxon signed rank test was used for PMI as the values were non normally distributed. For pretest and posttest 2 comparison of PMI, the calculated z value was 3.51 and the table value was 1.96. Since, the calculated values is greater than the table value, there is statistically significant long term follow up effect in conventional group, but the values didn't achieve normal PMI range (8.54 ± 0.88).

In between group comparison of posttest 1 scores of PPT for middle deltoid and PMI were non normally distributed and therefore are analysed using Mann Whitney U test, whereas PPTs for levator scapulae and upper trapezius, SDT and SPADI follow normal distribution and therefore are analysed using Independent t test. At 95% confidence interval, the table value of z is 1.96 and the calculated values of PPT for middle deltoid and PMI is 4.82. The calculated values of t for 12 degrees of freedom for PPTs for levator scapulae and upper trapezius, SDT and SPADI are 39.13, 26.26, 44.81 and 34.74, respectively and the table value of t for <0.051 significance level is 3.72. Since, the calculated values are greater than the table values of z and t there exist statistically significant effect of SMT over conventional training. Thus, this study rejects all null hypothesis except H_{09} & H_{012} and accept all alternative hypothesis except H_{A9} & H_{A12}. Therefore, from the results it is understood that, there is significant effect of scapular movement training on pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis. Moreover, there is also a significant long term follow up effect of scapular movement training on PPTs for middle deltoid and upper trapezius, pectoralis minor length and scapular dyskinesis in adhesive capsulitis, except for PPT for levator scapulae and shoulder function.

- *Baseline Characteristics of Data in Scapular Movement Training Group and Conventional Physiotherapy Group*

The baseline parameter considered in the study is age. The tabular and graphical methods of the results are given below.

Table 2 Distribution of age in SMT and Conventional Physiotherapy Groups

Age	SMT group		Control group	
	Frequency	Percentage	Frequency	Percentage
40-50	5	38.48%	6	46.15%
51-60	8	61.52%	7	53.85%
Total	13	100%	13	100%

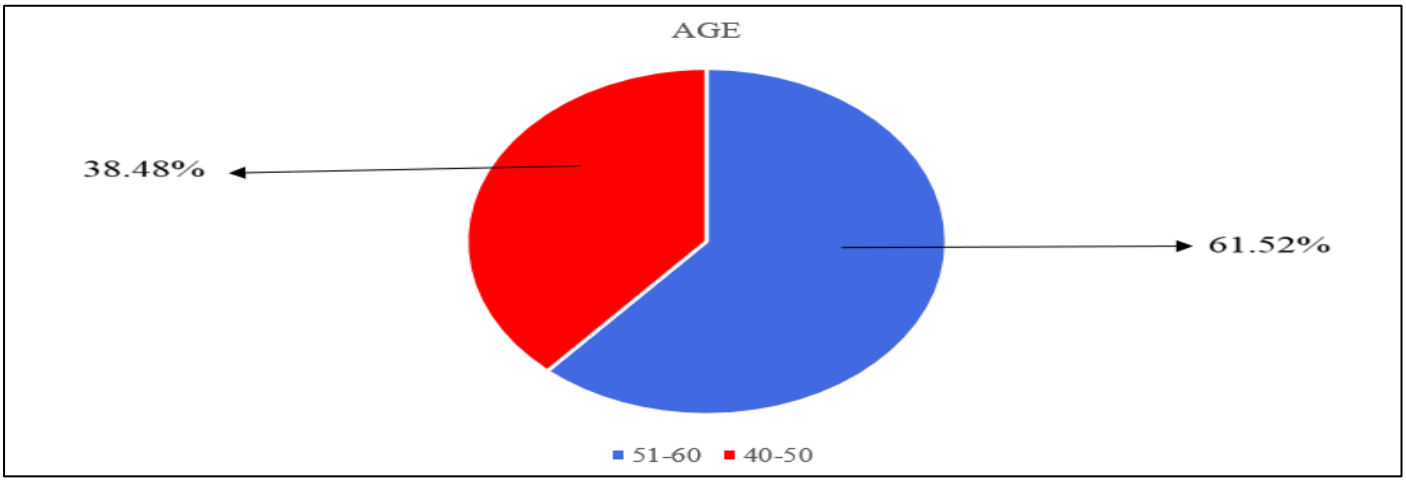

Fig 1 Demographic Representation of Age in Intervention Group

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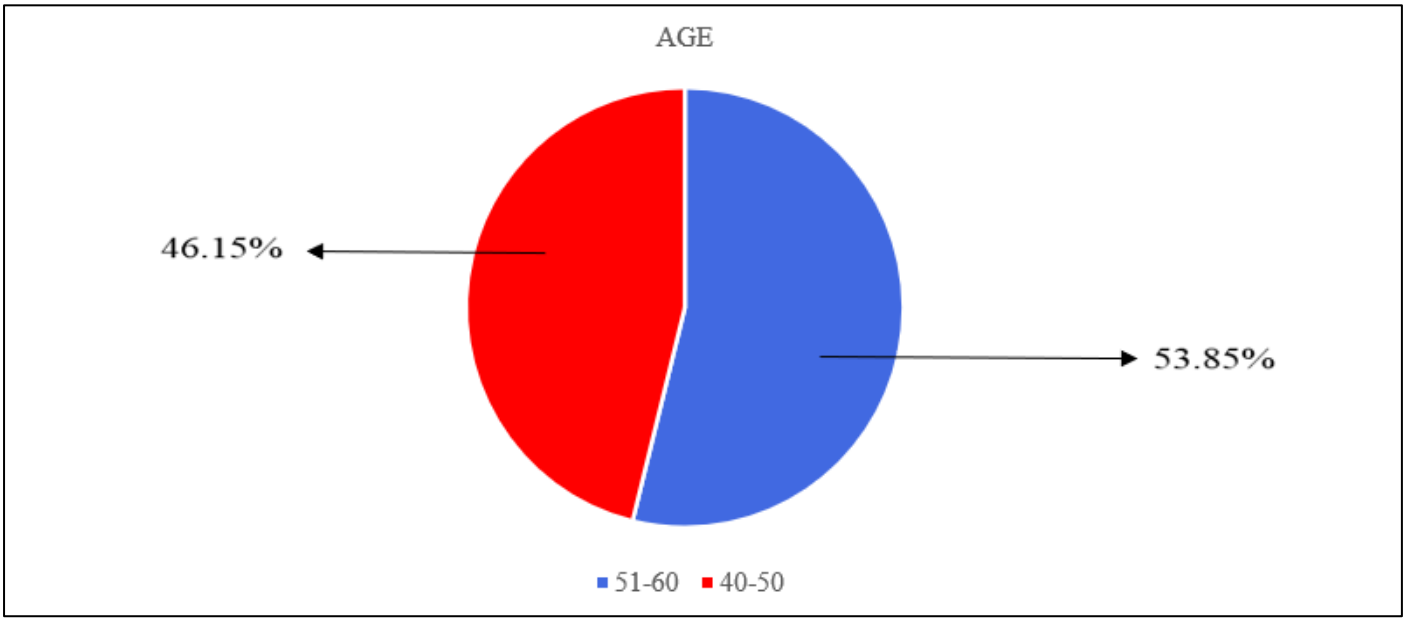


Fig 2 Demographic Representation of Age in Control Group

- *Objective 1*

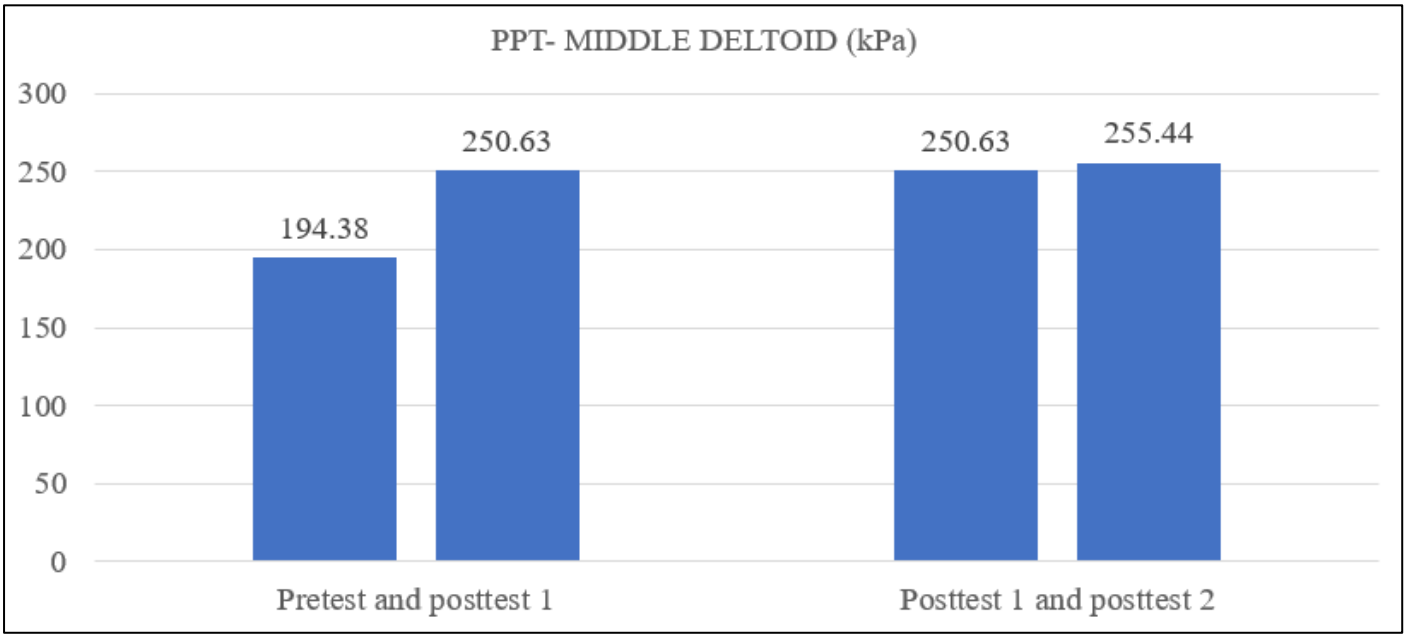
To determine the effect of scapular movement training on pressure pain threshold for middle deltoid in adhesive capsulitis.

