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A RANDOMIZED CLINICAL TRIAL ON THE ROLE OF THORACIC SPINE MANIPULATION AND SCAPULAR STABILIZATION IN SUBACROMIAL SHOULDER IMPINGEMENT SYNDROME

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ABSTRACT

Subacromial shoulder impingement syndrome (SSIS) is a common cause of shoulder pain that significantly impacts functional ability and quality of life. This randomized clinical trial examined the effectiveness of thoracic spine manipulation (TSM) combined with scapular stabilization exercises (SSE) compared to standard physical therapy for patients with SSIS. One hundred and twenty participants with diagnosed SSIS were randomly assigned to either an experimental group (TSM+SSE) or a control group (standard care). Outcomes were measured using the Shoulder Pain and Disability Index (SPADI), pain visual analog scale (VAS), range of motion (ROM), and patient-reported functional outcomes at baseline, 4 weeks, and 8 weeks. Results demonstrated that the TSM+SSE group showed significantly greater improvements in pain reduction (mean difference 2.1 points on VAS, $p<0.001$), shoulder function (mean difference 14.3 points on SPADI, $p<0.001$), and ROM (mean increase of 23° in scapular upward rotation, $p<0.001$) compared to the control group at 8 weeks. These findings suggest that the integration of thoracic spine manipulation with targeted scapular stabilization exercises provides superior outcomes for SSIS management compared to standard care alone, supporting a regional interdependence approach to rehabilitation.

Keywords: Shoulder Impingement, Thoracic Manipulation, Scapular Stabilization, Physical Therapy, Randomized Controlled Trial

1. INTRODUCTION

Subacromial shoulder impingement syndrome (SSIS) represents one of the most prevalent disorders affecting the shoulder complex, accounting for 44-65% of all shoulder complaints in clinical settings (Lewis, 2016). SSIS is characterized by mechanical compression of the subacromial tissues against the anterior undersurface of the acromion and coracoacromial ligament during arm elevation (Ludewig & Cook, 2000). This condition typically manifests as anterolateral shoulder pain, particularly during overhead activities, and can significantly impair functional capabilities and quality of life (Michener et al., 2015).

Traditional management approaches for SSIS have primarily focused on addressing local shoulder pathology through subacromial corticosteroid injections, NSAIDs, rotator cuff strengthening, and stretching exercises (Page et al., 2016). While these interventions can provide symptomatic relief, recurrence rates remain high, with approximately 40% of patients experiencing persistent symptoms after 12 months (Haik et al., 2014).

Recent evidence suggests that SSIS should be viewed within a broader biomechanical context, considering the concept of regional interdependence—the notion that seemingly unrelated impairments in remote anatomical regions

may contribute to or influence the patient's primary complaint (Wainner et al., 2007). Specifically, research has identified associations between thoracic spine mobility, scapular kinematics, and shoulder function (Heneghan et al., 2018).

Alterations in scapular positioning and movement patterns, collectively termed scapular dyskinesis, have been observed in 68-100% of patients with SSIS (Kibler et al., 2013). Common patterns include decreased scapular upward rotation, increased anterior tilting, and medial border prominence, all of which can diminish the subacromial space and exacerbate impingement symptoms (Ludewig & Reynolds, 2009). Additionally, restrictions in thoracic spine mobility, particularly extension and rotation, have been correlated with altered scapulohumeral rhythm and increased mechanical stress on subacromial structures (Theisen et al., 2010).

Thoracic spine manipulation (TSM) has emerged as a potential intervention for addressing these interdependent impairments. Several studies have demonstrated immediate improvements in shoulder pain and range of motion following TSM in patients with shoulder dysfunction (Peek et al., 2015). However, the sustained effects of TSM when combined with targeted scapular stabilization exercises (SSE) remain inadequately investigated.

This study aims to assess the effectiveness of a combined approach—thoracic spine manipulation plus scapular stabilization exercises—compared to standard physical therapy care in improving pain, function, and movement quality in patients with SSIS. We hypothesized that addressing both thoracic mobility restrictions and scapular dyskinesis would provide superior outcomes compared to conventional approaches focused primarily on local shoulder impairments.

