

## ORIGINAL ARTICLE

# Targeted Costotransverse Manipulation in Rotator Cuff Related Shoulder Pain: A Randomized Controlled Trial

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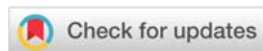
**This article may be cited as:**

Ehsan A, Shafiq M, Saadullah, Abideen ZU, Shabbir S, Targeted Costotransverse Manipulation in Rotator Cuff Related Shoulder Pain: A Randomized Controlled Trial. Pak J Med Health Sci, 2026; 20(06): 25-34.

Received: 02-03-2026

Accepted: 15-06-2026

Published: 30-06-2026



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**ABSTRACT**

**Background:** Shoulder pain is a common musculoskeletal disorder typically associated with rotator cuff and can result in chronic pain, disability and limitation of shoulder movements. Central to conservative management is therapeutic exercise and an adjunct is often taken in the form of thoracic manual therapy. The extra advantage of the localized effect on the costotransverse joints is however, not clear. This research compared effect of costotransverse joint manipulation, when combined with thoracic spine manipulation and exercise on patients with rotator cuff-related shoulder pain and cervicothoracic dysfunction.

**Methods:** The trial was a parallel-group randomized controlled trial that was run in the physiotherapy units of the Jinnah Hospital Lahore, Services Hospital Lahore, and Shalamar Hospital Lahore in Pakistan. Convenience sampling was employed to select the participants who had shoulder pain associated with the rotator cuff and cervicothoracic impairment, and assigned to an experimental or control group in a random manner. The experimental group was manipulated as far as the manipulation on costotransverse joints was used along with the manipulation of the thoracic spine and therapeutic exercise; the control group was manipulated with thoracic spine and the same exercise without the manipulation of the costotransverse joints. Measures were pain intensity (NNPRS) by measuring the pain, shoulder disability (SPADI) by evaluating the shoulder pain and disability index, shoulder range of motion, cervicothoracic mobility, posture alignment, and Global Rating of Change (GROC). Appropriate between- and within-group statistical tests were applied to analyze the data, reporting mean between and within group differences, 95% confidence interval, p-values, and the effect sizes.

**Results:** The experimental group showed more improvements than the control group in the intensity of pains, the disability of the shoulder, the shoulder range of motion, the cervicothoracic mobility range, the postural alignment, and the perceived recovery around the world. Post-treatment NPRS was  $2.41 \pm 0.91$  in the experimental group compared with  $3.47 \pm 1.04$  in the control group ( $p < 0.001$ ). SPADI scores were also significantly lower in the experimental group ( $28.6 \pm 7.9$  vs.  $38.7 \pm 8.6$ ;  $p < 0.001$ ). There were greater between group differences in shoulder flexion, abduction, internal and external rotation, cervical and thoracic mobility ( $p < 0.05$ ). The experimental group also demonstrated a greater GROC score ( $5.63 \pm 1.14$  vs.  $4.31 \pm 1.27$ ;  $p < 0.001$ ). There were moderate to large effect sizes on the major outcomes.

**Conclusion:** Adding costotransverse joint manipulation to thoracic spine manipulation and therapeutic exercise may provide additional benefits in reducing pain and disability and improving shoulder and cervicothoracic function in patients with rotator cuff-related shoulder pain and cervicothoracic dysfunction. Costotransverse manipulation can thus be viewed as used as a supplement to exercise-based rehabilitation in the right patients.

**Keywords:** Rotator cuff related shoulder pain; subacromial pain syndrome; costotransverse joint manipulation; thoracic manipulation; manual therapy; therapeutic exercise; shoulder disability; randomized controlled trial.

## INTRODUCTION

Subacromial impingement syndrome (SIS), which is now often referred to in more general terms as subacromial pain syndrome (SAPS) or as rotator cuff related shoulder pain (RCRSP) is a common phenomenon in musculoskeletal practice and a key cause of pain, disability and loss of quality of life. Shoulder pain is extremely common in all parts of the world and rotator cuff and subacromial images make up a significant percentage of presentations. Chronic shoulder symptoms can also have a considerable impact on physical functioning, day-to-day activities, work involvement, and health-related quality of life<sup>1-2</sup>.

Therapy exercise is a primary focus of conservative management of subacromial and rotator cuff related shoulder disorders. Rehabilitation programs which are exercise-based typically involve progressive strengthening, stretching, mobility and functional exercises, targeted at the rotator cuff and scapular muscles. Evidence on systematic reviews indicates that exercise is an efficient intervention that leads to a better pain and decreased functioning in patients with rotator cuff tendinopathy and subacromial shoulder pain, although there may be patients, who are not able to participate efficiently in active rehabilitation due to pain, reduced movement of the affected part, performances in muscles, and changes in movement strategies<sup>2-4</sup>.

As a result, it is becoming common to integrate the use of manual therapy (MT) with exercise-based rehabilitation. Manual treatment can involve joint mobilization, joint manipulation, soft-tissue techniques and shoulder-girdle performance- toward-the-shoulder-girdle and cervicothoracic region interventions. The synthesis of evidence indicates that, in patients with subacromial shoulder pain, systematic reviews suggest that combination interventions with both manual and exercise therapy, as compared to interventions alone, can lead to short-term pain and functional benefits, although the strength and sustainability of these effects is unpredictable across outcomes and follow-up times<sup>3-6</sup>.