The effect of SMT on PPT for middle deltoid was analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 3 Tabular Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of PPT for Middle Deltoid in SMT Group

PPT for Middle Deltoid	Mean ± SD	z Value	p Value
At 6 weeks			
Pretest	194.38±2.92	3.51	<0.001
Posttest 1	250.63±4.13		
At 9 weeks			
Posttest 1	250.63±4.13	3.52	<0.001
Posttest 2	255.44±4.20		

Wilcoxon Signed Rank Test, p<0.05 Considered as Statistically Significant.



Graph 1 Graphical Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of PPT for Middle Deltoid in SMT Group

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- *Objective 2*

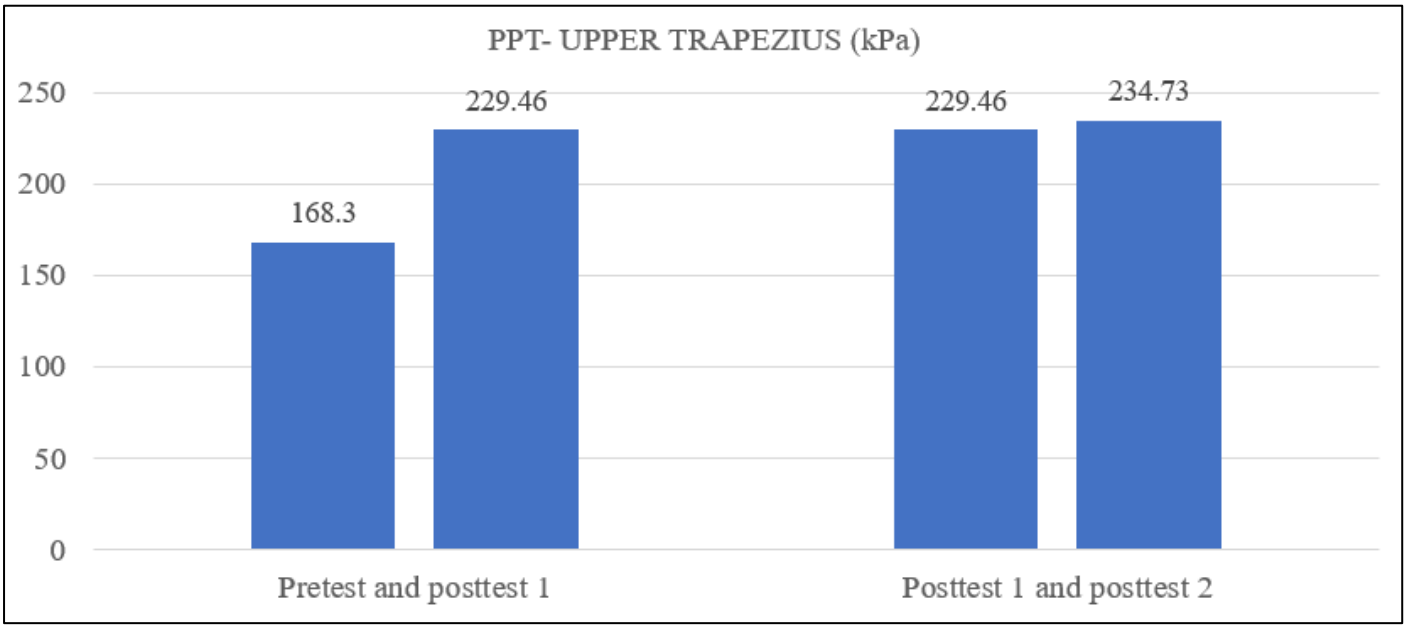
To determine the effect of scapular movement training on pressure pain threshold for upper trapezius in adhesive capsulitis.

The effect of SMT on PPT for upper trapezius was analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 4 Tabular Representation of Pretest and Post 1 Test & Posttest 1 and Posttest 2 Scores Comparison of PPT for Upper Trapezius in SMT Group

PPT for upper trapezius	Mean ± SD	Paired Difference	t Value	p Value
At 6 weeks				
Pretest	168.30±3.17	61.16±3.75	65.24	<0.001
Posttest 1	229.46±5.49			
At 9 weeks				
Posttest 1	229.46±5.49	5.27±0.87	24.11	<0.001
Posttest 2	234.73±5.49			

Paired t Test, $p<0.05$ Considered as Statistically Significant



Graph 2 Graphical Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Comparison of PPT for Upper Trapezius in SMT Group

- *Objective 3*

To determine the effect of scapular movement training on pressure pain threshold for levator scapulae in adhesive capsulitis.

The effect of SMT on PPT for levator scapulae was analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 5 Tabular Representation of Pretest and Posttest 1 Scores Comparison of PPT for Levator Scapulae in SMT Group (At 6 Weeks)

PPT for Levator Scapulae	Mean ± SD	Paired Difference	t Value	p Value
Pretest	245.54±3.59	81.30±6.02	53.99	<0.001
Posttest 1	326.84±4.41			

Paired t Test, $p<0.05$ Considered as Statistically Significant.

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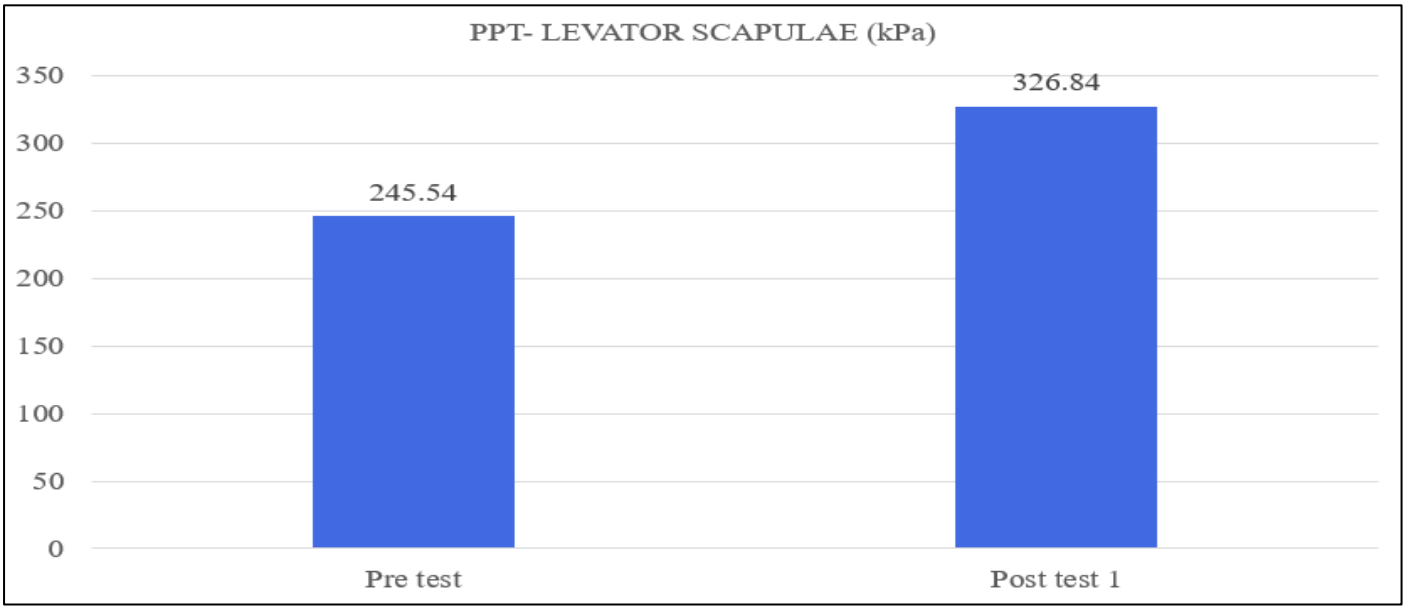
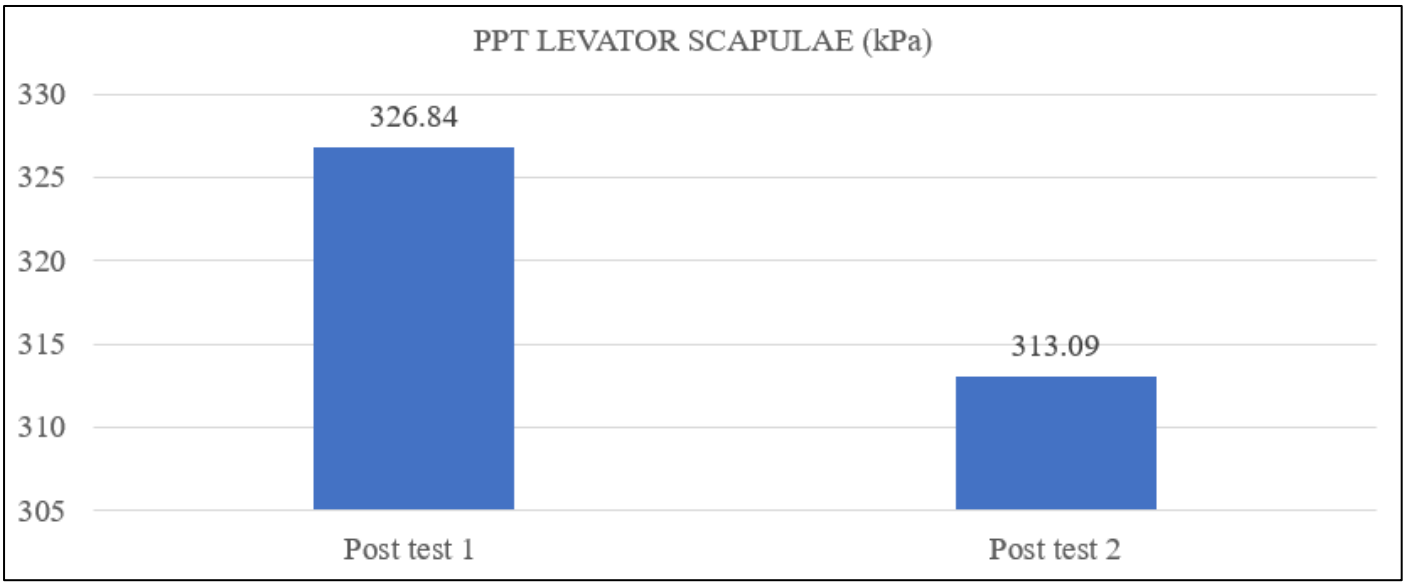


Graph 3 Graphical Representation of Pretest and Posttest 1 Scores Comparison of PPT for Levator Scapulae in SMT Group.