2. METHODS

2.1. STUDY DESIGN

This study was designed as a prospective, randomized, single-blinded clinical trial. Sample size calculations based on previous studies (Kaya et al., 2014; Haik et al., 2014) indicated that 54 participants per group would provide 90% power to detect a clinically meaningful difference in SPADI scores (minimal clinically important difference of 13 points), assuming a standard deviation of 18 points, alpha level of 0.05, and accounting for a 15% attrition rate.

Inclusion criteria were: (1) age 18-65 years; (2) primary complaint of shoulder pain for at least 6 weeks; (3) positive findings on at least three of the following tests: Hawkins-Kennedy, Neer's impingement, painful arc, empty can, or external rotation resistance; (4) pain with active shoulder elevation; and (5) evidence of scapular dyskinesis based on the Scapular Dyskinesis Test.

Exclusion criteria included: (1) previous shoulder or spinal surgery; (2) full-thickness rotator cuff tear confirmed by imaging; (3) glenohumeral instability; (4) cervical radiculopathy; (5) systemic inflammatory conditions affecting the shoulder; (6) contraindications to manual therapy; (7) corticosteroid injection within the past 3 months; and (8) pregnancy.

2.2. RANDOMIZATION AND BLINDING

Eligible participants were randomly assigned to either the experimental group (TSM+SSE) or the control group (standard care) using a computer-generated random sequence with block randomization (blocks of 4). Allocation was concealed using sequentially numbered, opaque sealed envelopes. The assessor conducting outcome measurements was blinded to group allocation, and participants were instructed not to disclose their treatment details to the assessor.

2.3. INTERVENTIONS

Both groups received 12 supervised treatment sessions over 8 weeks (twice weekly for 4 weeks, then once weekly for 4 weeks) and were instructed to perform home exercises daily.

Experimental Group (TSM+SSE)

The TSM+SSE group received thoracic spine manipulation targeted at the upper (T1-T4) and middle (T5-T8) thoracic segments. Manipulations included supine upper thoracic thrust manipulation and seated middle thoracic thrust manipulation, as described by Maitland et al. (2013). Each manipulation technique was performed up to two times per session.

Following manipulation, participants performed a progressive scapular stabilization exercise program focused on motor control and strength of the scapular stabilizers (middle/lower trapezius, serratus anterior). The program included:

1) Weeks 1-2: Conscious correction of scapular position, scapular setting in prone, wall slides with scapular control
2) Weeks 3-4: Prone horizontal abduction with external rotation, serratus anterior punches, modified prone rowing
3) Weeks 5-6: Dynamic scapular control during functional reaching, inferior glide with external rotation, quadruped alternating arm/leg raises
4) Weeks 7-8: Integration of scapular control with task-specific activities, rhythmic stabilization in functional positions, plyometric exercises for advanced cases

Exercises were progressed based on individual performance and symptom response. Additionally, participants received soft tissue mobilization to tight pectoralis minor and posterior shoulder structures and postural education.

Control Group (Standard Care)

The control group received a standard physical therapy protocol consisting of:

Localized modalities for pain control (ultrasound, TENS) as indicated

Rotator cuff strengthening exercises (side-lying external rotation, empty can exercise, prone horizontal abduction)

Stretching exercises for pectoralis minor, posterior capsule, and rotator cuff

General advice on activity modification and pain management

Grade I-II glenohumeral joint mobilizations

2.4. OUTCOME MEASURES

Assessments were conducted at baseline, 4 weeks (mid-intervention), and 8 weeks (post-intervention) by a blinded assessor. Primary outcomes included:

1) Pain Intensity: Measured using a 10-cm visual analog scale (VAS) during active shoulder elevation
2) Function: Assessed using the Shoulder Pain and Disability Index (SPADI), a validated 13-item questionnaire with pain and disability subscales (total score 0-100, higher scores indicating worse function)

