Rehabilitation & Performance INSTITUTE

The Shoulder

The Shoulder

ASSESS

Subjective History

- What increases/decreases your pain?
- Numbness/tingling? If so, where at?

Initial observation

- When the pt walks in the room observe:
    - Posture of the arm and shoulder girdle
    - If the pt holds the arm close to their side or across chest
    - Are upper arm movements symmetrical?
- Observe Breathing Pattern: Are they using accessory muscles or diaphragm to breath?

Inspection

- Patient's overall posture
- Spinal curves from front, side, and behind the pt.
- Any discolorations, abrasions, scars, atrophy, and any other signs of pathology

Posture of arm and shoulder girdle

- Height of scapula, distance from spine, size, rotated position
- AC and SC joint symmetry
- Humeral head resting position

Selective Functional Movement Assessment (SFMA): BIG SEVEN & BREAKOUTS AS NEEDED

It is very important to assess functional mobility of the patient. Where is the patient's pain? Identify dysfunctions that are likely causing the patients pain.

- Cervical flexion
    - Functional if able to reach chin to sternum
    - Breakouts if Dysfunctional

        - Active flexion test (chin to chest)
        - Passive supine cervical flexion
        - Active supine OA cervical Flexion test (20 degrees)
- Cervical extension
    - Functional if nose parallel to the ceiling
    - Breakouts
        - Supine cervical extension
- Cervical rotation-lateral bend
    - Functional if able to reach chin to clavicle
    - Breakouts performed if dysfunctional
        - Active supine cervical rotation test (80 degrees)
        - Passive supine cervical rotation test (45 degrees with fully flexed lower cervical spine)
        - C1/2 cervical rotation test
- Pattern 1 (medial rotation) for the UE
    - Functional if able to take hand to opposite Inferior angle of scapula
    - Breakouts performed if dysfunctional
        - Active prone shoulder patterns for MR
        - Passive prone shoulder patterns for MR
        - Supine reciprocal shoulder pattern test
- Pattern 2 (lateral rotation) for the UE
    - Functional if able to take hand to opposite spine of scapula
- Shoulder Clearing Tests
    - Horizontal Adduction
    - Impingement Sign
- Upper extremity flexion and extension rolling patterns

Active ROM

- Quick tests in addition to SFMA
    - Place both hands across chest to back of shoulders
    - Quadruped position (test for weight bearing)
- Glenohumeral joint (test bilaterally)
    - Flexion
    - Extension
    - Abduction
    - Horizontal adduction
    - Horizontal abduction
    - Adduction with flexion/extension
    - Internal/external rotation

    ***NOTE: Goniometric measurements:** If you are uncomfortable with measurements, please make sure you review. The following link will help you review all measurements throughout the body.http://www.continuing-ed.cc/hsgoniometry/goniometrystandards.pdf

Observe:

- Scapulothoracic rhythm (normal or abnormal)
  - Winging or Dumping
  - Distance of the medial border of the scapulae from the spine
- Is there a painful arc
- Is there a capsular pattern (reduced ER >ABD>IR)

- SC and AC joint
  - Elevation
  - Depression
  - Protraction
  - Retraction
  - Circumduction

Passive ROM

- Compare passive ROM to active ROM and note sequence of pain and limitation, feel for "end feel." Assess GH joint mobility by fixing the inferior angle of scapula.

Resisted Isometric Testing

- Test throughout ROM of the muscle-typically in 3 different positions. Start with neutral and then maximally shortened and maximally lengthened positions.
  - If painful in all three positions, it indicates involvement of tested muscle.

Joint mobility testing

- Glenohumeral joint
  - Distraction (open pack and 90 degrees)
  - Caudal Glide (open pack and 90 degrees)
  - Dorsal Glide
  - Anterior glide (open pack and 90 degrees)
- Thoracoscapular Articulation: Prone
  - Cranial glide
  - Caudal glide
  - Medial glide
  - Lateral glide
  - Rotation upward and downward
  - Circumduction
  - Separation from thoracic wall
- Sternoclavicular
  - Distraction and compression (sidelying)
  - Anterior glide
  - Posterior glide
  - Cranial glide
  - Caudal glide
  - Rotation (lift arm)
- Assess Regionally: Thoracic Spine, Cervical Spine, and First Rib Mobilty

Neurology
Myotomes
- SC and AC Joints:
    - C3-4: Elevation: trapezius innervated by cranial XI/spinal accessory n., levator scapula innervated by C3-4 (5), occasionally dorsal scapular n.
    - C5: Retraction-rhomboids innervated by dorsal scapular nerve (C4-5)
    - C6: Protraction-seratus anterior innervated by long thoracic n. (C5-7)
    - C6-8: Depression-latissimus dorsi innervated by thoracodorsal n. (C6-8).
- Glenohumeral Joint:
    - C5-6
        - Flexion- anterior deltoid innervated by axillary n. (C5); coracobrachialis innervated by musculocutaneous n. (C5/6).
        - Abduction-mid deltoid innervated by C5; supraspinatous innervated by suprascapular n.
        - Internal rotation-subscapularis innervated by upper and lower subscapular n.; Pectoralis major innervated by medial and lateral pectoral n.; latissimus dorsi innervated by thoracodorsal n.; teres major innervated by lower subscapular n.
        - External rotation-infraspinatus innervated by suprascapular n (C5-6); teres minor innervated by axillary n. (C5

Dermatomes: Assess C2-T1 dermatomes

Reflexes: C5-bicep brachialis, C6-brachioradialis; C7-triceps

Special Testing-the tests you choose to use are based on what you observe and patient symptoms.
- Nerve Tension
    - Check for neural tension with the patient in supine and is taken through full ROM in the appropriate order for the nerve to glide through each joint
        - Median n. (ULTT A), Radial n. (ULTT B), Ulnar n.

Breakouts for Upper Extremity 1 Pattern
• Active prone IR • Passive prone IR -FN- Active lumbar locked ext/rot test (50 deg); passive lumbar locked ext/rot test (50 deg) • Active prone shoulder 90/90 IR test (60 deg) • Passive prone shoulder 90/90 IR test (60 deg) • Active prone shoulder extension (50 deg) • Passive prone shoulder extension (50 degrees) • Active prone elbow flexion • Passive prone elbow flexion
Possible JMD/TED's from Breakouts for Upper Extremity 1 Pattern
General: A) Shoulder IR JMD/TED B) Shoulder Ext JMD/TED C) Elbow Flex JMD/TED D) Thorax Ext/Rot JMD/TED

Specific Tissues: A) Supraspinatus, infraspinatus, teres minor, posterior capsular restriction, radial n. limit. B) Pectoralis major, anterior deltoid, long head biceps, coracobrachialis, teres major/subscap, anterior capsule restriction C) Triceps, coronoid process, radial head ant against fossa D) Anterior tissue limiting rotation: pecs/obliques, limited joint mobility at thoracic spine at various levels