Table 6 Tabular Representation of Posttest 1 and Posttest 2 Scores Comparison of PPT for Levator Scapulae in SMT Group (At 9 Weeks)

PPT for levator scapulae	Mean ± SD	z Value	p Value
Posttest 1	326.84±4.41	1.19	0.23
Posttest 2	313.09±42.16		

Wilcoxon Signed Rank Test, $p<0.05$ Considered as Statistically Significant.



Graph 4 Graphical Representation of Posttest 1 and Posttest 2 Scores Comparison of PPT for Levator Scapulae in SMT Group

- *Objective 4*

To determine the effect of scapular movement training on pectoralis minor length in adhesive capsulitis.

The effect of SMT on PMI was analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 7 Tabular Representation of Pretest and Posttest 1, Posttest 1 and Posttest 2 & Posttest 2 and Pretest Scores Comparison of PMI in SMT Group

PMI	Mean ± SD	z Value	p Value
At 6 weeks			
Pretest	6.21±0.34	3.51	<0.001
Posttest 1	8.38±0.52		
At 9 weeks			

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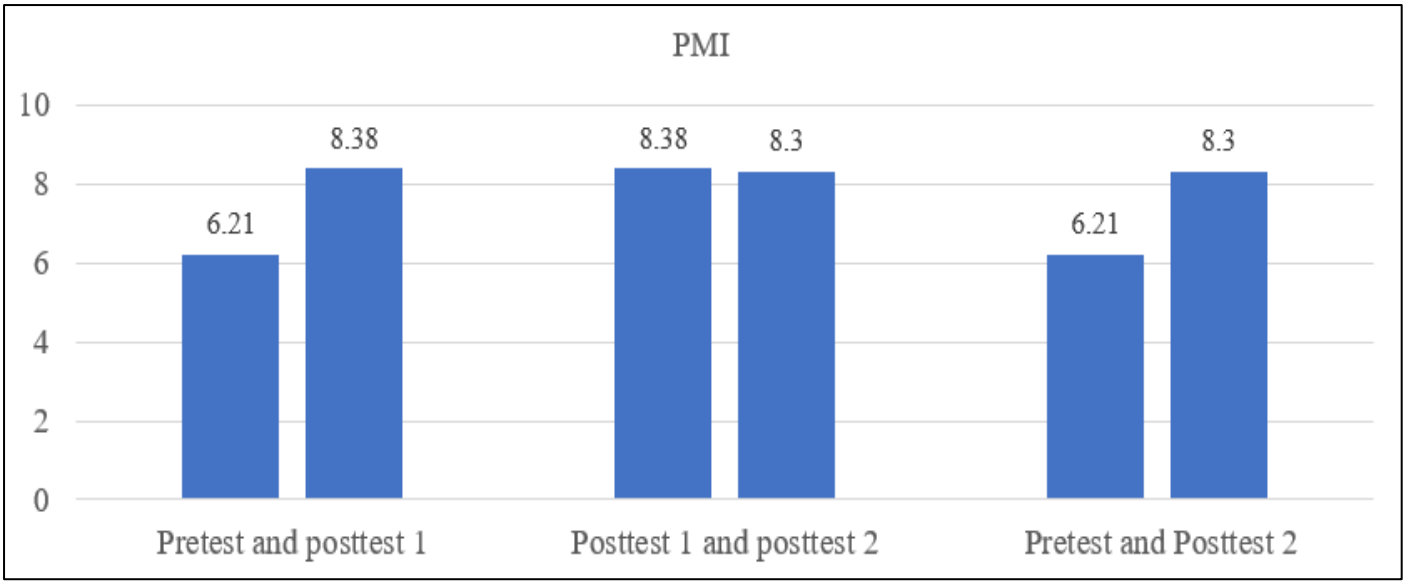
Posttest 1	8.38±0.52	2.43	0.015
Posttest 2	8.30±0.55		
baseline and 9 weeks			
Pretest	6.21±0.34	3.51	<0.001
Posttest 2	8.30±0.55		

Wilcoxon Signed Rank Test, p<0.05 Considered as Statistically Significant.



Graph 5 Graphical Representation of Pretest and Posttest 1, Posttest 1 and Posttest 2 & Posttest 2 and Pretest Scores Comparison of PMI in SMT Group

- *Objective 5*

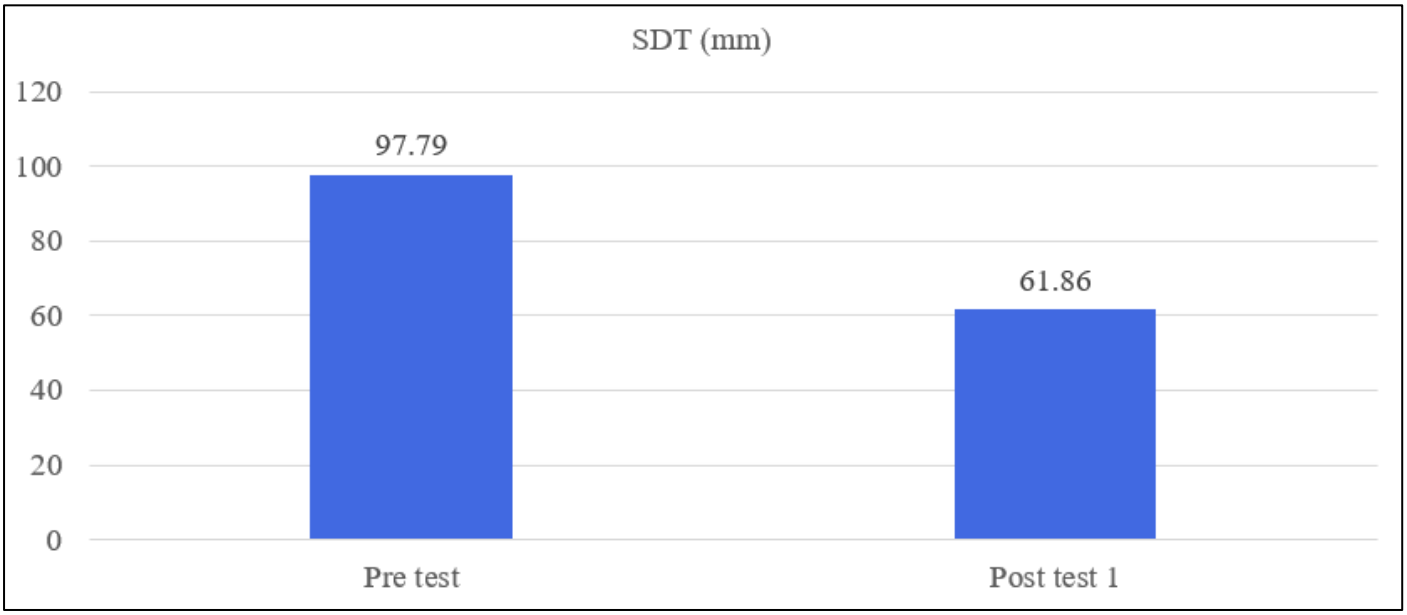
To determine the effect of scapular movement training on scapular dyskinesis in adhesive capsulitis.

The effect of SMT on SDT was analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 8 Tabular Representation of Pretest and Posttest 1 Scores Comparison of SDT in SMT Group (At 6 Weeks)

SDT	Mean ± SD	Paired Difference	t Value	p Value
Pretest	97.79±1.63	35.93±0.99	143.86	<0.001
Posttest 1	61.86±1.54			

Paired T Test, p<0.05 Considered as Statistically Significant.



Graph 6 Graphical Representation of Pretest and Posttest 1 Scores Comparison of SDT in SMT Group.

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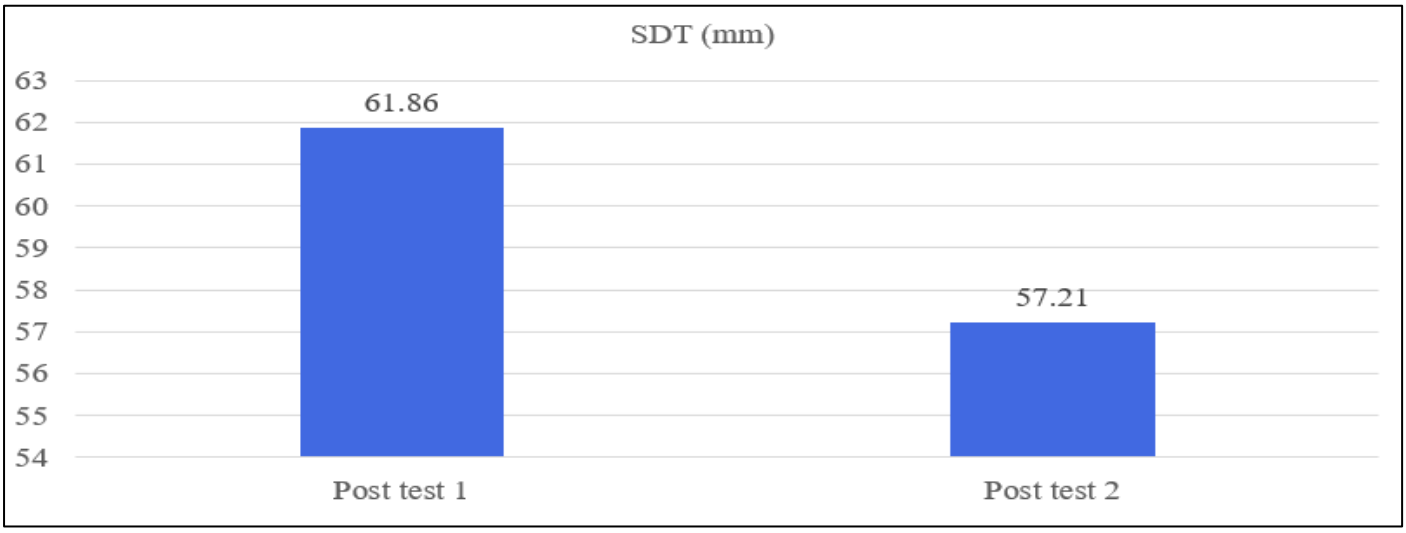
Table 9 Tabular Representation of Posttest 1 and Posttest 2 Scores Comparison of SDT in SMT Group (At 9 Weeks)

SDT	Mean ± SD	z Value	p Value
Posttest 1	61.86±1.54	3.51	<0.001
Posttest 2	57.21±1.61		

Wilcoxon Signed Rank Test, p<0.05 Considered as Statistically Significant.