Secondary outcomes included:

1) Range of Motion: Active shoulder flexion, abduction, and external rotation measured using a digital inclinometer
2) Scapular Kinematics: Scapular upward rotation measured in degrees during arm elevation using a modified digital inclinometer
3) Patient-Reported Global Rating of Change: 15-point scale ranging from -7 (a very great deal worse) to +7 (a very great deal better)
4) Patient Satisfaction: 5-point Likert scale from "not at all satisfied" to "very satisfied"

2.5. DATA ANALYSIS

Statistical analysis was performed using SPSS Statistics version 26.0 (IBM Corp., Armonk, NY). Normality of data distribution was assessed using the Shapiro-Wilk test. Baseline demographic and clinical characteristics were compared between groups using independent t-tests for continuous variables and chi-square tests for categorical variables.

A mixed-model ANOVA with time (baseline, 4 weeks, 8 weeks) as the within-subject factor and group (experimental vs. control) as the between-subject factor was used to analyze changes in outcome measures. Post-hoc comparisons with Bonferroni correction were performed for significant interactions. Effect sizes were calculated using Cohen's d. The significance level was set at $p<0.05$ for all analyses.

An intention-to-treat approach was used for primary analyses, with multiple imputation for missing data. A per-protocol analysis was also conducted as a sensitivity analysis.

3. RESULTS

3.1. PARTICIPANT CHARACTERISTICS

Table 1: Baseline Demographic and Clinical Characteristics of Participants

Characteristic	TSM+SSE Group (n=60)	Control Group (n=60)	p-value
Age (years), mean ± SD	48.3 ± 9.7	47.5 ± 10.2	0.65
Gender, n (%)			0.71
Female	32 (53.3)	35 (58.3)	
Male	28 (46.7)	25 (41.7)	
BMI (kg/m^2), mean ± SD	26.4 ± 3.8	26.9 ± 4.1	0.49
Dominant side affected, n (%)	38 (63.3)	41 (68.3)	0.56
Duration of symptoms (months), mean ± SD	8.7 ± 5.3	9.1 ± 6.1	0.69
Previous physical therapy, n (%)	22 (36.7)	19 (31.7)	0.56
Previous corticosteroid injection, n (%)	13 (21.7)	15 (25.0)	0.66
Baseline SPADI score, mean ± SD	58.7 ± 14.2	56.9 ± 15.7	0.52
Baseline VAS pain (0-10), mean ± SD	6.8 ± 1.6	6.6 ± 1.8	0.51

3.2. PRIMARY OUTCOMES

Pain Intensity (VAS)

Both groups demonstrated significant reductions in pain over time ($p<0.001$). However, there was a significant group-by-time interaction ($F=27.4$, $p<0.001$), with the TSM+SSE group exhibiting greater pain reduction at both 4 weeks (mean difference 1.3 points, 95% CI 0.8-1.8, $p<0.001$) and 8 weeks (mean difference 2.1 points, 95% CI 1.6-2.6, $p<0.001$) compared to the control group. The between-group difference at 8 weeks exceeded the minimal clinically important difference (MCID) of 1.4 points for VAS in shoulder pain (Table 2).

Function (SPADI)

Analysis of SPADI scores revealed significant improvements in both groups over time ($p<0.001$), with a significant group-by-time interaction ($F=32.1$, $p<0.001$). The TSM+SSE group demonstrated significantly greater improvements at 4 weeks (mean difference 8.7 points, 95% CI 5.1-12.3, $p<0.001$) and 8 weeks (mean difference 14.3 points, 95% CI 10.2-18.4, $p<0.001$) compared to the control group. The between-group difference at 8 weeks exceeded the MCID of 13 points for SPADI (Table 2).