The above consideration to apply to the thoracic spine in the case of shoulder pain is based on the principle of regional interdependence, i.e., the limitations of one anatomic area are possible to affect symptoms and movement in another area. Scapular position and shoulder movement may be affected by thoracic hypomobility, abnormal thoracic posture, and cervicothoracic mechanics. High-velocity low-amplitude (HVLA) manipulation and thoracic manual therapy, which involves mobilization and high-velocity low-amplitude (HVLA) is thus examined as both an adjunction to the shoulder rehabilitation. Trial evidence available shows that manipulation of the thorax may induce short-term modifications in pain, shoulder

movement and scapular kinematics, some trials using a sham intervention have indicated two to three times smaller effects<sup>5-8</sup>.

Thus, well-designed randomized controlled trials are required to assess particular thoracic and costotransverse manual therapy methods as supplementary to physical activities. The current study was aimed to fill this gap with the comparisons of costotransverse joint manipulation to thoracic spine manipulation and exercise against thoracic spine manipulation and exercise to determine which of the aforementioned therapies applied in the treatment of rotator cuff-associated shoulder pain, and cervicothoracic dysfunction by itself is more effective. Some of the clinically relevant outcomes the study assesses are pain intensity, shoulder disability, shoulder range of motion, cervicothoracic mobility and cervicothoracic outcome as perceived by the patient.

## MATERIAL AND METHODS

Costotransverse joint manipulation with thoracic spine manipulation and therapeutic exercise was used to perform randomized controlled trial (RCT) in patients with rotator cuff-related shoulder pain and cervicothoracic dysfunction in assessing the added benefit of costotransverse joint manipulation compared to thoracic spine manipulation alone. This was done in the physiotherapy units of Jinnah Hospital Lahore, Services Hospital Lahore, and Shalamar Hospital Lahore, Punjab, Pakistan. The researchers compared two treatment methods, i.e. experimental intervention and control interventions, i.e. costotransverse joint manipulation that was added to thoracic spine manipulation and exercise, and thoracic spine manipulation and exercise, respectively. The aim of the study was to find out whether the addition of extra treatment to the conventional thoracic treatment by treating the costotransverse joints led to better improvement in pain, shoulder disability, range of movement, cervicothoracic mobility, postural parameters, and general recovery by the patients.

### Population and Sampling

The patients were divided into three study groups, adult patients who were referred to the physio departments of Jinnah Hospital, Services Hospital, and Shalamar Hospital in Lahore with clinical features of rotator cuff shoulder pain and cervicothoracic dysfunction. The convenient sampling method was employed to select the participants because they were at the right place and time and were fully qualified and willing to participate in the study. The identified patients that met the established eligibility criteria were approached and informed about the purpose of the study, procedures, potential benefits, and potential

risks. Informed consent was informed by the way of a written agreement prior to enrolment. The randomization was done to balance the numbers between the treatment groups and after recruitment the eligible participants were randomly assigned to either the experimental or control group in a randomization procedure.

### Eligibility Criteria

All the participants were 35 years or older, and had rotator cuff related shoulder pain of 3 months or more with a clinically significant level of pain occurring during active shoulder movement. The participants had to possess a minimum intensity of pain of about 3/10 on the Numeric Pain Rating Scale (NPRS) and clinical examination showing signs of rotator cuff adjacent shoulder pain. Moreover, the participants had to exhibit clinical evidence of cervicothoracic dysfunction such as limited cervical or thoracic mobility, altered thoracic position, or mechanical impairment concerning shoulder complaint. It was also necessary that the participants should have adequate cognitive and physical ability to comprehend the study procedures, accomplish the outcome measures and adhere to the exercise program.

Patients were not allowed to have a history of shoulder fracture, or dislocation, prior shoulder/cervical/thoracic surgical procedures, or a significant traumatic injury, or other pathology that might warrant surgical treatment. People with possible cervical radiculopathy or myelopathy, neurological or systemic inflammatory or rheumatological disease, very severe osteoporosis, malignancy or other contraindications to spinal or costotransverse manipulation were also eliminated. Acute infection patients, severe cardiopulmonary disease cases and other patients with medical conditions that would expose them to harm were eliminated. The participants were also not allowed to participate in another structured physiotherapy or manual-therapy intervention of the same shoulder condition at the time of the study to minimize treatment contamination.

### Randomness and Assignment

After the evaluation of baseline, the participants meeting the selection criteria were randomly divided into two parallel groups of treatment or control. The experimental group was treated to costotransverse joint manipulation as well as thoracic spine manipulation and therapeutic exercise and control group was treated to thoracic spine manipulation and therapeutic exercise without the use of costotransverse joint manipulation. Random assignment was done following the completion of the baseline assessment in order to limit selection bias. The two groups were treated in similar clinical conditions and were subjected to the general rehabilitation technique that

depends on exercises with the costotransverse intervention only being the main difference in the two treatment regimens.