Graph 7 Graphical Representation of Posttest 1 and Posttest 2 Scores Comparison of SDT in SMT Group

- *Objective 6*

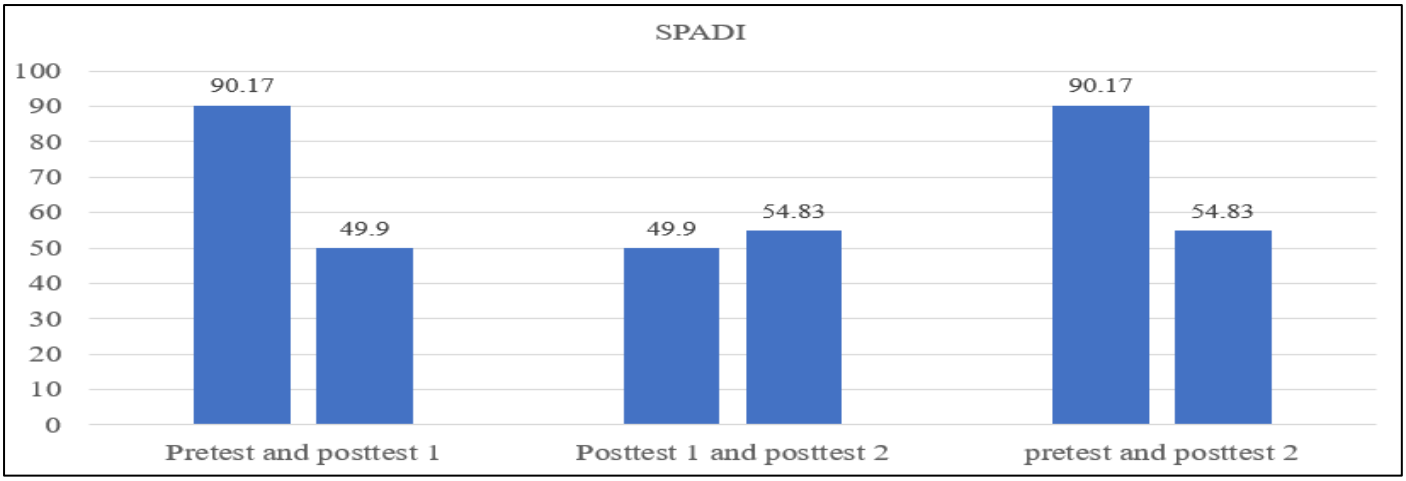
To determine the effect of scapular movement training on shoulder function in adhesive capsulitis.

The effect of SMT on SPADI was analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 10 Tabular Representation of Pretest and Posttest 1, Posttest 1 and Posttest 2 & Posttest 2 and Pretest Scores Comparison of SPADI in SMT Group

SPADI	Mean ± SD	Paired Difference	t Value	p Value
At 6 weeks				
Pretest	90.17±1.57	40.27±1.88	85.38	<0.001
Posttest 1	49.90±1.93			
At 9 weeks				
Posttest 1	49.90±1.93	4.92±1.02	19.24	<0.001
Posttest 2	54.83±1.99			
baseline and 9 weeks				
Pretest	90.17±1.57	35.34±1.98	71.28	<0.001
Posttest 2	54.83±1.99			

Paired T Test, p<0.05 Considered as Statistically Significant.



Graph 8 Graphical Representation of Pretest and Posttest 1, Posttest 1 and Posttest 2 & Posttest 2 and Pretest Scores Comparison of SPADI in SMT Group

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- *Objective 7*

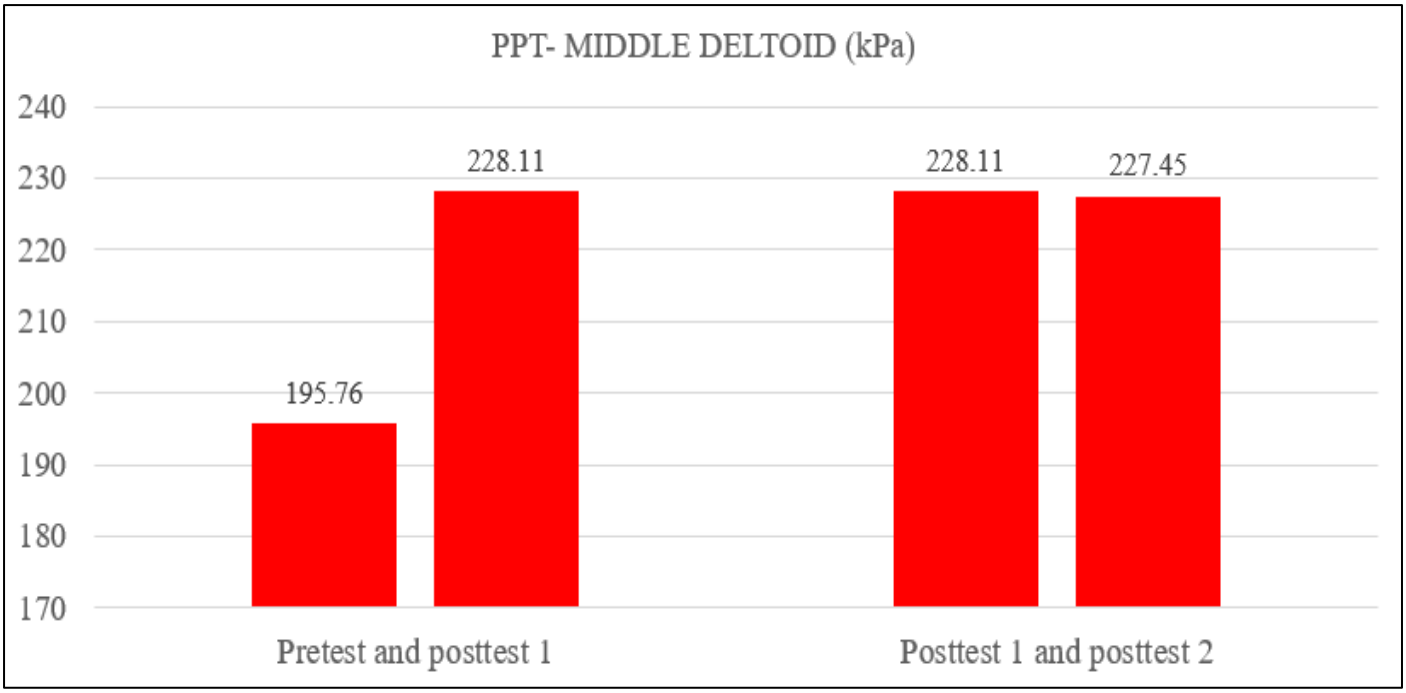
To analyse the effect of conventional physiotherapy intervention on pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis.

The effect of conventional training on PPTs for middle deltoid, upper trapezius and levator scapulae, SDT, PMI and SPADI were analysed at 6 weeks (after the intervention) and its long term follow up effect was analysed at 9 weeks (after the follow up).

Table 11 Tabular Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of PPT for Middle Deltoid in Conventional Training Group

PPT for Middle Deltoid	Mean ± SD	z Value	p Value
At 6 weeks			
Pretest	195.76±2.31	3.51	<0.001
Posttest 1	228.11±3.41		
At 9 weeks			
Posttest 1	228.11±3.41	1.81	0.070
Posttest 2	227.45±3.55		

Wilcoxon Signed Rank Test, p<0.05 Considered as Statistically Significant.



Graph 9 Graphical Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of PPT for Middle Deltoid in Conventional Training Group

Table 12 Tabular Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of PPT for Upper Trapezius in Conventional Training Group

PPT for upper trapezius	Mean ± SD	Paired Difference	t Value	p Value
At 6 weeks				
Pretest	169.48±2.18	19.20±1.69	45.27	<0.001
Posttest 1	188.68±2.89			
At 9 weeks				
Posttest 1	188.68±2.89	0.050±1.19	0.16	0.86
Posttest 2	188.63±2.59			

Paired T Test, p<0.05 Considered as Statistically Significant.