<table>
<tr><th colspan="2">Breakouts for Upper Extremity 2 Pattern</th></tr>
<tr><td colspan="2">• Active Prone UE pattern 2
• Passive prone UE pattern2
• Active Prone shoulder 90/90 ER (arc or 150 or 90 degrees)
• Passive prone Shoulder ER (arc of 150 or 90 degrees)
• Active prone shoulder flexion/abduction (170 degrees)
• Passive prone Shoulder flexion/abduction (170 degrees)
• Active prone elbow flexion (touch shoulder)
• Passive prone elbow flexion (touch shoulder)
• Lumbar locked active flexion/extension (50 degrees)
• Lumbar locked passive extension and rotation (50 degrees)</td></tr>
<tr><th>JMDs/TEDs</th><th>SMCD</th></tr>
<tr><td>General:
(A)Elbow flexion JMD/TED
(B) T-Spine extension Rot JMD/TED
(C) Shoulder flexion/abduction JMD/TED
(D) Shoulder ER JMD/TED

Specific Tissues:
(A) Tricep tone, restricted Radioulnar or humeralulnar mobility, radial head against fossa
(B) Ant Tissue (pecs, obliques) limiting thoracic rotation, hypomobility of the thoracic spine
(C) Limited glenohumeral inferior glide, limited AC/SC joint mobility, Restriction of the lats, subscapularis, posterior deltoid, posterior capsule, ulnar/median nerve tension
(D) Subscapularis, supraspinatous, posterior cuff soft tissue restriction, hypomoblity of GH joint in anterior or posterior direction.</td><td>(A) Postural SMCD
(B) Shoulder Girdle SMCD
(C) Shoulder flexion/Abduction SMCD
(D) Shoulder ER SMCD</td></tr>
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RESET THE SYSTEM

Treatment Perspectives: Important to combine tools from various theories, studies, and approaches to best suit your patient concerning their functional needs.

Manual Therapy Perspective: It is important to restore normal joint motion and movement around the appropriate mechanical axis in a pain-free fashion (as much as possible) through soft tissue mobilizations and joint mobilizations/ manipulations. It is then imperative to supplement what you did with your hands with therapeutic exercises that mimics or reinforces the appropriate movement patterns.

Mobility before Stability.

Shoulder Mobilizations and Mobilization of Joints that Affect Outcomes in the Shoulder:

Glenohumeral Joint: Convex on Concave (Roll/glide opposite)

- Open-packed: 70 deg abd, 30 deg horizontal add, 60 deg elbow flex, 70 deg ER
- Distraction: supine or prone *(can use belt)*
- Posterior glide for IR/ER (supine with towel roll to block scapula) **(YouTube)**
- Inferior glide for flexion/abduction (supine or seated) **(YouTube)**
    - Keep in mind conjunct rotations:
        - Initiation of flexion--> IR
        - After 75 deg of flexion--> ER
    - Can mobilize by working into end-range in pain-free fashion; initiating pain with most patients only causes increased inflammation and guarding.

Acromioclavicular Joint: Flat (or slightly concave acromion, convex clavicle)

- Open-packed position: supine arm at side
- Anterior glide for retraction
- Posterior glide for protraction
- Distraction: in the plane of the joint- glide post-inf-lateral


Clinician stands opposite the affected side while mobilizing to give appropriate force.

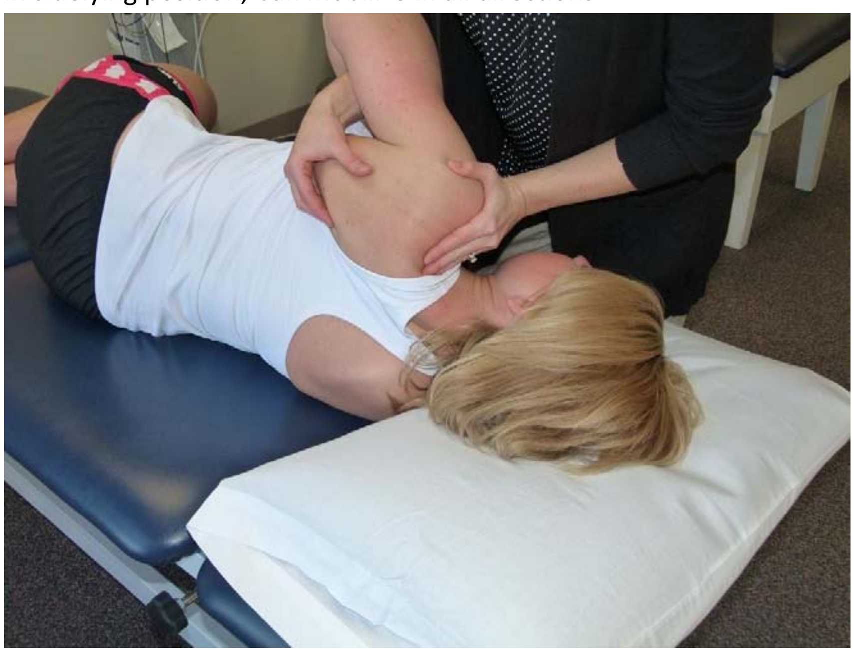
Sternoclavicular Joint: Saddle Joint (AP concave on convex/ ML convex on concave)

- Open-packed position: supine arm at side
- Posterior glide for protraction (roll and glide same)
- Anterior glide for retraction (roll and glide same)

- Inferior glide for elevation/abduction (roll and glide opposite)
- Superior glide for adduction (rarely will do) (roll and glide opposite)
- Distraction: in sidelying **(YouTube)**

Scapularthoracic Joint:

- Make sure you assess rhythm, joint mobility, and strength of scapular stabilizers.
- Perform in sidelying position; Can mobilize in all directions

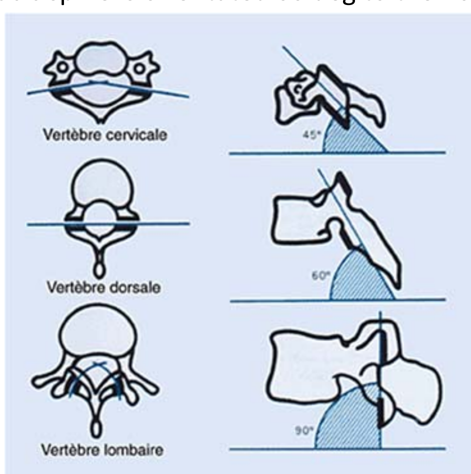


- Don't forget about inferior angle and medial border lifting- this helps to decrease tone throughout the rhomboids and decrease trigger points/ myofascial restrictions.
- Distraction/ Medial Border Lifting: can perform for people with decreased IR or anterior tilt of scapula **(YouTube)**

Clinician hand placement is important. Make sure patient is relaxing affected side.

Thoracic Spine:

- If patient does not have appropriate t/s extension mobility, they will only achieve 150 deg of active flexion without compensation!
- PA glides in prone/ manipulations
- Spinal orientation: Thoracic spine is orientated 60 deg to the horizontal.