### Intervention

Experimental group subjects were provided with costotransverse joint manipulation and thoracic spine manipulation and therapeutic exercise. Costotransverse manipulation followed the clinically relevant thoracic rib articulations found in the physical examination. Depending on the presentation of the patient, and tolerance to therapy, spinal manipulation of the thoracic region was done with the help of a suitable manual-therapy skill. Therapeutic activities were comprised of progressive shoulder and thoracic activity, stretching, and strengthening activities which were aimed at enhancing the shoulder functions or cervicothoracic mechanical performance.

In the control group, participants were given thoracic spine manipulation, and the same therapy exercise program but without costotransverse joint manipulation. The manipulation intervention was therefore the typical control of thoracic manipulation-plus-exercise which enabled the further therapeutic enhancement of costotransverse manipulation. The use of trained physiotherapists who administered treatment through standard procedures occurred in the participating hospitals.

### Outcome Measures

The primary outcomes were shoulder pain intensity and shoulder-related disability. The pain intensity was measured by the Numeric Pain Rating Scale (NPRS) and shoulder pain and disability measured by Shoulder Pain and Disability Index (SPADI). The secondary outcomes were active shoulder range of motion such as flexion, abduction, internal rotation, and external rotation. Cervicothoracic activity was measured using cervical and thoracic mobility measurements and postural evaluation. Global Rating of Change (GROC) was used to measure patient-perceived improvement. These are the outcomes that were chosen since the current evidence base of thoracic manipulation and exercise in shoulder disorders utilizes NPRS, SPADI, shoulder ROM, thoracic mobility, and GROC as clinically outcomes.

### Data Collection Procedure

Pretreatment baseline data were gathered prior to the beginning of treatment and involved demographic information (age, sex, BMI, duration of symptoms, affected shoulder, and pertinent clinical factors). Measures were taken (baseline NPRS, SPADI, shoulder ROM, and cervicothoracic) prior to randomization. The participants

were then subjected to the intervention they received as part of the treatment. Post treatment tests were conducted with outcome measures and methods of assessment that were done at baseline. An after-check evaluation was also done, to find out whether the treatment-related gains were to be sustained beyond treatment. Each data was inputted on standardized data-collection forms which were later inputted into a statistical database where they were analyzed.

### Statistical Analysis

Data analysis was done via relevant descriptive and inferential statistics. Mean and standard deviation (SD) were used to summarize continuous variables when the variables are categorical, but frequencies and percentages were used to summarize the categorical variables. The comparison of baseline in the experimental group and the control group was done using the relevant statistical tests. The differences in within-group pain, disability, ROM, and functional outcomes were evaluated through comparing the baseline with the post-treatment values, and the differences between the groups were applied to determine the extra effect of costotransverse joint manipulation. Mean differences were also reported with p-values, the 95-percent confidence intervals (CI). The magnitude of the between-group treatment effects were computed by using the effect sizes, such as Cohen d. A p-value of less than 0.05 was considered statistically significant.

### Ethical Considerations

The research was undertaken in good faith and ethics in conducting research on human subjects. They were briefed of the objective and courses of the research, of their voluntary participation, as well as their right to discontinue participation at any point in time without risking to their clinical care. All participants gave informed consent in writing before the collection of data. The information on participants was anonymous and data were presented and analyzed in aggregates. Before the intervention/manual therapy, specific focus was put on screening of participants based on contraindications to this intervention.

## RESULTS

Table 1 shows the demographic and baseline clinical factors of the members of the experimental and control groups. The average age of test participants and the control group was similar (47.647.8 and 48.348.1, respectively;  $p = 0.734$ ). Equally, there was no statistically significant difference found in terms of sex, BMI and duration of symptoms, affected shoulder, NPRS, SPADI, and the cervicothoracic dysfunction scores ( $p > 0.05$ ). The baseline

NPRS scores were  $6.18 \pm 1.02$  and  $6.25 \pm 1.08$ , while SPADI scores were  $58.4 \pm 8.7$  and  $59.1 \pm 9.1$  in the experimental and control groups, respectively. These results suggest that there were no material differences between the two groups at the beginning of the treatment and therefore chances of the differences at the baseline affecting the later treatment results are lower.

As shown in Table 2, there is a more significant change in shoulder pain in the experimental group which is exposed to the manipulation of the costotransverse joint as an extra tool, to thoracic manipulation and exercise. There was no significant difference in baseline NPRS scores ( $p = 0.798$ ), but there was a significant difference in post-treatment pain- the experiment group ( $2.41 \pm 0.91$ ) as compared to the control ( $3.47 \pm 1.04$ ). The between-group mean difference was  $-1.06$  points (95% CI:  $-1.56$  to  $-0.56$ ;  $p < 0.001$ ). Moreover, the difference (between groups) (MD =  $-0.99$ , 95% CI:  $-1.58$   $-0.40$ ) between the change from baseline was greater in experimental ( $-3.77$ ) compared with control ( $-2.78$ ), and the difference in changes was statistically significant ( $p = 0.002$ ). The results imply that costotransverse manipulation might be an extra analgesic value, as compared to thoracic manipulation and exercise alone.