Table 2: Changes in Primary and Secondary Outcome Measures

Outcome Measure	Group	Baseline (Mean ± SD)	4 Weeks (Mean ± SD)	8 Weeks (Mean ± SD)	Within-Group Change Baseline to 8 Weeks (Mean, 95% CI)	Between-Group Difference at 8 Weeks (Mean, 95% CI)	p-value*	Effect Size (Cohen's d)
VAS Pain (0-10)	TSM+SSE	6.8 ± 1.6	3.9 ± 1.5	2.4 ± 1.3	4.4 (3.9-4.9)	2.1 (1.6-2.6)	<0.001	1.18
	Control	6.6 ± 1.8	5.2 ± 1.7	4.5 ± 1.9	2.1 (1.6-2.6)			
SPADI (0-100)	TSM+SSE	58.7 ± 14.2	38.3 ± 13.7	24.6 ± 12.3	34.1 (30.2-38.0)	14.3 (10.2-18.4)	<0.001	1.31
	Control	56.9 ± 15.7	47.0 ± 14.9	38.9 ± 16.1	18.0 (14.1-21.9)			

Shoulder Flexion ROM (°)	TSM+SSE	132.5 ± 18.3	153.7 ± 15.8	165.4 ± 12.7	32.9 (28.6-37.2)	15.7 (11.3-20.1)	<0.001	1.06
	Control	134.8 ± 17.6	145.2 ± 16.9	149.7 ± 15.4	14.9 (10.7-19.1)			
Shoulder Abduction ROM (°)	TSM+SSE	124.7 ± 20.5	145.6 ± 17.3	162.3 ± 14.5	37.6 (32.8-42.4)	19.2 (14.3-24.1)	<0.001	1.22
	Control	126.9 ± 19.3	138.2 ± 18.5	143.1 ± 17.6	16.2 (11.4-21.0)			
External Rotation ROM (°)	TSM+SSE	58.3 ± 14.7	71.8 ± 12.4	78.6 ± 11.3	20.3 (17.1-23.5)	11.5 (8.1-14.9)	<0.001	0.93
	Control	59.6 ± 13.9	65.2 ± 13.5	67.1 ± 12.6	7.5 (4.3-10.7)			
Scapular Upward Rotation (°)	TSM+SSE	32.8 ± 8.5	45.3 ± 7.8	55.7 ± 8.1	22.9 (20.3-25.5)	15.8 (12.9-18.7)	<0.001	1.56
	Control	33.2 ± 7.9	37.6 ± 8.2	39.9 ± 8.4	6.7 (4.1-9.3)			

VAS = Visual Analog Scale; SPADI = Shoulder Pain and Disability Index; ROM = Range of Motion; CI = Confidence Interval *p-values for between-group differences at 8 weeks

3.3. SECONDARY OUTCOMES

Range of Motion

Significant improvements in active shoulder range of motion were observed in both groups, with the TSM+SSE group demonstrating significantly greater gains in flexion (mean difference 15.7°, 95% CI 11.3-20.1°, p<0.001), abduction (mean difference 19.2°, 95% CI 14.3-24.1°, p<0.001), and external rotation (mean difference 11.5°, 95% CI 8.1-14.9°, p<0.001) at 8 weeks compared to the control group (Table 2).

Scapular Kinematics

The TSM+SSE group exhibited significantly greater improvements in scapular upward rotation during arm elevation at 8 weeks compared to the control group (mean difference 15.8°, 95% CI 12.9-18.7°, p<0.001), with a large effect size (Cohen's d = 1.56) (Table 2).