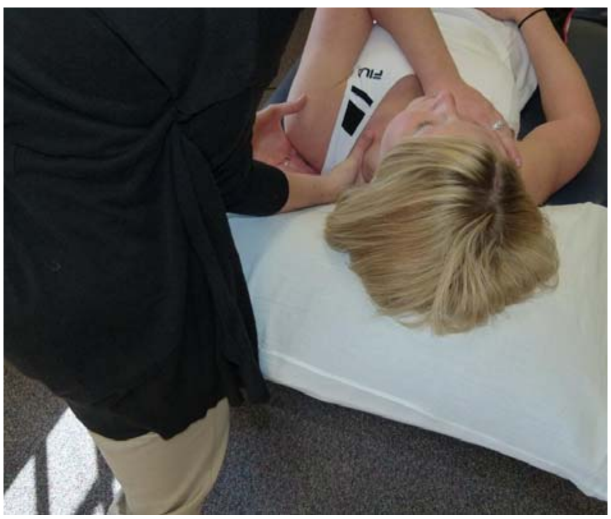


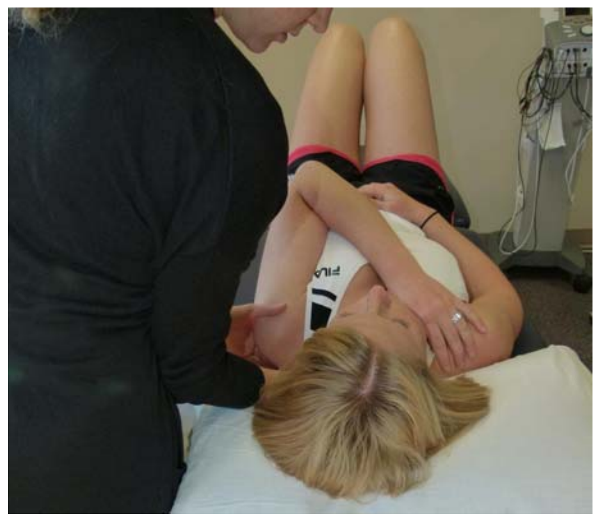
Cervical Spine:

- Distraction: pt. in supine; pt. has to relax, give only as much force as can tolerate.
- Suboccipital Release: fingers at the base of occiput; prolonged hold 10 seconds. **(YouTube)**

1st Rib:

- If patient experiences nerve tension, tone through upper trapezius and scalenes, and reports pain and tightness, the 1st rib could not be moving appropriately.
- Teach diaphragmatic breathing: Have patient lie on back with knees bent up; 1 hand on chest; 1 hand on diaphragm. Teach them to take deep breaths making their stomach rise and fall while keeping hand on chest still.
- Make sure you address the scalenes when dealing with the first rib
- If you are not sure what to feel; check other side and feel the difference. It takes time to cultivate sensitivity to minute changes.
- To mobilize: pt. is supine, involved hand is crossed over body to opposite shoulder and head is tilted toward involved side in order to put UT on slack. Therapist is placing web space between thumb and 1st digit along first rib and giving force towards opposite hip as the patient breathes out. Hold 10 seconds and repeat.
- **(YouTube)** (Difference is to cross arm across body)





Head is side-bent towards clinician to put upper trapezius on slack. Clinician should use body weight and hip to mobilize in medial and anterior direction (in line with patient's opposite hip), not hands alone. Follow the patient's respiratory rate with downward pressure upon exhalation.

Possible Resets for Upper Extremity 1 Pattern			
Purpose	**Technique**	**Set Up**	**Direction of Force**
Resolve TED of IR limitation in shoulder	STM/IASTM supraspinatus, infraspinatus, teres minor	Pt. in sidelying	In the direction of fibers or across fibers with working into IR
Resolve JMD limiting shoulder IR	Mulligan posterior glide MWM	Pt. sitting, PT behind with arm wrapped around	AP (can pull scapula down as well or combine with C4-5 side glide)
Resolve radial nerve excursion	Radial n. flossing	Pt. supine	Shoulder IR- elbow flex, wrist flex then elbow ext, wrist ext + floss with cervical spine
Resolve TED of shoulder extension limitation	STM/IASTM anterior deltoid, pecs, biceps, teres major	Supine or sidelying	"Bunny ears" for pecs working into limitation, various soft tissue techniques
Resolve JMD limiting shoulder extension	Anterior glide of the GH joint	Pt. prone with shoulder at edge of table and abducted to 90 deg, elbow flexed at 90 degrees	Anterior force (PA) with stabilization at the humerus
Resolve TED of elbow limiting flexion	STM to triceps, contract-relax	Supine PNF or overhead soft tissue mobilization	Various techniques
Resolve JMD of elbow limiting flexion	Flexion joint mob	Seated with elbow off table, block fossa with towel or arm	Distract + flex
Resolve JMD of elbow limiting flexion	Radial head manipulation (Mill's Manipulation)	Standing behind the patient, thumb blocks ant radial head	Quick extension of elbow with wrist flexion and UD
Resolve thoracic spine extension/rotation JMD/TED	Seated thoracic spine rotation/extension mobilization/manipulation	Pt. genie arms, PT standing behind and contacting transverse process opposite side of rotation limitation	Force is up and forward
Resolve thoracic spine ext/rotation JMD/TED	STM of the obliques and anterior limiting tissues	Pt. supine	Various techniques

Possible Resets for Upper Extremity 2 Pattern			
Purpose	**Technique**	**Set Up**	**Direction of Force**
Resolve TED of elbow limiting flexion	STM of tricep-various techniques	Pt prone or sidelying	
Resolve JMD of elbow flexion at humeroulnar joint	Supine distraction mobilization	Pt supine or seated, elbow on towel, stabilize humerus, opposite hand in fossa around the radius and ulna	Distract in line of joint and flex elbow
Resolve elbow flexion JMD at humeroulnar joint	Med/lateral glide of the ulna	Supine, seated, elbow slightly bent, stabilize at humerus, use opposite hand to apply medial force, switch hand placement and give lateral flexor	Medial and lateral force give at the humeraloulnar or humeroradial joint
Resolve JMD of radial head limiting flexion	Radial Head manipulation	Standing behind the patient, thumb blocks ant radial head	Quick extension of elbow with wrist flexion and UD
Resolve thoracic spine Rot/Ext JMD	Thoracic rotation mob/manipulation	Seated-arms cross across chest, PT standing behind pt, hand on transverse process on opposite of rotation limitation Seated or prone Ext mobilizations Also perform prone or supine manipulation	Force is up and forward with the seated mobilization Force is anterior and slightly downward for extension mob Force is downward with manipulation
Resolve thoracic ext/rot TED	STM of obliques, pec and other anterior tissues	Pt supine	Multiple techniques utilized-FDN, graston, TPR, etc
Resolve shoulder abd/flex JMD	Inferior glide of GH joint	Seated or supine, give slight distraction through GH joint, ulnar side of hand against the acromion	Force in inferior direction