Table 3 shows that there was significant change in the state of shoulder related pain and disability after treatment. Although baseline SPADI scores were comparable between groups ( $p = 0.759$ ), post-treatment scores were significantly lower in the experimental group ( $28.6 \pm 7.9$ ) than in the control group ( $38.7 \pm 8.6$ ; MD =  $-10.1$ , 95% CI:  $-14.4$  to  $-5.8$ ;  $p < 0.001$ ). Both pain and disability measures of SPADI showed significant between-group statistics. The experimental group had an average of 29.8 points reduction compared to 20.4 points in the control group. The total SPADI is improved (approximately, 9.4 points) more with the additional costotransverse manipulation, and suggests that the overall function of the shoulder is possibly improved significantly.

Table 4 indicates that an improvement in shoulder movements has been achieved after the intervention. There was no significant difference in baseline ROM values between groups, but there was post-treatment increase in shoulder flexion to  $164.8 \pm 12.7^\circ$  in the experimental group and  $154.1 \pm 14.2^\circ$  in the control group (MD =  $10.7^\circ$ , 95% CI:  $3.9$   $17.5$ ;  $p = 0.003$ ). This was also found to improve abduction, internal and external rotation. The most significantly differentiated between-group differences were on shoulder abduction ( $11.4^\circ$ ) and flexion ( $10.7^\circ$ ). These results suggest that costotransverse joint manipulation when used along with thoracic manipulation and exercise can help restore shoulder mobility more than the comparator intervention.

**Table 1:** Demographic and Baseline Characteristics of Participants

| Variable                               | Experimental Group (n=30) | Control Group (n=30) | p-value |
|----------------------------------------|---------------------------|----------------------|---------|
| Age, years, mean $\pm$ SD              | 47.6 $\pm$ 7.8            | 48.3 $\pm$ 8.1       | 0.734   |
| Age groups, n (%)                      |                           |                      | 0.821   |
| 35–44 years                            | 10 (33.3)                 | 9 (30.0)             |         |
| 45–54 years                            | 13 (43.3)                 | 14 (46.7)            |         |
| $\geq$ 55 years                        | 7 (23.3)                  | 7 (23.3)             |         |
| Sex, n (%)                             |                           |                      | 0.793   |
| Male                                   | 17 (56.7)                 | 16 (53.3)            |         |
| Female                                 | 13 (43.3)                 | 14 (46.7)            |         |
| BMI, kg/m <sup>2</sup> , mean $\pm$ SD | 26.8 $\pm$ 3.4            | 27.1 $\pm$ 3.7       | 0.741   |
| Symptom duration, months               | 7.4 $\pm$ 3.2             | 7.7 $\pm$ 3.5        | 0.728   |
| Dominant shoulder affected, n (%)      | 21 (70.0)                 | 22 (73.3)            | 0.781   |
| Right shoulder, n (%)                  | 19 (63.3)                 | 18 (60.0)            | 0.792   |
| Left shoulder, n (%)                   | 11 (36.7)                 | 12 (40.0)            |         |
| NPRS, mean $\pm$ SD                    | 6.18 $\pm$ 1.02           | 6.25 $\pm$ 1.08      | 0.798   |
| SPADI, mean $\pm$ SD                   | 58.4 $\pm$ 8.7            | 59.1 $\pm$ 9.1       | 0.759   |
| Cervicothoracic dysfunction score      | 42.6 $\pm$ 6.3            | 43.1 $\pm$ 6.7       | 0.768   |

**Table 2:** Between-Group Comparison of Pain Intensity

| Outcome                  | Experimental Group | Control Group    | Mean Difference | 95% CI         | p-value |
|--------------------------|--------------------|------------------|-----------------|----------------|---------|
| NPRS baseline            | 6.18 $\pm$ 1.02    | 6.25 $\pm$ 1.08  | –0.07           | –0.61 to 0.47  | 0.798   |
| NPRS post-treatment      | 2.41 $\pm$ 0.91    | 3.47 $\pm$ 1.04  | –1.06           | –1.56 to –0.56 | <0.001  |
| Change from baseline     | –3.77 $\pm$ 1.14   | –2.78 $\pm$ 1.17 | –0.99           | –1.58 to –0.40 | 0.002   |
| NPRS at 4-week follow-up | 2.28 $\pm$ 0.86    | 3.32 $\pm$ 1.02  | –1.04           | –1.53 to –0.55 | <0.001  |

**Table 3:** Interpretation Shoulder Pain and Disability (SPADI)

| SPADI Domain               | Experimental Group | Control Group   | Mean Difference | 95% CI        | p-value |
|----------------------------|--------------------|-----------------|-----------------|---------------|---------|
| Total SPADI baseline       | 58.4 $\pm$ 8.7     | 59.1 $\pm$ 9.1  | –0.7            | –5.3 to 3.9   | 0.759   |
| Total SPADI post-treatment | 28.6 $\pm$ 7.9     | 38.7 $\pm$ 8.6  | –10.1           | –14.4 to –5.8 | <0.001  |
| Pain subscale              | 27.4 $\pm$ 5.1     | 34.9 $\pm$ 5.8  | –7.5            | –10.3 to –4.7 | <0.001  |
| Disability subscale        | 31.2 $\pm$ 6.4     | 40.8 $\pm$ 7.1  | –9.6            | –13.1 to –6.1 | <0.001  |
| Change in total SPADI      | –29.8 $\pm$ 9.2    | –20.4 $\pm$ 9.5 | –9.4            | –14.2 to –4.6 | <0.001  |