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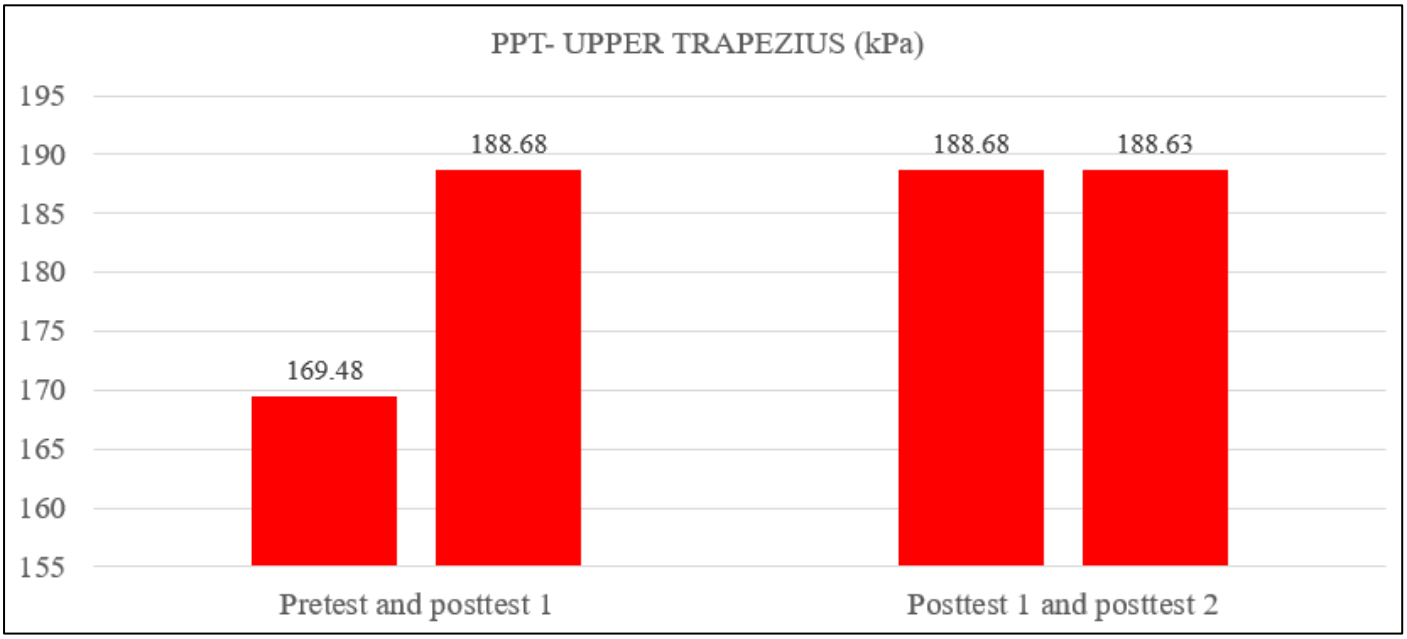
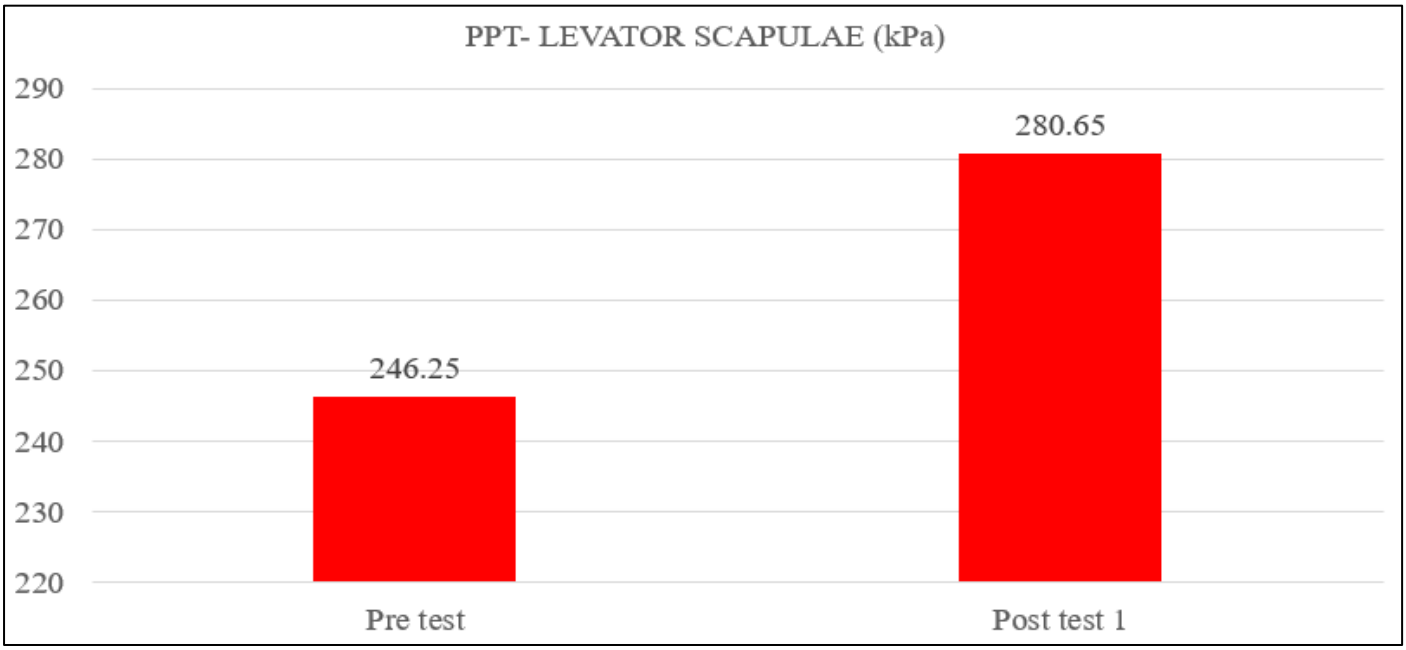


Graph 10 Graphical Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison for PPT for Upper Trapezius in Conventional Training Group

Table 13 Tabular Representation of Pretest and Posttest 1 Scores Comparison of PPT for Levator Scapulae in Conventional Training Group (At 6 Weeks)

PPT for levator scapulae	Mean ± SD	Paired Difference	t Value	p Value
Pretest	246.25±2.00	34.40±1.46	94.21	<0.001
Posttest 1	280.65±1.69			

Paired T Test, p<<0.055 Considered as Statistically Significant.



Graph 11 Graphical Representation of Pretest and Posttest 1 Scores Comparison of PPT for Levator Scapulae in Conventional Training Group

Table 14 Tabular Representation of Posttest 1 and Posttest 2 Scores Comparison of PPT for Levator Scapulae in Conventional Training Group (At 9 Weeks)

PPT for levator scapulae	Mean ± SD	z Value	p Value
Posttest 1	280.65±1.69	0.44	0.66
Posttest 2	280.70±1.43		

Wilcoxon Signed Rank Test, p<0.05 Considered as Statistically Significant.

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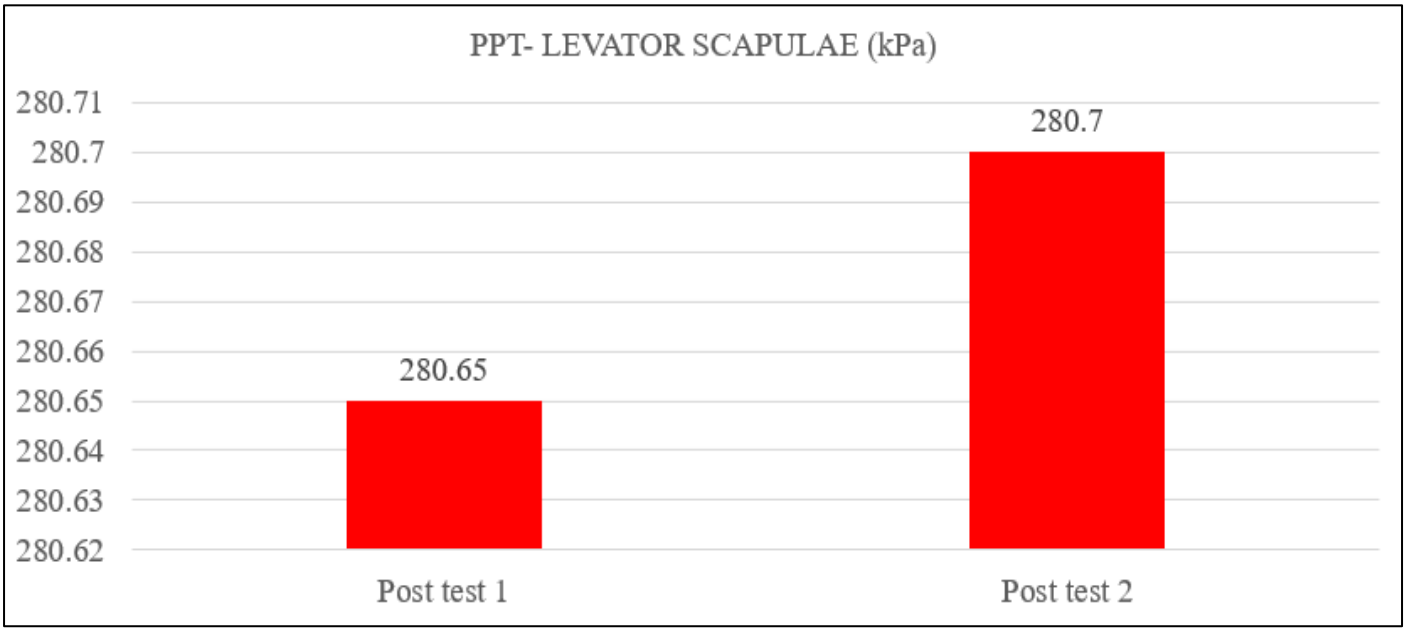
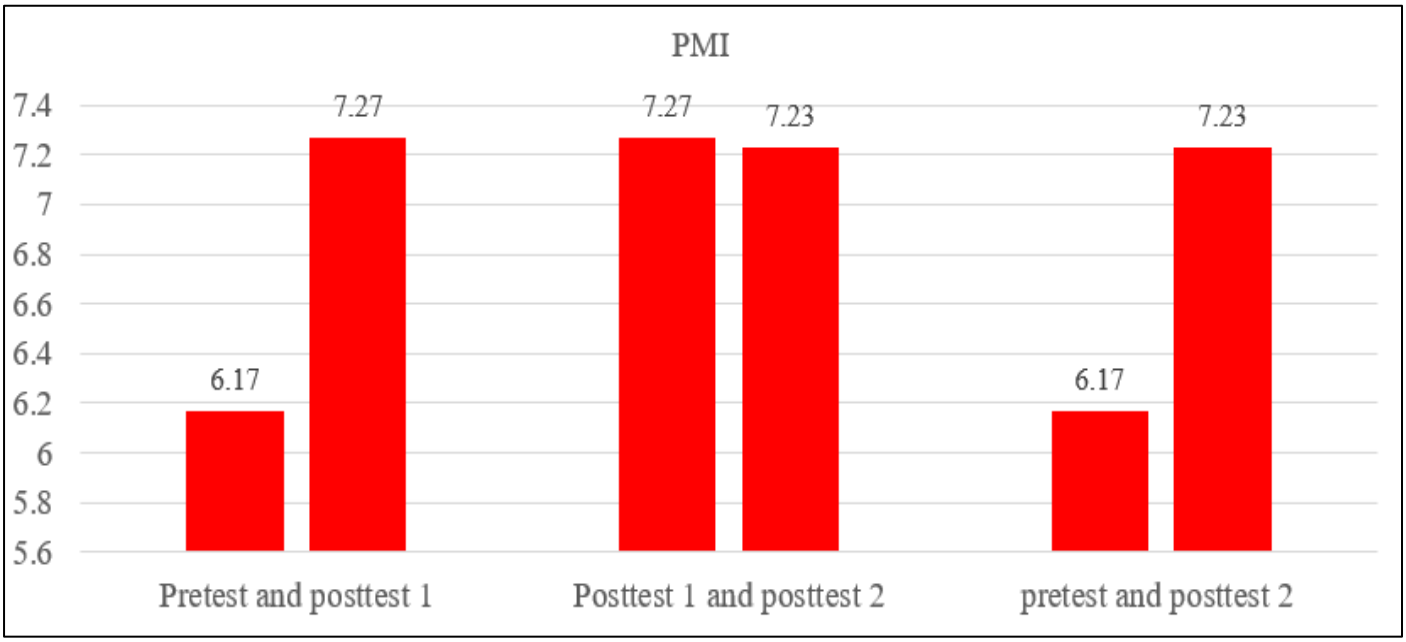


Graph 12 Graphical Representation of Posttest 1 and Posttest 2 Scores Comparison of PPT for Levator Scapulae in Conventional Training Group

Table 15 Tabular Representation of Pretest and Posttest 1, Posttest 1 and Posttest 2 & Posttest 2 and Pretest Scores Comparison of PMI in Conventional Training Group

PMI	Mean ± SD	z Value	p Value
At 6 weeks			
Pretest	6.17±0.32	3.51	<0.001
Posttest 1	7.27±0.27		
At 9 weeks			
Posttest 1	7.27±0.27	2.46	0.014
Posttest 2	7.23±0.29		
9 weeks and baseline			
Pretest	6.17±0.32	3.51	<0.001
Posttest 2	7.23±0.29		

Wilcoxon Signed Rank Test, $p<0.05$ Considered as Statistically Significant.