Resolve shoulder Flexion/abd JMD	AC distraction	Pt supine, one finger hooked behind the clavicle, other hand on the anterior aspect of the acromion	Force is inferior, posterior-lateral combined in one motion using the hand on the acromion
Resolve JMD of Shoulder external rotation	Anterior or posterior glide of humerus	**Posterior glide**-pt supine, slight distraction-open pact position of GH joint, ulnar side of hand against the acromian on humeral head **Anterior glide**-set up is the same but with pt prone hand at posterior humeral head	Force is posterior with hand on humeral head Force is anterior for anterior glide
Resolve JMD of shoulder external rotation	Scapular external rotation mobilization	S/L top hand pushes down and hand at inferior angle draws scap externally into rot	
Resolve TED of shoulder flexion/abduction	Various techniques including FDN, graston, contract relax stretching	Pt supine	
Resolve TED of shoulder ER	Various techniques including FDN, graston, contract/relax and TPR	Pt supine	
Resolve ulnar or median N tension	Manual nerve glides	Pt supine	**Ulnar N**-shoulder depressed, shoulder abd to 90, elbow flexion, wrist finger and thumb extension, floss through wrist/elbow **Median N**-shoulder depressed, elbow extension, wrist, finger and thumb extension, forearm supination, floss at wrist or elbow

<u>Other Treatment Considerations for the Shoulder</u>

Functional Dry Needling

- Assess soft tissue mobility and presence of myofascial trigger points
- Allow certified physical therapist to perform dry needling on patient

Nerve Glides: Please take time to review videos below.

- If you feel that the cervical spine or nerves of the brachial plexus may be involved, it is important to test **Upper Limb Tension Tests.**
- **Nerve Glides:** pt. is supine and is taken through full ROM in the appropriate order for the nerve to glide through each joint; "Flossing"= stopping at a joint and moving back and forth. (See Michael Shacklock's work for additional information).
    - **Median n. (ULTT A) (YouTube)**
        - Shoulder depression
        - Abducts humerus (110 deg)
        - Supinates forearm
        - Extends elbow, wrist, fingers
        - Sidebend head toward or away the involved side (depending on the patients symptoms).
    - **Radial n.** (Waiter's Tip position) **(ULTT B) (YouTube)**
        - Shoulder depression
        - Abducts humerus
        - IR shoulder
        - Pronates forearm
        - Extend elbow
        - Flex wrist and Thumb
        - Sidebend head toward/ away
    - **Ulnar n. (YouTube)**
        - Extends wrist
        - Supinates forearm
        - Full flexed elbow
        - depresses/ abducts shoulder
        - Sidebend head toward/ away

REINFORCE THE CORRECTION

Patient Education:

- Restrictions/ activity modification
- Postural education
- ADLs/ ANLs
- Driving
- Sleeping positions

Basic Reinforcement Interventions:

- "The Stick" – Reinforces any soft tissue work and helps remove additional TEDs: Along upper trapezius, posterior capsule, lats
- Foam Roller- Reinforces any soft tissue work and helps remove additional TEDs
    - Along upper trapezius, posterior capsule, lats
    - Pectoralis static stretch along the foam roller
    - Thoracic spine extension
- Stretches- assisting with various TEDs
    - Pectoralis stretching, Lat stretching

For Example- Capsular Tightness:

- Posterior Capsule Release: can perform in supine or sidelying with patient rolled 30 degrees posteriorly shoulder is in IR; palpate off distal acromion; pull forward. Block Scapula with towel.
    - Can have patient perform this at home by performing cross-body stretch or sleeper stretch on floor or wall.

Bracing: Sublux. Dislocation, Instability

- Sully **(YouTube)**

Functional Taping

For Example- Lower Trapezius Facilitation: Can utilize McConnell taping for lower trapezius facilitation by running the tape from the acromion down over the inferior angle of the scapula

Reinforcement Techniques for Upper Extremity 1 Pattern		
Purpose	**Technique**	**Set Up or Directions**
Inc. posterior glide of shoulder	AP glide of humerus in standing (self MWM)	Fingertips inferior-medial to corocoid process, soft tissue slack taken up, glide posterior-lateral and move into restriction (can also use mobilization belt)
Inc. radial n. excursion	Radial n. flossing	Depress shoulder, rotate flat palm in and out with straight elbow, SB head with the movement
Decrease posterior shoulder TED	Tennis ball self STM	Stand with tennis ball on wall contacting posterior shoulder for TP release
Inc. mobility of anterior shoulder	Foam roller pec stretch	Lie long-ways on foam roller, open up the arms and feel anterior stretch (angel arms)
Increase elbow flexion mobility	Self elbow flexion mobilization	Place towel in fossa and flex elbow up
Increase thoracic spine extension/rotation	Bretzel stretch or rib grabbing	Thoracic rotation stretch

Reinforcement Techniques for Upper Extremity 2 Patterns		
Purpose	**Technique**	**Set Up or Directions**
Increase elbow flexion	Self elbow mobilizations	Place towel in fossa and flex elbow up
Increase thoracic extension and rotation joint mobility	Foam Roller	Lay over foam roller, butt on floor and bend over roller, can also lift butt and roll back and forth for improved soft tissue tone
Improve inferior glide of shoulder	MWM in seated position	
Decrease tone in lats/subscap for improved flexion/ER	Foam roll lats and or subscap	Lay on your side, arm overhead and roll forward and backward on roller
Decreased nerve tension	Ulnar and median N flossing	Elbow resting on table and perform same movement as described above for each nerve

RELOADING THE SOFTWARE

Once mobility is established at the dysfunctional joint, treat as a SMCD and reload the system so that the patient can utilize their new mobility in a functional manner.

UPPER EXTREMITY 1 PATTERN RELOADS:

Corrective Matrix TO INCREASE SHOULDER EXTENSION				
Posture	**Standing**	Standing shoulder diagonals with band behind for assistance	Standing shoulder diagonals	Standing shoulder diagonals with band in front for resistance
	Stacked Spine (Kneeling)	Tall kneeling alternating shoulder flex/ext diagonals with band behind to assist	Tall kneeling alternating shoulder flex/ext diagonals	Tall kneeling alternating shoulder flex/ext diagonals with band in front for resistance
	Suspended Spine (Quadruped)	Bird dog arm raise into extension with band behind to assist	Bird dog arm raise into extension	Bird dog arm raise into extension with band in front for resistance
	Supported Spine (Supine/Prone)	Supine pillow press with band behind for assistance	Supine pillow presses	Resisted pillow presses with band above
		Facilitate (Expresses Mobility)	**Demonstrates** (Expresses Competency)	**Challenges** (Expresses Motor Control)

Corrective Matrix TO INCREASE THORACIC EXTENSION/ROTATION				
Posture	**Standing**	Split stance D1 extension with band around knees	Split stance D1 extension (pull down into extension)	Split stance D1 extension with resistance
	Stacked Spine (Kneeling)	Half kneeling lifts with pattern assistance with band around knees	Half kneeling lifts	Half kneeling lifts with resistance
	Suspended Spine (Quadruped)	Thoracic spine rotation in quadruped with band behind for assistance	Thoracic spine rotation in quadruped	Thoracic spine rotation in quadruped with band in front for resistance
	Supported Spine (Supine/Prone)	Upper body extension rolling with assistance	Upper body extension rolling	Resisted upper body extension rolling
		Facilitate (Expresses Mobility)	**Demonstrates** (Expresses Competency)	**Challenges** (Expresses Motor Control)