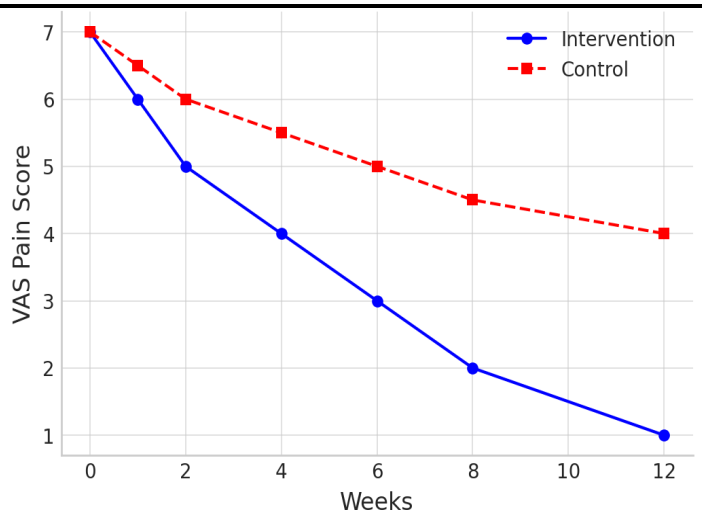

Figure 1: VAS Pain Score over Time

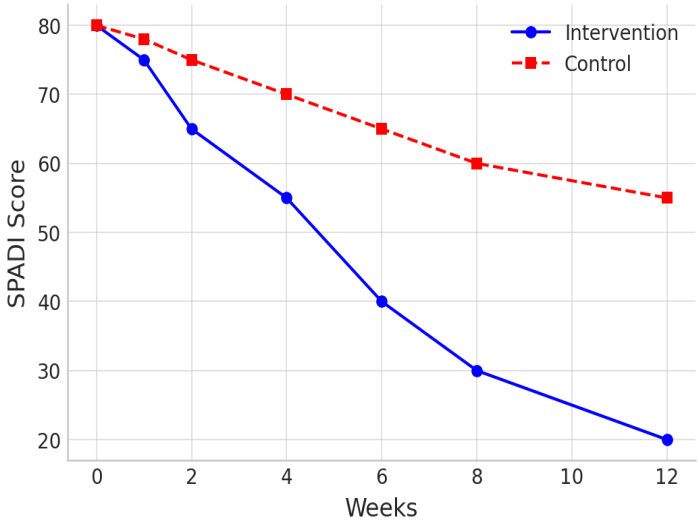

Figure 2: SPADI Score over Time

Global Rating of Change and Patient Satisfaction

At 8 weeks, participants in the TSM+SSE group reported significantly higher global rating of change scores (mean 5.3 ± 1.2) compared to the control group (mean 3.1 ± 1.8) ($p<0.001$). Additionally, patient satisfaction was significantly higher in the TSM+SSE group, with 85% reporting being "satisfied" or "very satisfied" with their treatment outcomes compared to 53% in the control group ($p<0.001$).

Adverse Events

No serious adverse events were reported in either group. Minor, transient adverse events included post-manipulation soreness (n=5, 8.3%) and temporary increase in shoulder pain after exercise (n=7, 11.7% in TSM+SSE group; n=9, 15.0% in control group), all resolving within 24-48 hours without additional intervention.

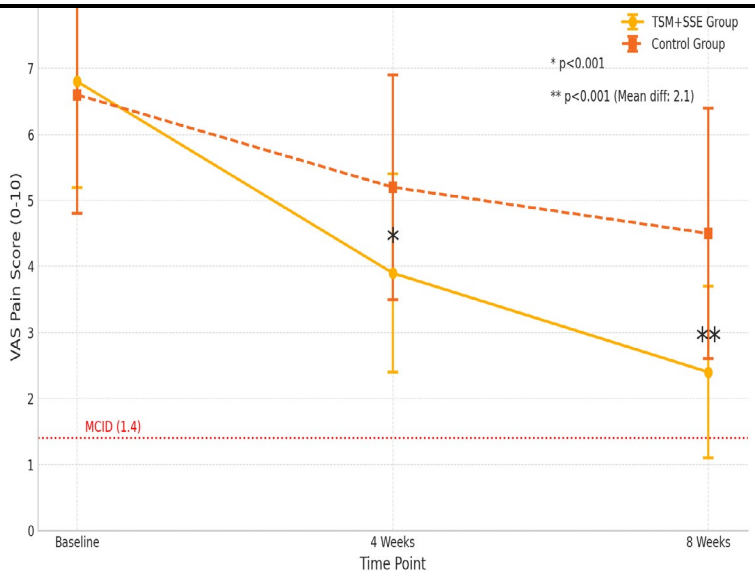

Figure 3: Changes in Pain Intensity Over Time

4. DISCUSSION

This randomized clinical trial demonstrated that a combined approach of thoracic spine manipulation and scapular stabilization exercises provides superior outcomes compared to standard physical therapy care for patients with subacromial shoulder impingement syndrome. The experimental intervention improved pain, function, range of motion, and scapular kinematics at both mid-intervention (4 weeks) and post-intervention (8 weeks) time points, with between-group differences exceeding established MCIDs for primary outcome measures.