**Table 4:** Shoulder Range of Motion

| ROM Variable                          | Experimental Group | Control Group    | Between-Group Difference | 95% CI      | p-value |
|---------------------------------------|--------------------|------------------|--------------------------|-------------|---------|
| Flexion, baseline (°)                 | 142.6 $\pm$ 15.3   | 141.8 $\pm$ 16.1 | 0.8                      | –7.2 to 8.8 | 0.842   |
| Flexion, post-treatment (°)           | 164.8 $\pm$ 12.7   | 154.1 $\pm$ 14.2 | 10.7                     | 3.9 to 17.5 | 0.003   |
| Abduction, baseline (°)               | 134.7 $\pm$ 17.2   | 133.9 $\pm$ 16.8 | 0.8                      | –7.7 to 9.3 | 0.852   |
| Abduction, post-treatment (°)         | 158.6 $\pm$ 14.3   | 147.2 $\pm$ 15.7 | 11.4                     | 3.9 to 18.9 | 0.004   |
| Internal rotation, baseline (°)       | 49.8 $\pm$ 8.6     | 50.3 $\pm$ 8.9   | –0.5                     | –4.9 to 3.9 | 0.822   |
| Internal rotation, post-treatment (°) | 65.7 $\pm$ 8.1     | 58.6 $\pm$ 8.7   | 7.1                      | 2.8 to 11.4 | 0.002   |
| External rotation, baseline (°)       | 57.4 $\pm$ 9.2     | 58.1 $\pm$ 9.5   | –0.7                     | –5.5 to 4.1 | 0.773   |
| External rotation, post-treatment (°) | 73.6 $\pm$ 8.4     | 66.8 $\pm$ 9.1   | 6.8                      | 2.3 to 11.3 | 0.004   |

**Table 5:** Cervicothoracic Mobility and Postural Outcomes

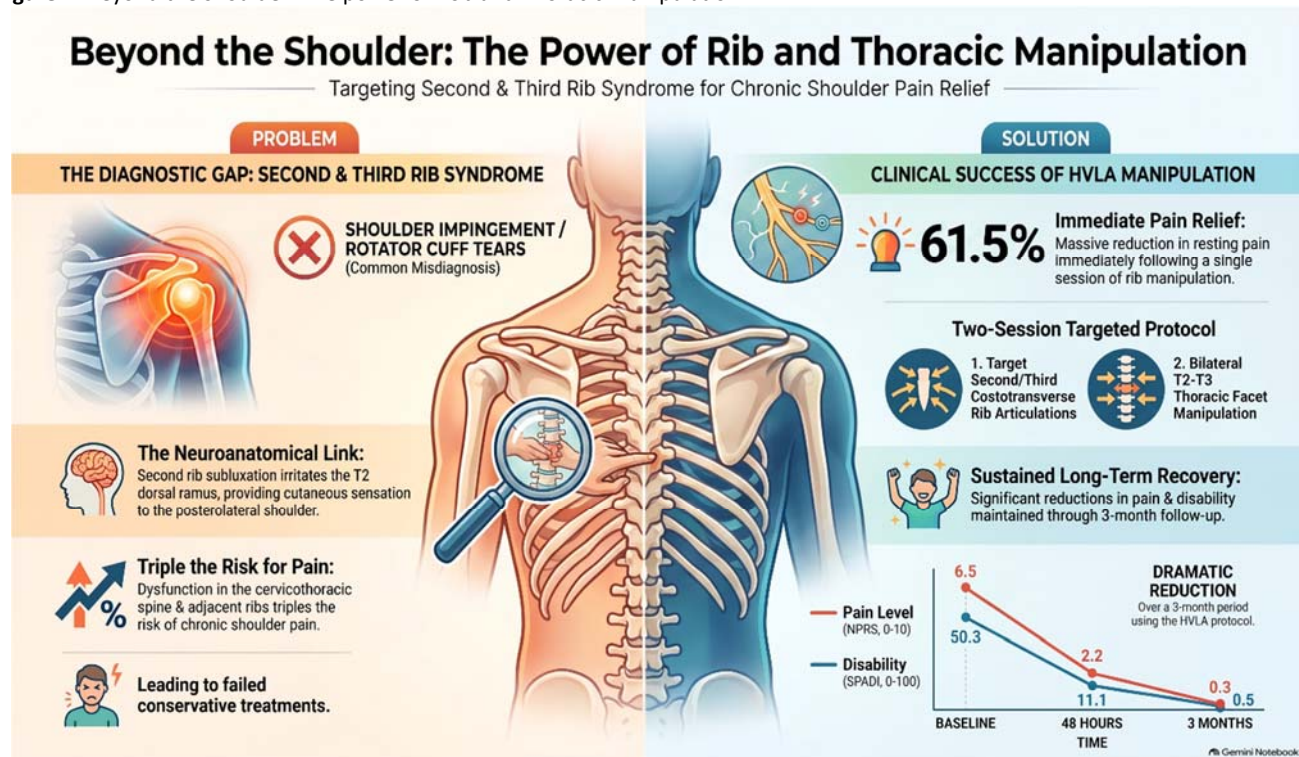
| Outcome                                | Experimental Group | Control Group  | Mean Difference | 95% CI       | p-value |
|----------------------------------------|--------------------|----------------|-----------------|--------------|---------|
| Cervical rotation, baseline (°)        | 61.2 $\pm$ 7.4     | 60.8 $\pm$ 7.7 | 0.4             | –3.5 to 4.3  | 0.841   |
| Cervical rotation, post-treatment (°)  | 69.8 $\pm$ 6.3     | 65.2 $\pm$ 7.1 | 4.6             | 1.1 to 8.1   | 0.011   |
| Thoracic extension, baseline (°)       | 27.6 $\pm$ 5.8     | 27.2 $\pm$ 6.1 | 0.4             | –2.7 to 3.5  | 0.801   |
| Thoracic extension, post-treatment (°) | 35.9 $\pm$ 6.2     | 31.4 $\pm$ 6.5 | 4.5             | 1.2 to 7.8   | 0.009   |
| Thoracic rotation, baseline (°)        | 36.8 $\pm$ 6.7     | 37.1 $\pm$ 6.4 | –0.3            | –3.6 to 3.0  | 0.859   |
| Thoracic rotation, post-treatment (°)  | 45.7 $\pm$ 6.1     | 41.3 $\pm$ 6.6 | 4.4             | 1.1 to 7.7   | 0.010   |
| Postural alignment score               | 20.8 $\pm$ 4.1     | 21.1 $\pm$ 4.3 | –0.3            | –2.4 to 1.8  | 0.774   |
| Postural alignment post-treatment      | 15.7 $\pm$ 3.6     | 18.4 $\pm$ 3.9 | –2.7            | –4.7 to –0.7 | 0.009   |