UPPER EXTREMITY 2 PATTERN RELOADS:

Corrective Matrix To increase shoulder flexion/ER				
Posture	**Standing**	Standing assisted "x" pattern, band behind back	Standing X pattern	Standing resisted X pattern into T pattern
	Stacked Spine (Kneeling)	Tall Kneeling lift with assist and t-band around knees	Tall kneeling with lift	Tall kneeling with resisted lifts
	Suspended Spine (Quadruped)	Quadruped with t-band assist into flexion	Quadruped with arm raise	Quadruped with resisted shoulder flexion
	Supported Spine (Supine/Prone)	Supine assisted shoulder flexion "x" pattern-band behind back	Supine X pattern	Supine X pattern with resistance into pattern
		Facilitate (Expresses Mobility)	**Demonstrates** (Expresses Competency)	**Challenges** (Expresses Motor Control)

Corrective Matrix To increase thoracic rotation/extension				
Posture	**Standing**	Standing thoracic rotations with t-band assist into pattern and band around knees	Standing thoracic rotations into extension	Standing resisted thoracic rotations into extension
	Stacked Spine (Kneeling)	Kneeling with band around knees and rotating/extension with arms in front of body-one arm stays in front and other arm opens up	Kneeling with rotation-one arm in front	Kneeling with thoracic rotation with resistance into rotation
	Suspended Spine (Quadruped)	Quadruped thread the needle with open ups into extension with assistance	Quadruped thread the needle	Quadruped thread the needle with resistance into rotation
	Supported Spine (Supine/Prone)	UE extension rolling with assistance	UE extension rolling	UE extension with resistance
		Facilitate (Expresses Mobility)	**Demonstrates** (Expresses Competency)	**Challenges** (Expresses Motor Control)

- **Therapeutic Exercise and Neuromuscular Re-education:**
    - Remember that your ther ex should supplement or mimic what you do with your hands.
    - If therapist prescribes thoracic PA mobilizations, it will be important to supplement this by having them perform active thoracic extension following. There are many ways to do this, so think out of the box!
        - FOR EXAMPLE: thoracic extension + rotation in quadruped or seated on the wall, thoracic extension over bolster, thoracic extension over chair, leaning over thoracic extension, prone thoracic extension.
        - You can also perform activities such as bilateral shoulder extension and scapular retractions to help patient with extension activities.
        - If thoracic extension is what is limiting them from reaching over 150 deg of flexion, then this should be the priority, not shoulder flexion exercises.
    - Progress by changing the position the patient is in, increasing reps or time performed, or combining various movement patterns.
        - EXAMPLE: If internal rotation is limited, combine adduction with IR.

IJSPT

ORIGINAL RESEARCH

IS THERE A RELATION BETWEEN SHOULDER DYSFUNCTION AND CORE INSTABILITY?

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ABSTRACT

Background: Overhead athletes often suffer injury to the glenohumeral joint secondary to inherent instability. However, little is known about the relationship between core stability and shoulder dysfunction among athletes.

Purpose: The purpose of this study was to analyze the difference between healthy athletes and those with shoulder dysfunction in regard to core stability measures. Secondary purpose was to explore the relationship between measures of core stability and measures of shoulder dysfunction.

Methods: Participants consisted of NCAA Division III overhead athletes (28 males, 33 females) with a mean age of 19.3 ± (1.1) years, mean weight of 173.6 ± (36.9) pounds, mean height of 67.8 ± (3.5) inches. Functional questionnaires (the Kerlan-Jobe Orthopaedic Clinical Scale [KJOC] and the QuickDASH sports module) as well as Single-Leg Stance Balance Test (SLBT), Double Straight Leg Lowering Test (DLL), Sorensen Test, and Modified Side Plank Test were completed in a randomized order with consistent raters.

Results: MANOVA was significant at ($p = .038$) for the comparison between the experimental group and the control group for the values of Right SLBT. The experimental group had significantly less balance than the control group with means of 10.14 ± (5.76) seconds and 18.98 ± (15.22) seconds respectively. Additionally, a positive correlation was found between the DLL and the KJOC at ($r = .394$, $p > .05$) and a negative correlation was found between the Right SLBT and the Quick DASH sports module (QD) at ($r = -.271$, $p > .05$).

Discussion and Conclusion: Balance deficiency was found in athletes with shoulder dysfunction. According to this study, greater shoulder dysfunction is correlated with greater balance and stability deficiency. Therapists and trainers should consider incorporating balance training as an integral component of core stability into rehabilitation of athletes with shoulder dysfunction.

Level of Evidence: 3b

Keywords: Core stability, KJOC, overhead athletes, shoulder dysfunction.

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This research was approved by Utica College Institutional Review Board (IRB) prior to conducting the study.

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INTRODUCTION

Athletes performing overhead motions require highly skilled movements performed at high velocities. This requires flexibility, muscular strength, coordination, synchronicity and neuromuscular control at the shoulder complex.[1] Considering the extraordinarily high demands placed on the shoulder during overhead motion, it is subsequently one of the most commonly injured sites in the human body.[1] Injuries to the shoulder complex range from shoulder impingement syndrome, rotator cuff pathology, biceps tendonitis, instability, and labral tears.[2]

In order to maintain functional stability during limb movement, muscular strength and endurance is required around the lumbar spine. This area is referred to as the core and includes the abdominal muscles anteriorly, the paraspinals and gluteals posteriorly, the diaphragm superiorly, and the pelvic floor and hip girdle musculature inferiorly.[3] The core musculature becomes active in a feed-forward fashion during upper extremity movement.[4] This mechanism occurs as the body prepares for potential perturbation of spinal stability when movement begins.[4] In sports that require a great degree of overhead skill, the core provides a foundation upon which muscles of the upper and lower extremities rely.[5]

Connections have also been made between core stability and athletic performance.[3] Core stability has been proven to be an essential component of biomechanical efficiency, allowing the athlete to maximize force production while minimizing loads placed on peripheral joints. This is especially important during complex movements such as: running, jumping, swimming, throwing, and spiking.[6] Due to the three-dimensional nature of complex movements, athletes must have adequate core strength in order to provide effective stability during a wide variety of movements.[7,8]

Core stability is becoming an increasingly popular topic in rehabilitation research with regard to the prevention of various spine and lower extremity injuries. Deficiency in core strength leads to a breakdown in form, therefore predisposing athletes to injury.[7]

Balance is an integral component of core stability. Many clinical neuromuscular imbalances occur between synergistic and antagonistic muscles. This is characterized by early dominant activation of trunk muscles and delay in activation of synergistic muscles.[9] This imbalance can cause instability and excessive joint motion in the direction of the overhead activity.[10] This faulty movement can lead to excessive abnormal accessory gliding, thereby increasing trauma to the joint and causing increased risk for dysfunction and pain.[10] The movement system is very adaptable to change and strives to maintain normal function. Therefore if imbalances develop, compensatory movements will occur to restore mobility, often resulting in tissue damage.[10]

Despite the current interest surrounding core stability, there is limited research on the relationship between the core and shoulder pathologies. Considering the high prevalence of shoulder injuries that occur in overhead athletes, there is a need to further examine the correlation between these injuries and core stability in terms of both strength and balance. Therefore, the purpose of this study was to analyze the difference between healthy athletes and those with shoulder dysfunction in regards to core stability measures. The secondary purpose was to explore the relationship between measures of core stability and measures of shoulder dysfunction.