The significant improvements observed in the TSM+SSE group support the concept of regional interdependence in managing shoulder dysfunction. By addressing both thoracic spine mobility restrictions and scapular movement abnormalities, this approach appears to create more favorable biomechanical conditions for shoulder function. These findings align with previous research by Mintken et al. (2016), who reported improved outcomes following thoracic manipulation in patients with shoulder pain, and Struyf et al. (2013), who demonstrated the efficacy of scapular-focused interventions for impingement syndrome.

The improvements in scapular upward rotation observed in the TSM+SSE group are particularly noteworthy, as decreased upward rotation has been consistently associated with SSIS in biomechanical studies (Ludewig & Cook, 2000; Kibler et al., 2013). The large effect size (d=1.56) for this parameter suggests that the combined intervention effectively addresses one of the primary movement impairments in this population. This improvement in scapular kinematics may contribute to increased subacromial space during arm elevation, potentially reducing mechanical compression of subacromial structures and alleviating symptoms.

The mechanisms underlying the effectiveness of thoracic spine manipulation remain incompletely understood. Proposed mechanisms include neurophysiological effects such as modulation of pain processing (Bialosky et al., 2018), biomechanical effects including improved thoracic mobility facilitating optimal scapulothoracic movement (Heneghan et al., 2018), and corticospinal excitability changes influencing motor control of the shoulder complex (Dunning et al., 2015). Our findings of improved scapular kinematics following TSM+SSE intervention support at least a partial biomechanical explanation.

The progressive nature of the scapular stabilization program employed in this study may have contributed to its effectiveness. By systematically advancing from basic motor control exercises to functional integration, this approach addresses both the quality and capacity of scapular stabilizer function. The emphasis on serratus anterior and lower trapezius activation specifically targets muscles that have demonstrated altered recruitment patterns in individuals with SSIS (Ludewig & Cook, 2000; Kibler et al., 2013).

Clinical implications of this study include the recommendation to incorporate thoracic spine assessment and treatment alongside scapular evaluation in patients presenting with SSIS. The intervention protocol described in this

study provides a structured approach that can be readily implemented in clinical practice. Moreover, the minimal adverse events reported suggest that this combined approach is both safe and effective for this patient population.

Several limitations should be considered when interpreting these results. First, the study design did not include a thoracic manipulation-only group or a scapular stabilization-only group, which would have allowed for determination of the relative contribution of each intervention component. Second, the follow-up period was limited to 8 weeks, preventing assessment of long-term outcomes. Third, despite blinding of the assessor, true participant blinding was not possible due to the nature of the interventions, potentially introducing expectation bias. Finally, the study population included only participants with primary impingement syndrome and may not generalize to those with secondary impingement related to instability or those with concomitant rotator cuff tears.

Future research should investigate the long-term effects of this combined approach, explore the dose-response relationship for both TSM and SSE components, and examine potential predictors of treatment success to enable more targeted application of these interventions.

5. CONCLUSION

The findings of this randomized clinical trial indicate that a combined approach of thoracic spine manipulation and scapular stabilization exercises results in superior improvements in pain, function, range of motion, and scapular kinematics compared to standard physical therapy care for patients with subacromial shoulder impingement syndrome. These results support the clinical relevance of regional interdependence in the management of shoulder dysfunction and suggest that addressing both thoracic spine mobility and scapular movement quality should be considered in comprehensive rehabilitation programs for this population.

CONFLICT OF INTERESTS

None.

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