**Table 6:** Global Perceived Recovery and Functional Improvement

| Outcome                            | Experimental Group | Control Group   | Mean Difference | 95% CI       | p-value |
|------------------------------------|--------------------|-----------------|-----------------|--------------|---------|
| GROC score, mean $\pm$ SD          | 5.63 $\pm$ 1.14    | 4.31 $\pm$ 1.27 | 1.32            | 0.70 to 1.94 | <0.001  |
| Clinically improved, n (%)         | 25 (83.3)          | 18 (60.0)       | 23.3%           | 1.2–45.4%    | 0.048   |
| Satisfactory recovery, n (%)       | 23 (76.7)          | 16 (53.3)       | 23.4%           | 0.7–46.1%    | 0.044   |
| Return to normal activities, n (%) | 24 (80.0)          | 17 (56.7)       | 23.3%           | 0.6–46.0%    | 0.047   |

**Table 7:** Effect Size and Clinical Significance

| Outcome            | Cohen's d | 95% CI    | Effect Magnitude |
|--------------------|-----------|-----------|------------------|
| NPRS               | 0.88      | 0.35–1.41 | Large            |
| SPADI              | 1.08      | 0.53–1.63 | Large            |
| Shoulder flexion   | 0.79      | 0.27–1.31 | Moderate–large   |
| Shoulder abduction | 0.76      | 0.24–1.28 | Moderate–large   |
| Internal rotation  | 0.84      | 0.32–1.36 | Large            |
| Thoracic extension | 0.71      | 0.20–1.22 | Moderate         |
| GROC               | 1.10      | 0.54–1.66 | Large            |

**Figure 1:** Beyond the shoulder: The power of Rib and Thoracic Manipulation

The results in table 5 exhibit greater changes in cervicothoracic mobility and postural parameters to the advantage of the experimental intervention. Experimental group experienced a 4.6o greater improvement in cervical rotation as compared to the control group (95% CI: 1.1 8.1;  $p = 0.011$ ). Between-group differences in thoracic extension and rotation were also statistically significant with mean differences of 4.5degrees ( $p = 0.009$ ), and 4.4degrees ( $p = 0.010$ ), respectively. Moreover, the post-intervention postural alignment score was much lower in the experimental group ( $15.7 \pm 3.6$ ) than the control group

( $18.4 \pm 3.9$ ;  $p=0.009$ ). All of this effectively indicates that the costotransverse joints might potentially be targeted to help in enhancing thoracic and cervicothoracic mechanical functions.

Table 6 indicates an improvement patient-reported recovery in the experimental group. Participants with costotransverse manipulation (mean)  $5.63 \pm 1.14$  had a significantly higher mean GROC score when compared to those receiving thoracic manipulation and exercise (mean)  $4.31 \pm 1.27$  with a mean difference of 1.32 points (95% CI: 0.70-1.94;  $p < 0.001$ ). In addition, 83.3% of experimental

group respondents were categorized as clinically improved as compared to 60.0% of control group respondents. The same differences were noted in terms of satisfactory recovery and recovery to normal activities. Such results indicate that introducing costotransverse manipulation could not only enhance objective clinical outcomes but also the overall perception of the recovery and functional restoration of patients.