Graph 13 Graphical Representation of Pretest and Posttest 1, Posttest 1 and Posttest 2 & Posttest 2 and Pretest Scores Comparison of PMI in Conventional Training Group

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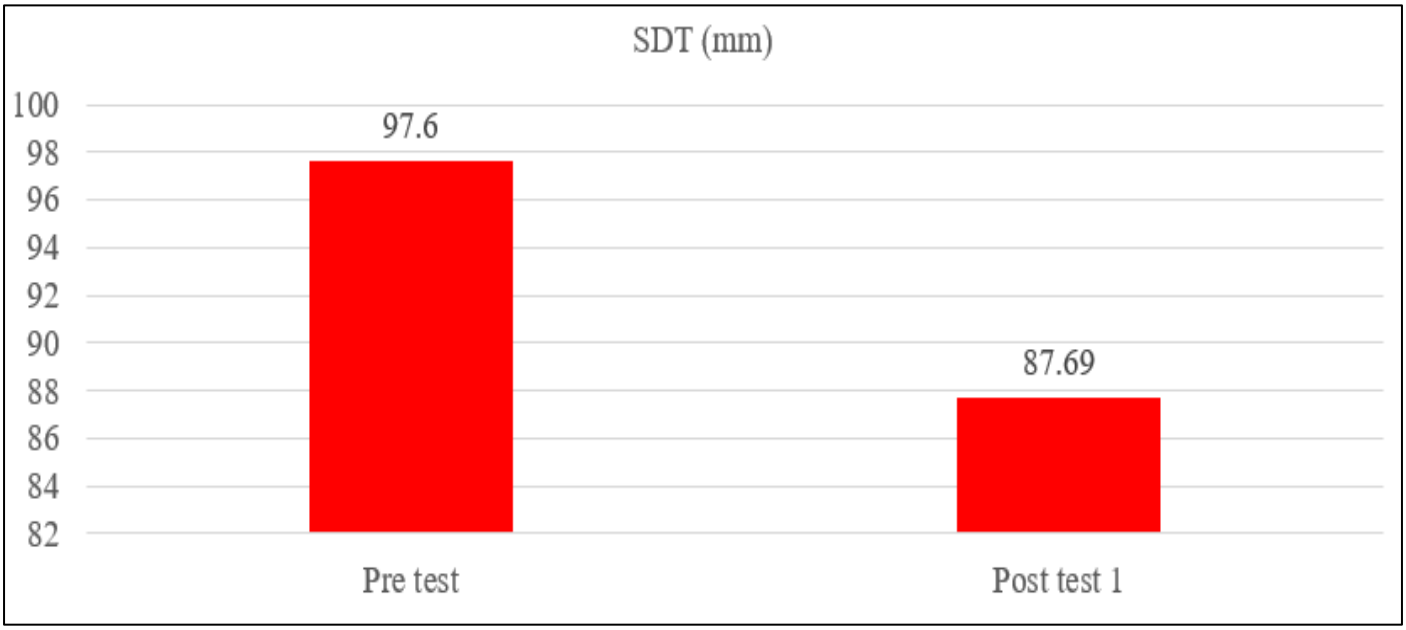
Table 16 Tabular Representation of Pretest and Posttest 1 Scores Comparison of SDT in Conventional Training Group (At 6 Weeks)

SDT	Mean ± SD	Paired Difference	t Value	p Value
Pretest	97.60±1.66	9.90±0.34	116.22	<0.001
Posttest 1	87.69±1.71			

Paired T Test, $p<0.05$ Considered as Statistically Significant.

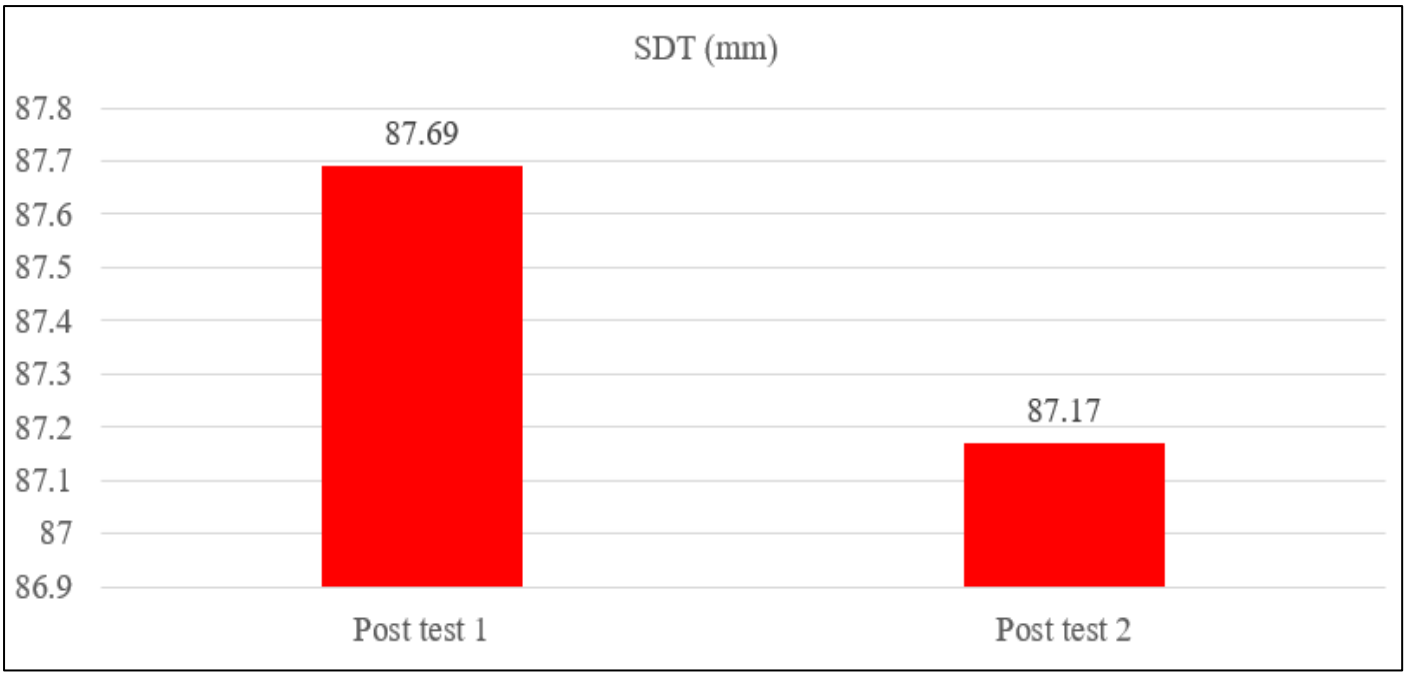


Graph 14 Graphical Representation of Pretest and Posttest 1 Scores Comparison of SDT in Conventional Training Group

Table 17 Tabular Representation of Posttest 1 and Posttest 2 Scores Comparison of SDT in Conventional Training Group (At 9 Weeks)

SDT	Mean ± SD	z Value	p Value
Posttest 1	87.69±1.71	1.39	0.16
Posttest 2	87.17±2.42		

Wilcoxon Signed Rank Test, $p<0.05$ Considered as Statistically Significant.



Graph 15 Graphical Representation of Posttest 1 and Posttest 2 Scores Comparison of SDT in Conventional Training Group

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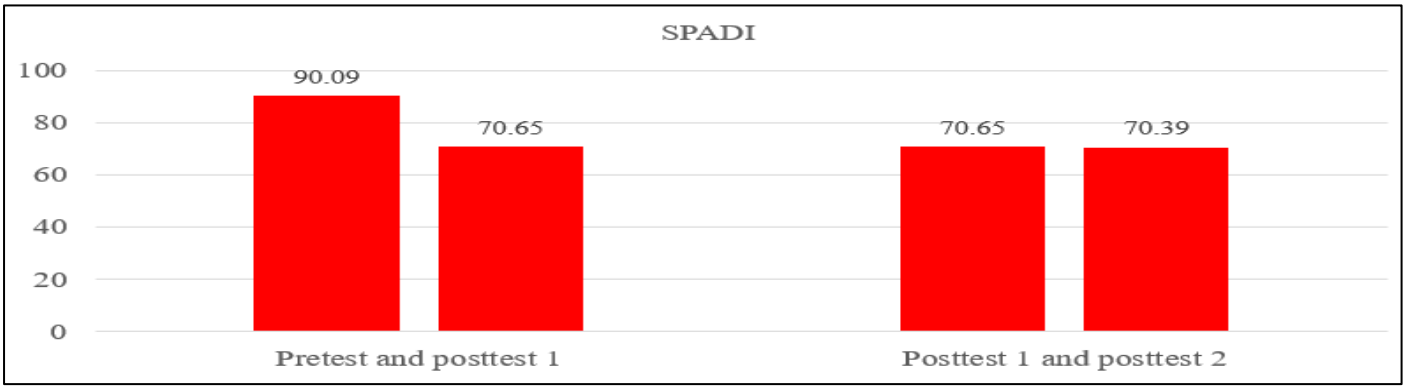
Table 18 Tabular Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of SPADI in Conventional Training Group

SPADI	Mean ± SD	Paired Difference	t Value	p Value
At 6 weeks				
Pretest	90.09±1.61	19.44±1.24	62.39	<0.001
Posttest 1	70.65±1.40			
At 9 weeks				
Posttest 1	70.65±1.40	0.25±1.14	0.90	0.38
Posttest 2	70.39±1.55			

Paired T Test, p<0.05 Considered as Statistically Significant.