METHODS

Sixty-one Division III overhead athletes (28 males, 33 females) were recruited to participate in this study. Their mean age was 19.3 $\pm$ (1.1) years, mean weight was 78.7 $\pm$ (16.7) kg., and mean height was 172.2 $\pm$ (8.9) cm. Several overhead sports were represented in the sample (six football players, seven swimmers, three water polo players, thirty one lacrosse players, one baseball player, six softball players, six field throwing athletes, and six basketball players). There were 48 healthy participants and 14 participants with shoulder dysfunction. Subjects were classified as having shoulder dysfunction if they had history of noncontact shoulder injury and scored less than 80 on the KJOC.[11] Subjects were excluded if they were either in the acute stage of the injury or if they were not actively participating in their respective sports as a part of their team when the study was conducted.

Upon entering the data collection station subjects completed the KJOC and QD scales and had demographic measures taken. Subjects were then randomly assigned to start at one of the core measures stations as follows; Single-Leg Stance Balance Test (SLBT), Double Straight Leg Lowering Test (DLL), Sorensen Test, and Modified Side Plank Test. Each test was conducted by consistent raters.

At the SLBT station, the participant's ability to maintain single leg balance with eyes closed was tested as an integral component of core stability. Preceded by a practice trial, three trials were performed on each lower extremity with eyes closed, arms crossed at the chest, contra lateral leg slightly flexed, and foot at height of opposite ankle. The timer began once the foot was raised off the ground and stopped once the participant either opened eyes, uncrossed arms, shifted weight, contacted floor or stance leg with the elevated foot, or if the participant's stance leg was no longer in the starting position. In addition, the test was stopped if the participant held the position for a maximum of 45 seconds. The test was then repeated on the opposite foot utilizing the same format. The best score on each foot was recorded.[12]

At the DLL station, the stability of the abdominal muscles was tested. Participants were supine with a standard sphygmomanometer underneath the lumbar curve inflated to a baseline of 40 mmHg with the knees straight and hips bent to 90 degrees. The degree to which the participant could lower their legs (movement toward hip extension), while maintaining the same cuff pressure was recorded using an Absolute Plus Axis Digital Goniometer. If pressure dropped below 40 mmHg on the dial, the participant was instructed to pause and attempt to return the pressure on the dial to baseline. If the participant was unable to return the pressure to baseline after maximal encouragement and visual cueing utilizing the sphygmomanometer dial, the test was discontinued. If able to achieve 40 mmHg, the test would continue until pressure dropped below baseline again, which indicated the end of the test. At this point, the amount of terminal hip extension angle was measured in degrees using the aforementioned digital goniometer. Three consistent raters were needed for appropriate administration of this test.[13]

At the Sorenson Test station, the stability of the back muscles was tested. Participants were in prone lying (supported by standard gait belts) with the upper body off the end of the examining table supported by a chair. A right angled apparatus was positioned in level with the highest point of the sacrum and on top of both scapulae. During instruction, emphasis was placed on maintaining contact of the back with this apparatus to provide participants with tactile feedback. Upon commencement of the test, participant was instructed to keep their arms crossed over the chest while maintaining a neutral position of the head and neck. At this time, participants were instructed to perform an isometric contraction of trunk extensors and to hold it for as long as possible. The test was stopped if contact with the apparatus was lost or once two minutes had elapsed. Positive verbal reinforcements were given each thirty-second interval.[14]

Finally, at the Modified Side plank Station, the stability of the lateral trunk walls were tested. (Figure 1) The participant was instructed to lay with one shoulder on the ground, arms crossed over chest, head resting on a wedge, and feet supported on a peanut ball. The examiner then asked participant to lift hips off the ground as high as possible. A dangling pulley system rope was aligned at their iliac crest to provide tactile feedback to the position of maximum hip elevation. A practice trial was allowed, followed by the test trial, which was recorded in seconds. Time started when maximum hip elevation was reached and was stopped when the participant's hip lost contact with the pulley system. Encouragement and

Figure 1. *Participant in the Modified Side Plank test starting position on the left side. Arms crossed over chest, head resting on a wedge, and feet stacked on a peanut ball. The examiner then asked participant to lift hips off the ground as high as possible, in order to perform a modified side plank, with a pulley system aligned at their iliac crest to provide tactile feedback.*

feedback was given at 20-second intervals. The test side was chosen in random order, and then repeated on the opposite side by consistent raters.[15]

STATISTICAL ANALYSIS

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS™) version 20 for Windows. Prior to final analysis, data were screened for transcription errors, bivariate correlation, normality assumptions, homogeneity of variance, as prerequisites for parametric calculations of the analysis of difference and analysis of relationship measures. Alpha level was set at 0.05 to control for type I error.

Multivariate Analysis of Variance test (Hotelling Trace test) was used to analyze the difference between healthy participants and participants with shoulder dysfunction. This was followed by an analysis of relationship between the scores of the KJOC and core stability measures using the Pearson Product Moment Correlation Coefficient followed by the respective significance testing and regression analysis.

RESULTS

Criteria for parametric testing were met and a multivariate analysis of differences was performed to compare the six dependent variables (Sorensen test, DLL test, right and left Side Plank tests, and right and left SLBT) between healthy participants (control group n = 47) and participants with shoulder dysfunction (experimental group n = 14). MANOVA was significant at $p = .038$ for the comparison between the experimental group and the control group for the right SLBT. The experimental group had significantly lower balance than the control group with means ± (SD) of 10.14 ± (5.76) and 18.98 ± (15.22) respectively. No other significant statistical differences were found between the remainder of the dependent variables. Outcomes are presented in Table 1.

Additionally, the correlation between the QuickDASH sports module and the KJOC with each core stability test was calculated using Pearson Correlation Coefficient. A moderate positive correlation was found between the Double Leg Lowering test and the KJOC questionnaire with $r = .394$, $p > .05$. Similarly, a weak negative correlation was found between the right Single Leg Balance test and the QuickDASH sports module with $r = -.271$, $p > .05$. Both correlations support the fact that greater shoulder dysfunction is associated with greater balance and stability deficiencies.

DISCUSSION

According to the results of this study, balance was found to be statistically lower in participants with shoulder dysfunction compared to healthy participants. Since balance is one of the components of core stability,[16] one can imply that overhead athletes with shoulder dysfunction that participated in this study had non-optimal core stability compared to their healthy peers.