The size of the observed treatment effects is summarized in Table 7. Group effects were found to be large (GROC:  $d = 1.10$  and SPADI:  $d = 1.08$ ), which were the largest effects. NPRS showed a significant effect ( $d = 0.88$ ), shoulder flexion ( $d = 0.79$ ), internal rotation ( $d = 0.84$ ) and shoulder abduction ( $d = 0.76$ ) showed moderate-to-large effects. A middle effect was observed in thoracic extension ( $d = 0.71$ ). The confidence intervals surrounding these estimates were positive, which indicated regularity of the direction of effect observed. The effect-size results, in general, indicate that the introduction of costotransverse joint manipulation might have clinically significant effects on pain, disability, mobility and perceived recovery.

## DISCUSSION

The current randomized controlled trial was to determine the additive benefits of adding costotransverse joint manipulation to thoracic spine manipulation and exercise on the patients with rotator cuff-related shoulder pain and cervicothoracic dysfunction in comparison to thoracic manipulation and exercise. Generally, the results showed more improvements in the intensity of pain, shoulder disability, shoulder range of motion, cervicothoracic mobility, postural alignment and global perceived recovery among the experimental groups. The findings thus justify the possibility of the clinical importance of targeting the costotransverse region with a multimodal rehabilitation approach.

The greatest finding was the fact that significant reduction of pain was noted in the experimental group. The baseline level of NPRS, which was about 6.2, dropped to 2.4 after treatment, as compared to a decrease to about 3.5 in the control group. The difference between the groups was statistically significant indicating that the addition of costotransverse manipulation can give an analgesic advantage over thoracic manipulation and exercise alone<sup>9-12</sup>.

These findings are in line with existing evidence which shows that manual therapy with exercise can also serve to alleviate pain in patients with subacromial shoulder pain. In a randomized trial of 93 patients, the combination of exercise and manual therapy yielded better long-term disability outcomes than those provided by exercises alone, although no significant differences were observed during

the first six weeks of treatment. Likewise, a study of patients with subacromial pain syndrome documented large, significant decreases in SPADI and NPRS with the aid of the addition of spinal thrust manipulation to therapy. The results of this paper encourage the idea that manual therapy could be useful in amplifying the action of an exercise-based rehabilitation program, especially when the intervention is focused on the issues of the relevant mechanical impairments<sup>11-14</sup>.

The current results are however to be viewed against the backdrop of conflicting evidence. A randomized trial of 120 chronic rotator cuff disease patients yielded no difference between home exercise with manual therapy and total sham ultrasound in which the composite difference of SPADI was not found to be of statistical significance. Such a variation indicates that the efficacy of manual therapy might be influenced by the type of therapeutic procedure, dosage, patient variables, the type of a comparator therapy, and the anatomical area addressed<sup>13-16</sup>.

Another significant result is the large reduction in the SPADI scores. Those who received costotransverse manipulation presented more improvement in total SPADI, its pain and disability component than those that received thoracic manipulation and exercise alone. This means that the intervention can have any effects on pain severity, but it can also have an impact on functional implications of the shoulder symptoms. This interpretation is supported by previous studies. Exercise with manual therapy had significantly better DASH scores at 26 and 52 weeks than exercise alone in a randomized trial of adults with subacromial shoulder pain but there was no difference between the two treatments at the time of the initial treatment. Likewise, a trial on spinal thrust manipulation and electrical dry needling led to reporting a significant reduction of SPADI at three months as compared to non-thrust mobilization, exercise, and interferential current. These findings indicate that manual interventions can be an additive intervention in functional recovery among identified patients<sup>14-18</sup>.

However, not all evidence is in support. Manual therapy, education and exercise did not show a significant difference of QuickDash in patients with a history of a rotator and persistent shoulder pain but did not lead to a significant change in QuickDASH compared to education and exercise at six months of follow-up. Therefore, the current results can suggest that manual therapy as a general term, particularly specific joint-directed manual therapy is especially useful in enhancing disability. Experimental group showed a lot more improvements in shoulder flexion, abduction, internal rotation, and external rotation. This observation would have clinical significance as limited shoulder range can lead to lack of ability in

activities of daily living and may also help maintain inappropriate patterns of shoulder movement<sup>15, 18-21</sup>.

It might be improved partly because of the restoration of thoracic and costotransverse mobility. Thoracic transverse and costovertebral mobilization in T1-T 6 combined with home thoracic extension exercises and passive internal rotation, the tightness of the posterior shoulder, thoracic posture, and the active thoracic ROM have been studied in prior trials. Thoracic manipulation with shoulder ROM is also an outcome of other studies. Thus, the enhancement of the shoulder ROM reported in the current study corresponds to the hypothesized regional correlation between the motion of the thoracic region and shoulder movement<sup>11, 17,21</sup>.

Notably thoracic manipulation potentially affects the operation of shoulders by modifying the scapular motion rather than directly affecting the glenohumeral joint. Past placebo-controlled randomized studies have given positive results that lateral rotation of the scapula is increased after thoracic spinal manipulation, but the extent of pain change has been minimal. This evidence favoring the idea that alterations in proximal thoracic mechanics can result in better shoulder motions. Previously thoracic and cervicothoracic manipulation has been clinically studied in patients with shoulder disorders, the results have comprised of scapular kinematics, muscle activation, shoulder functioning, and pain. The enhancement of thoracic extension experienced in the present study can hence be an indication of the restoration of mechanical movement in an area that helps in the movement of the scapular and shoulder<sup>20-22</sup>.