Graph 16 Graphical Representation of Pretest and Posttest 1 & Posttest 1 and Posttest 2 Scores Comparison of SPADI in Conventional Training Group

- *Objective 8*

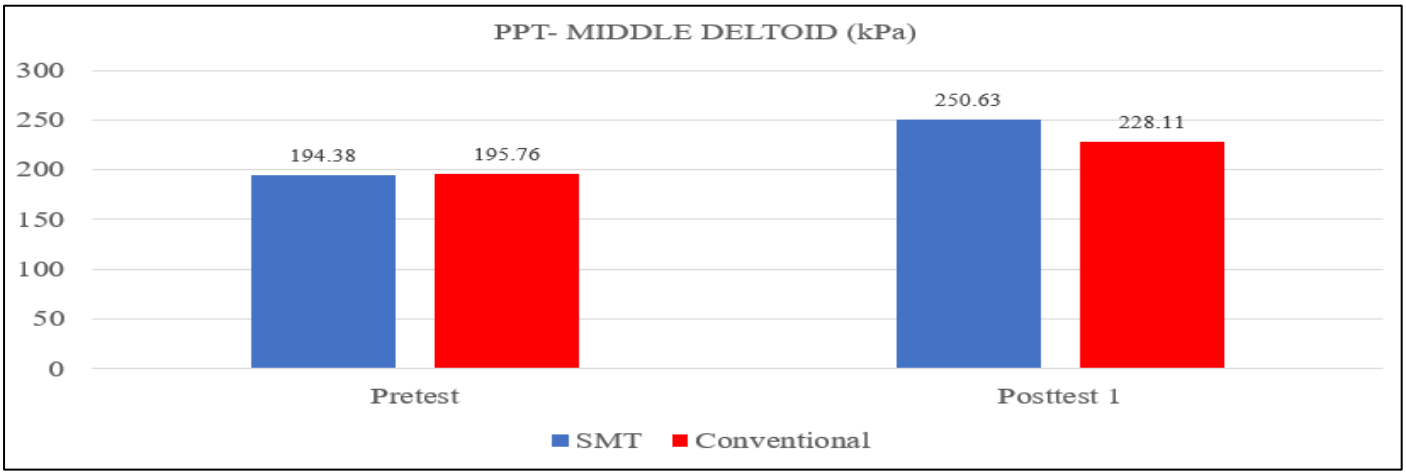
To compare the effect of scapular movement training and conventional physiotherapy intervention on pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis.

The effect of SMT and conventional training on PPTs for middle deltoid, upper trapezius and levator scapulae, SDT, PMI and SPADI were compared between baseline (before intervention) and after 6 weeks (after the intervention).

Table 19 Tabular Representation of Pretest and Posttest 1 Scores Comparison of PPT for Middle Deltoid in SMT and Conventional Training Groups

	Pretest			Posttest 1		
PPT for middle deltoid	**Mean ± SD**	**z Value**	**p value**	**Mean ± SD**	**z value**	**p value**
SMT group	194.38 ± 2.92	1.58	0.11	250.63 ± 4.13	4.82	<0.001
Conventional Training group	195.76 ± 2.31			228.11 ± 3.41		

Mann Whitney U Test, p<0.05 Considered as Statistically Significant.



Graph 17 Graphical Representation of Pretest and Posttest 1 Scores Comparison of PPT for Middle Deltoid in SMT and Conventional Training Groups

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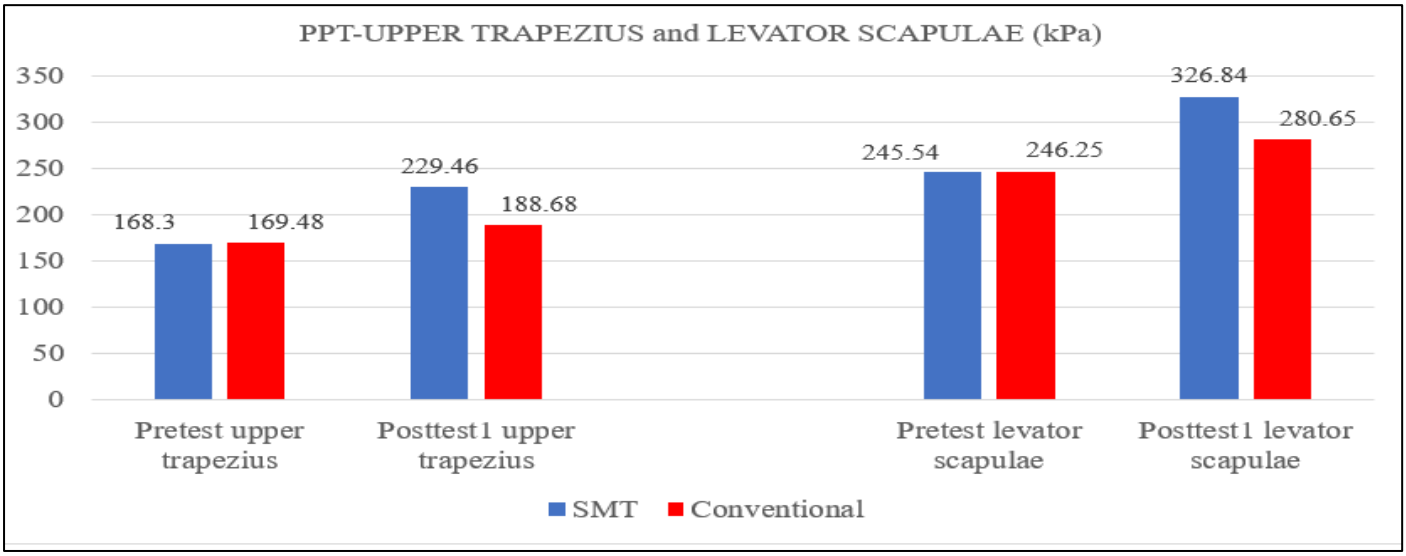
Table 20 Tabular Representation of Pretest and Posttest 1 Scores Comparison of PPTs for Upper Trapezius and Levator Scapulae in SMT and Conventional Training Groups

	Pretest			Posttest 1		
PPT for upper trapezius	**Mean ± SD**	**t Value**	**p value**	**Mean ± SD**	**t value**	**p value**
SMT group	168.30±3.17	1.22	0.23	229.46 ± 5.49	26.26	<0.001
Conventional Training group	169.48±2.18			188.68 ± 2.89		
PPT for levator scapulae	**Mean ± SD**	**t Value**	**p value**	**Mean ± SD**	**t value**	**p value**
SMT group	245.54±3.59	0.68	0.49	326.84 ± 4.41	39.13	<0.001
Conventional Training group	246.25±2.00			280.65 ± 1.69		

Independent T Test, p<0.05 Considered as Statistically Significant.

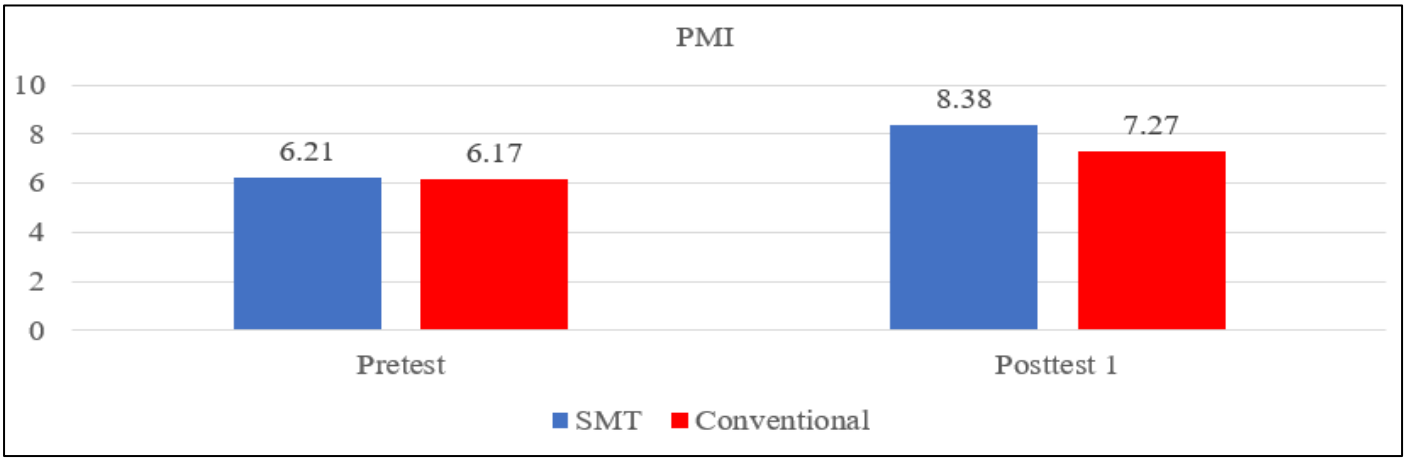


Graph 18 Graphical Representation of Pretest and Posttest 1 Scores Comparison of PPTs for Upper Trapezius and Levator Scapulae in SMT and Conventional Training Groups

Table 21 Tabular Representation of Pretest and Posttest 1 Scores Comparison of PMI in SMT and Conventional Training Groups

	Pretest			Posttest 1		
PMI	**Mean ± SD**	**z Value**	**p value**	**Mean ± SD**	**z value**	**p value**
SMT group	6.21±0.34	0.45	0.65	8.38 ± 0.52	4.82	<0.001
Conventional Training group	6.17±0.32			7.27 ± 0.27		

Mann Whitney U Test, p<0.05 Considered as Statistically Significant.