In concordance with Gribble and Hertel,[16] the SLBT was utilized as the tool for measuring static postural control. Postural control is essential to athletes, as it is an indicator of appropriate neuromuscular function and stability therefore, important for both injury prevention and rehabilitation. Ease of administration, high reliability, and low cost of this test

Table 1. *Comparison Between Normal Athletes and Athletes With Shoulder Dysfunction Regarding Dependent Measures of Core Stability.*

Core stability measure	Athletes with shoulder dysfunction	Normal athletes
Sorenson Test	81.8±(30.7) seconds	70.2 ±(31.4) seconds
Double Leg Lowering Test	9.4 ±(4.9) degrees	8.4 ±(7.5) degrees
Modified Side plank (right)	43 ±(28.6) seconds	35.1±(25.7) seconds
Modified Side plank (left)	52.1±(36.8) seconds	47.4±(41.9) seconds
Single Leg Balance (right)	10.1 ±(5.8) seconds *	18.9±(15.2) seconds
Single Leg Balance (left)	10.1±(6.7) seconds	16.9 ±(13.7) seconds

*significant at p = 0.05

are all reasons why the SLBT can be used to assess one of the components of core stability. In addition, Cosio-Lima, Reynolds, Winter, Paolone, and Jones[17] advocate the use of the SLBT in assessing core stability in patients with Low Back Pain.

In the current study there was no significant difference between the control and the shoulder dysfunction group in scores on the Side Bridge Test. The current study used a Modified Side Bridge Test (as described earlier in the methodology section) in order to account for shoulder pathology and possible pain in subjects. This differed from the test position used by McGill et al.[15] The difference in the test positions may account for the variation of the study results.

The use of the Sorensen Test to measure core stability by examining the isometric endurance of the trunk extensors is commonly mentioned throughout the literature. The Sorensen Test is the best test used to evaluate endurance of back extensors. In the current study there was no significant difference of Sorensen Test score between the shoulder dysfunction and the control group. The difference in results between this study and ours may be attributed to the difference in subjects' demographics, pathologies, and overall number of participants.[14]

The core flexors were assessed by the use of the DLL test. Arab et al concluded that the DLL test is reliable, sensitive, and specific for the core flexors. In their study, there was a lower score in the group of subjects that had low back pain compared to subjects without pain. The difference in the way the DLL test was performed in the two studies may explain the varying results. Arab et al.[18] had the patient hold his or her legs 20 degrees from the floor and for as long as possible. The current study involved the subject's legs being taken to 90 degrees and then the subject was asked to slowly lower legs to table while maintaining 40mmHg on a sphygmomanometer that was placed beneath the lumbar spine. The first method may allow for more substitution by the subject, such as arching his or her back and hence allowing for longer period of hold.

The results of the current study confirm that the KJOC scores were moderately correlated with the DLL scores. The importance of the DLL Test as a measure of core stability has been recommended for the assessment of core stability among the athletic population by Sharrock, Cropper, Mostad, Johnson, and Malone.[13] This test requires a high level of muscle activation and stabilization throughout the trunk because of the long lever arms of the lower extremities and narrow base of support for the trunk and upper extremities. It was reported in literature that this test is both valid and reliable in assessing core strength.[13]

Although there is a lack of evidence to support the correlation between shoulder dysfunction and core stability, there is information to show how the core musculature is activated during upper extremity movements.[4] The results of the current study are in agreement with Brumitt and Dale, who recommended that core stability exercises should be included when an athlete is completing a rehabilitation program for their shoulder injury.[4]

The previously found clinically sensitive but statistically insignificant correlations between measures of core stability and extent of shoulder dysfunction might have occurred due to various reasons. Many of the tests that were utilized in this study required modifications to minimize the stresses and strains on the shoulder joint complex. Second, the battery of tests administered may be sensitive to the general population and not a specific set of individuals with shoulder dysfunction. Lastly, the subjects with shoulder dysfunction who participated in this study were not in the acute phase of injury and demonstrated overall high scores on the functional questionnaires.

LIMITATIONS OF THE STUDY

The study is limited by the small sample size of participants with shoulder dysfunction, the randomized sample of convenience, the strict inclusion criteria, and the absence of dynamic multi-planar testing procedures. Finally, modifying the Side Plank test to evade participants' discomfort may have threatened the validity of its use.

CONCLUSION

The results of this study demonstrated that collegiate overhead athletes with shoulder dysfunction had less balance compared to healthy athletes. Additionally, poor performance of these athletes in some of the core stability measures was correlated to the extent of their shoulder dysfunction. Such results may support the use of balance and core stability training in the design of successful rehabilitation protocols for overhead athletes with shoulder dysfunction.

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Scapular Kinematics Pre– and Post–Thoracic Thrust Manipulation in Individuals With and Without Shoulder Impingement Symptoms: A Randomized Controlled Study

STUDY DESIGN: Randomized controlled trial with immediate follow-up.

OBJECTIVES: To evaluate the immediate effects of a low-amplitude, high-velocity thrust thoracic spine manipulation (TSM) on pain and scapular kinematics during elevation and lowering of the arm in individuals with shoulder impingement syndrome (SIS). The secondary objective was to evaluate the immediate effects of TSM on scapular kinematics during elevation and lowering of the arm in individuals without symptoms.

BACKGROUND: Considering the regional interdependence among the shoulder and the thoracic and cervical spines, TSM may improve pain and function in individuals with SIS. Comparing individuals with SIS to those without shoulder pathology may provide information on the effects of TSM specifically in those with SIS.

METHODS: Fifty subjects (mean ± SD age, 31.8 ± 10.9 years) with SIS and 47 subjects (age, 25.8 ± 5.0 years) asymptomatic for shoulder dysfunction were randomly assigned to 1 of 2 interventions: TSM or a sham intervention. Scapular kinematics were analyzed during elevation and lowering of the arm in the sagittal plane, and a numeric pain rating scale was used to assess shoulder pain during arm movement at preintervention and postintervention.

RESULTS: For those in the SIS group, shoulder pain was reduced immediately after TSM and the sham intervention (mean ± SD preintervention, 2.9 ± 2.5; postintervention, 2.3 ± 2.5; $P<.01$; moderate effect size [Cohen d = 0.2]). Scapular internal rotation increased 0.5° ± 0.02° (P = .04; small effect size [Cohen d<0.1]) during elevation of the arm after TSM and sham intervention in the SIS group only. Subjects with and without SIS who received TSM and asymptomatic subjects who received the sham intervention had a significant increase (1.6° ± 2.7°) in scapular upward rotation postintervention ($P<.05$; small effect size [Cohen d<0.2]), which was not considered clinically significant. Scapular anterior tilt increased 1.0° ± 4.8° during elevation and lowering of the arm postmanipulation ($P<.05$; small effect size [Cohen d<0.2]) in the asymptomatic subjects who received TSM.

CONCLUSION: Shoulder pain in individuals with SIS immediately decreased after a TSM. The observed changes in scapular kinematics following TSM were not considered clinically important.