The supplement with costotransverse manipulation could have supplemented these effects by directly treating rib thoracic articulation mobility. Past trials involve bilateral HVLA mobilization aimed on the costotransverse faculties of the ribs 2-9, and the outcomes of thoracic mobility, pain, and functional capacity. There is also evidence of manipulation that involves the second and third costotransverses in conjunction with upper thoracic manipulation using SPADI, NPRS, and GROC to measure the results. The studies offer a probable clinical justification of the current intervention<sup>7,15,19,22,23</sup>.

The study focused on the use of a combined intervention indicated that there were significantly more improvements at the global level according to the GROC scale among the participants that received the combined intervention. A higher percentage of the participants also experienced a clinically meaningful improvement and had satisfactory recovery and return to normal activities. These results are significant since statistical gains in pain or ROM may not result in significant changes in perceptions of recovery among patients<sup>22-24</sup>.

GROC has been intensively used in trials of manual therapy of the thoracic and cervicothoracic regions. GROC and NPRS, SPADI and shoulder function have been previously employed as a measure of patient-perceived improvements in costotransverse or thoracic surgery. The observed improvement in the current study thus extrapolates the results beyond impairment-level results and connotes a greater benefit which is patient-focused.

The extra effects of costotransverse manipulation can be attributed to a number of mechanisms. Biomechanically, costotransverse mobilization or manipulation could enhance rib and thoracic movement, which could be more beneficial scapulothoracic movement. Better thoracic extension and rotation can then lead to the decrease of mechanical constraints with respect to shoulder elevation (figure 1).

### Strengths and limitations

One of the strong points of the current research is the randomized controlled nature of the study and direct comparison of costotransverse manipulation and thoracic manipulation and exercise with thoracic manipulation and exercise only studies. This design enables the contribution of costotransverse manipulation to be assessed more specifically than those that have compared manual therapy with entirely different treatment strategies. Multidimensional assessment of treatment response is also offered by the use of pain, disability, ROM, cervicothoracic mobility, and global recovery.

However, there are a number of restrictions which should be taken into account. The convenience sampling method of recruitment was done through the physiotherapy departments in three hospitals within Lahore, which could perhaps reduce the applicability of the results on the general Pakistani population. The comparatively small treatment environment can also create institutional or therapist disparities as well. Moreover, participants and treating physiotherapists could not be completely blind with allocation to manual therapy. Other trials of manual therapy also experienced issues of therapist blinding. The evidence would be further reinforced by future trials in multiple centers with larger probability-based samples, assessor blinding of outcome, extended follow-up and standardized treatment-related fidelity measures.

## CONCLUSION

The results indicate that costotransverse joint manipulation to supplement thoracic spine manipulation and exercise, could offer extra benefits in pain and disability reduction and improved shoulder ROM, cervicothoracic mobility, postural stance, and perceived recovery among patients

with rotator cuff related shoulder pain and cervicothoracic dysfunction. The results are justified by an increasing amount of research exploring the topic of thoracic and rib-focused manual treatment, though the evidence varies in general. These current findings thus indicate a regionally focused, multimodal physiotherapy strategy and indicate the necessity of bigger, more rigorously designed studies to determine the sustenance and externalizability of these impacts.

### Clinical Implications

Its findings reveal that costotransverse joint manipulation can offer increased clinical improvements in association with the thoracic spine manipulation and therapeutic exercise in patients who have had shoulder pain which is caused by rotator cuff, and cervicothoracic dysfunction. Thoracic mobility, costotransverse joint function, cervical mobility, posture, and scapular movement are some of the things that physiotherapists should examine when carrying out clinical assessment. Costotransverse manipulation can be a complement to active exercise, especially in patients who come in with pertinent restrictions of the thoracic or cervicothoracic nature. Manual therapy should not substitute exercise, which should continue to be a significant part of rehabilitation.

### RECOMMENDATIONS

Further studies are needed to assess this intervention in larger multicenter samples at various hospitals and regions in Pakistan to enhance its generalizability. Future research that has a longer follow-up is encouraged to find out whether pain, disability, and range of motion, and functional recovery improvements are sustained over time. Next RCTs must also adopt standardized interventions, hidden randomization, and blind outcome evaluators, and proactive trial registration to enhance methodological rigor. The study should encourage further research on the optimal dosage of the costotransverse manipulation and the frequency of this intervention, as well as what clinical factors may predict a positive response to the mentioned intervention. Lastly, future research should take treatment adherence, adverse events, quality of life, resumption to daily activities, and cost-efficacy into consideration to create the enhanced clinical value of this treatment modality.

### DECLARATION

**Conflict of Interest:** The authors declare no conflict of interest.

**Funding:** This research did not receive any external funding.

**Author's Contribution:** All authors contributed equally in the complication of current study.

**Acknowledgments:** The authors express their sincere gratitude to all colleagues and participants for their valuable contributions to this study.

**Data Availability Statement:** The data that supports the findings of this research are available on request from Corresponding Author.

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