Graph 19 Graphical Representation of Pretest and Posttest 1 Scores Comparison of PMI in SMT and Conventional Training Groups

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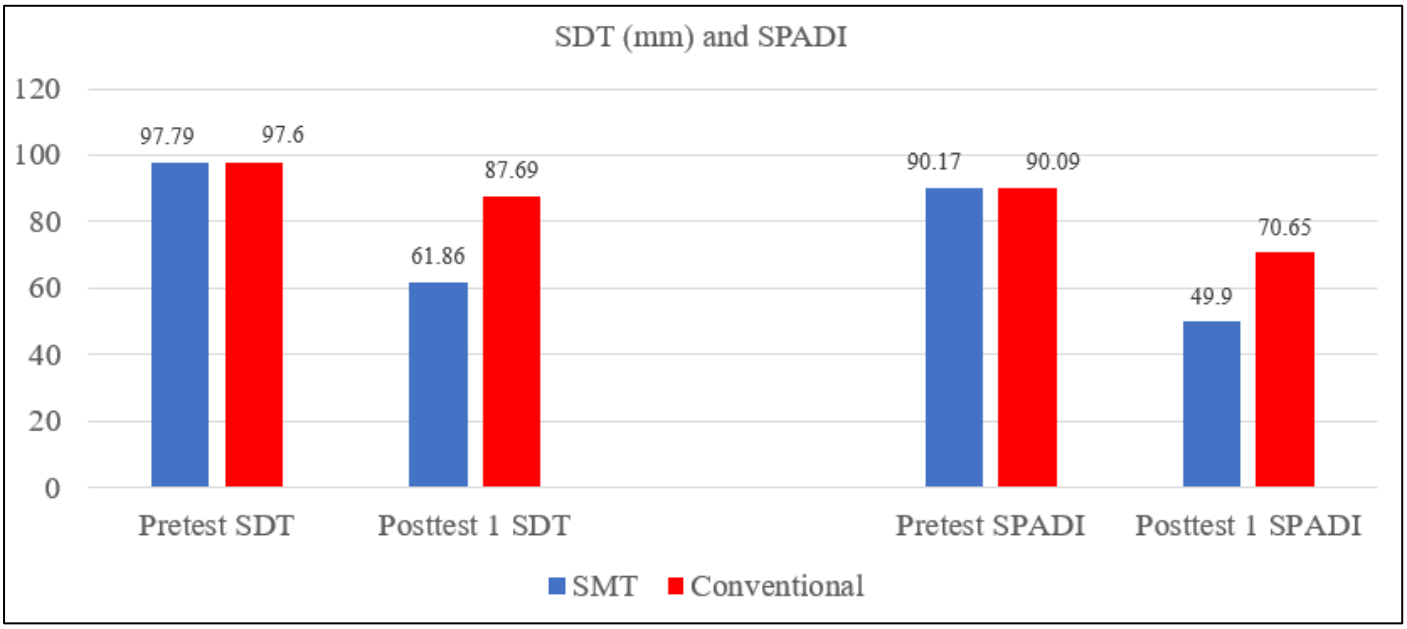
Table 22 Tabular Representation of Pretest and Posttest 1 Scores Comparison of SDT and SPADI in SMT and Conventional Training Groups

	Pretest			Posttest 1		
SDT	**Mean ± SD**	**t Value**	**p value**	**Mean ± SD**	**t value**	**p value**
SMT group	97.79±1.63	0.29	0.73	61.86 ± 1.54	44.81	<0.001
Conventional Training group	97.60±1.66			87.69 ± 1.71		
SPADI	**Mean ± SD**	**t Value**	**p value**	**Mean ± SD**	**t value**	**p value**
SMT group	90.17±1.57	0.14	0.88	49.90 ± 1.93	34.74	<0.001
Conventional Training group	90.09±1.61			70.65 ± 1.40		

Independent T Test, $p<0.05$ Considered as Statistically Significant.



Graph 20 Graphical Representation of Pretest and Posttest 1 Scores Comparison of SPADI in SMT and Conventional Training Groups

IV. DISCUSSION

The present research is aimed to determine the effects of scapular movement training on pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor index, scapular dyskinesis test and SPADI in adhesive capsulitis. Twenty six subjects with adhesive capsulitis, who met our inclusion criteria were recruited into 2 groups – scapular movement training group and conventional training group of thirteen each. Scapular movement training group received scapular movement training whereas conventional training group received conventional exercises.

The outcome measures were pressure pain threshold, pectoralis minor length, scapular dyskinesis and shoulder function, which were assessed using algometer, pectoralis minor index, scapular dyskinesis test and SPADI, respectively. Assessment were taken on the day prior to the treatment (pretest), after 6 weeks (posttest 1) and after 9 weeks (posttest 2- follow up) of training. The baseline parameter considered was age. In both groups, subjects aged between 51 and 60 were most affected.

The results of this study reveals that scapular movement training has a greater significant effect on pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor index, scapular dyskinesis test and SPADI whereas a greater significant follow up effect was found on pressure pain thresholds for middle deltoid and upper trapezius, pectoralis minor index and scapular dyskinesis test compared to control group. Scapular movement training group exhibited an increase in these outcome measures indicating the importance of considering scapular movement based exercises in treating patients with adhesive capsulitis.

Roy J S et al[19] suggest that patients with adhesive capsulitis exhibit improper activation and control of muscles and weakness, resulting in decreased pressure pain thresholds of shoulder muscles. Pain tolerance of middle deltoid, upper trapezius and levator scapulae are decreased in patients with adhesive capsulitis causing painful shoulder resulting in altered activation of scapular stabilising muscles and pectoralis minor muscle shortening.[16]

Shortened pectoralis minor muscle is reported to increase scapular dyskinesis by increasing anterior scapular tilt.[9] Both shortened pectoralis minor muscle and altered

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activation of scapular stabilizing muscles ultimately result in scapular dyskinesis.[9,18] Our study suggest that, scapular movement training is effective in improving pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor length and scapular dyskinesis. This effect persisted even in the absence of supervised intervention, except for levator scapulae. Chrstina dos et al[20] suggested that scapular focused exercises concentrating on controlled exercise progressions with feedback can help to improve muscle control, re-educate neuromuscular activity, improve motor control and central processing and optimize internal feedback. These mechanisms might have altered the activation patterns and control of the affected muscles like middle deltoid, upper trapezius, levator scapulae, pectoralis minor and other scapular stabilising muscles, resulting in the improvement in pressure pain threshold, pectoralis minor length and scapular dyskinesis in subjects with adhesive capsulitis. Even if pectoralis minor index showed a significant decrease during the follow up period, it is still considered effective as the values were falling under the normal pectoralis minor index range (8.54 ± 0.88).

Even though, most of these outcome measures exhibited significant improvement and significant long term follow up improvement in scapular movement training group after the intervention, pressure pain threshold for levator scapulae showed no significant long term follow up improvement. This may be because of lack of supervision during the home exercise program after the intervention phase. Scapular movement training mainly involves carefully controlled arm elevation exercises for scapular muscles including levator scapulae which has a role in scapular elevation during arm elevation.[18] Since there was no supervision and feedback, subjects may have not properly concentrated on the activation of levator scapulae muscle during arm elevation resulting in poor prognosis.

Shoulder function showed a significant effect in scapular movement training group. This improvement in shoulder function may be attributed to the improvement of other outcomes i.e., pressure pain threshold, pectoralis minor length and scapular dyskinesis test, which in turn resulted in the overall improvement of shoulder function. Though, shoulder function showed significant improvement when compared with baseline, it exhibited a significant decrease in the long term follow up period. This may be because of the decrease in pressure pain threshold for levator scapulae during the follow up period. Proper control and activation of all the shoulder and scapular muscles are needed for the improvement in shoulder function. Since levator scapulae did not show any significant effect during the follow up, this might possibly explain the significant decrease in shoulder function during the follow up period. Thus, continuation of supervised exercises with feedback for longer duration are needed for proper activation of levator scapulae in order to maintain the significant improvement in shoulder function.

Conventional training group showed significant improvement in pressure pain thresholds for middle deltoid and upper trapezius, pectoralis minor length, scapular dyskinesis and shoulder function. But, when compared to scapular movement training group, it showed less significant effect in these outcome measures. Conventional group showed no significant long term follow up effect in any of the outcome measures. For pectoralis minor index, even though conventional training exhibited significant effect and long term follow up effect, none of the values reached to the normal pectoralis minor index range (8.54 ± 0.88) in the conventional training group. These additional benefits were achieved in the scapular movement training group due to the application of scapular movement based controlled exercise program to the subjects.

In this study, within and between group analysis reveal that scapular movement training is more beneficial in improving pressure pain thresholds, pectoralis minor length, scapular dyskinesis and shoulder function than the conventional training. Thus, it can be inferred that, scapular movement training have an important role in improving pressure pain thresholds, pectoralis minor length, scapular dyskinesis and shoulder function in adhesive capsulitis.

V. LIMITATIONS

- Unable to meet the estimated minimum sample size due to unwillingness of participants for a 9 week long study.

VI. SUGGESTIONS FOR FUTURE STUDY

- Future studies can be done on female subjects with other outcome measures.
- Future studies can be conducted to evaluate the effect of SMT on other shoulder conditions like shoulder impingement.
- Future studies can be conducted to analyse the long term follow up effect of SMT on shoulder function by increasing the treatment duration of scapular movement training with supervision and feedback.

VII. CONCLUSION

This study concluded that, scapular movement training is effective in improving pressure pain thresholds for middle deltoid, upper trapezius and levator scapulae, pectoralis minor length, scapular dyskinesis and shoulder function, and this effect even persists in follow up period with the exception for pressure pain threshold in levator scapulae and SPADI, in adhesive capsulitis.

- For pressure pain threshold in middle deltoid- Scapular movement training has more significant effect as well as significant long term follow up effect than conventional physiotherapy.
- For pressure pain threshold in upper trapezius- Scapular movement training has more significant effect as well as significant long term follow up effect than conventional physiotherapy.
- For pressure pain threshold in levator scapulae- Scapular movement training has more significant effect than conventional physiotherapy.

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- For pectoralis minor length- Scapular movement training has more significant effect as well as significant long term follow up effect than conventional physiotherapy.
- For scapular dyskinesis- Scapular movement training has more significant effect as well as significant long term follow up effect than conventional physiotherapy.
- For shoulder function- Scapular movement training has more significant effect than conventional physiotherapy.

LIST OF ABBREVIATIONS

- AC : Adhesive Capsulitis
- LS : Levator Scapulae
- MD : Middle Deltoid
- PMI : Pectoralis Minor Index
- PPT : Pressure Pain Threshold
- RCT : Randomized Controlled Trial
- RM : Repetition Maximum
- ROM : Range Of Motion
- SD : Scapular Dyskinesis
- SDT : Scapular Dyskinesis Test
- SMT : Scapular Movement Training
- SPADI : Shoulder Pain And Disability Index
- UT : Upper Trapezius

➢ *Author Contributions:*

The author's confirm contribution to the paper as follows:

- Study conception and Design: Chinchu Alwin and Nelson Joy;
- Data Collection: Nelson Joy;
- Review and Editing: Chinchu Alwin and Reeba Roy
- Analysis and Interpretation: Rejimol Jos Pulicken, Rakhi Balagopal
- Draft Manuscript: Nelson Joy

All the authors reviewed the results and approved the final version of manuscript.

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- Ethical Approval: Approved

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