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KEY WORDS: *manipulation, manual therapy, rehabilitation, spine*

Shoulder pain is a common and debilitating condition, and its prevalence is second only to low back pain.[9,42,52,63] Shoulder impingement syndrome (SIS) is the most frequently encountered shoulder condition and accounts for 44% to 65% of all shoulder pain.[63] A greater amount of scapular internal rotation, as well as a lesser amount of scapular upward rotation and posterior tilt during arm elevation, has previously been documented in individuals with symptoms of SIS compared to asymptomatic individuals.[35-38] These kinematic alterations have been associated with lesser activation of the middle and lower trapezius and serratus anterior muscles and excessive upper trapezius muscle activation.[37,51]

Systematic literature reviews support the efficacy of therapeutic exercises for the rehabilitation of individuals with SIS,[29,43] and the results of randomized clinical trials suggest that providing manual therapy

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in conjunction with therapeutic exercises may lead to even greater improvements in shoulder pain, function, range of motion, and muscle activation.[4,5,25,56,60,68] High-velocity, low-amplitude thrust thoracic spine manipulation (TSM) is one of a variety of manual therapy techniques that have been investigated for the treatment of shoulder conditions, with a few studies[8,59] using the technique in isolation to determine its effectiveness.

The clinical rationale for using TSM for shoulder pain is in part based on the concept of regional interdependence described by Wainner et al,[64] which suggests that seemingly unrelated impairments in a remote anatomical region may be associated with the patient's primary symptoms.[64,65] This concept has received support from the outcomes of recent clinical trials that investigated the effects of spine manipulation in regions of the body adjacent to the manipulated segment,[11,12,14,16,19] and from evidence of reduced mobility of upper thoracic segments being related to neck-shoulder pain.[48,49] Additional clinical trials have shown improvements on shoulder range of motion, pain, and function following TSM.[5,8,59] Three studies have shown immediate reduction in pain and improvement in function following the application of TSM in individuals with SIS[8,46,59]; however, the only study[46] to assess the effects of TSM on scapular kinematics and muscle activity in individuals with SIS has suggested that the immediate improvements in shoulder pain and function could not be explained by alterations in scapular kinematics or shoulder muscle activity.[46] Furthermore, none of these studies included a symptomatic control group or an asymptomatic group for comparison.[8,46,59]

Two studies have evaluated the effects of TSM on the shoulder in asymptomatic individuals compared to a sham group.[10,55] Rosa et al[55] found no changes in scapulohumeral rhythm and scapular kinematics postintervention, whereas Cleland et al[10] demonstrated improvement of lower trapezius muscle strength following TSM. The reason why TSM may produce effects in other body regions is not fully understood. It has been proposed that neurophysiological effects of joint manipulation, along with induced biomechanical changes, may alter the inflow of sensory information to the central nervous system.[53,66] Existing evidence indicates that spinal manipulation impacts primary afferent neurons from paraspinal tissues, the motor control system, and pain processing.[23,53] Independent of the underlying mechanisms of spinal manipulation, there is general agreement

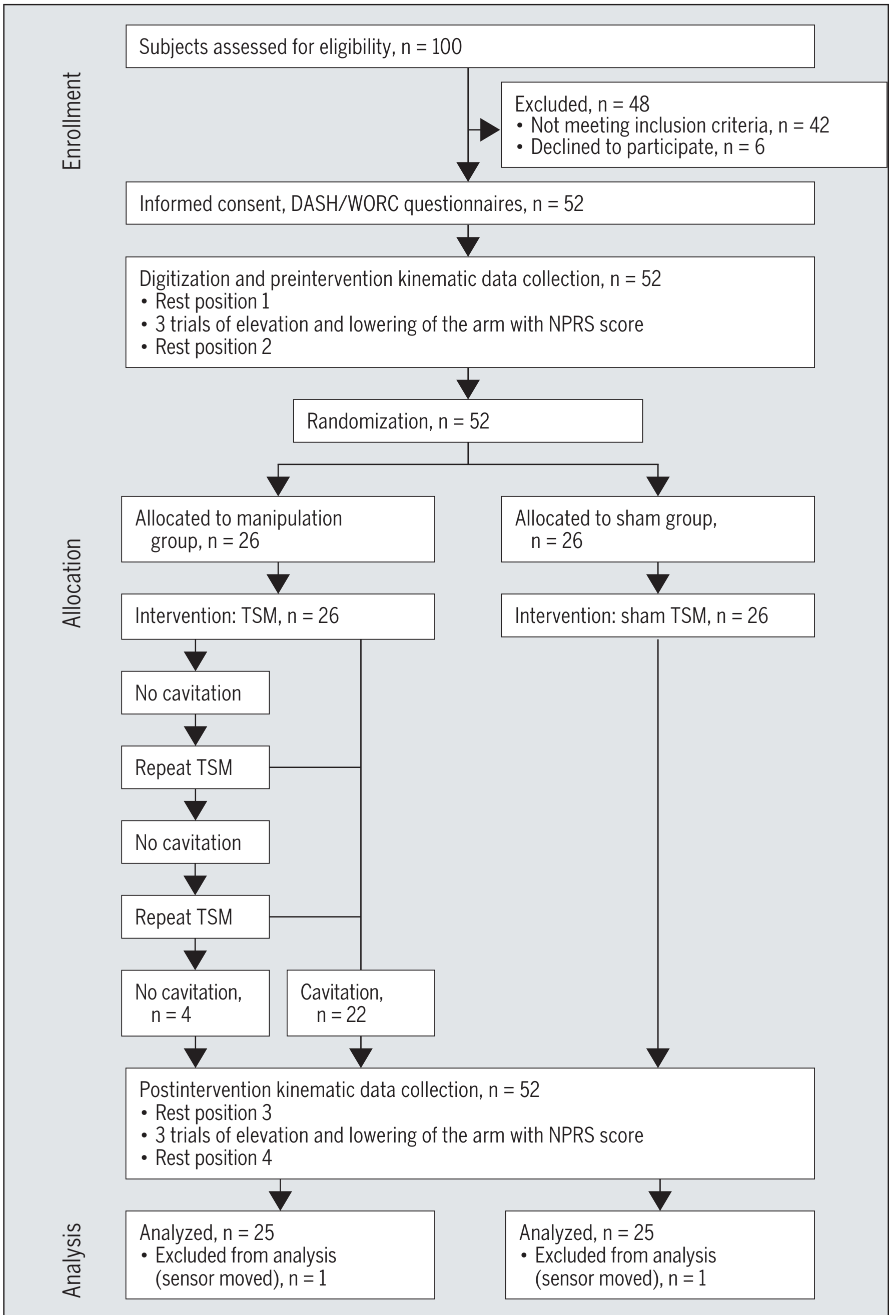

FIGURE 1. Flow diagram representing enrollment, allocation, procedures, and analysis for subjects with shoulder impingement syndrome. Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; NPRS, numeric pain rating scale; TSM, thoracic spine manipulation; WORC, Western Ontario Rotator Cuff index.

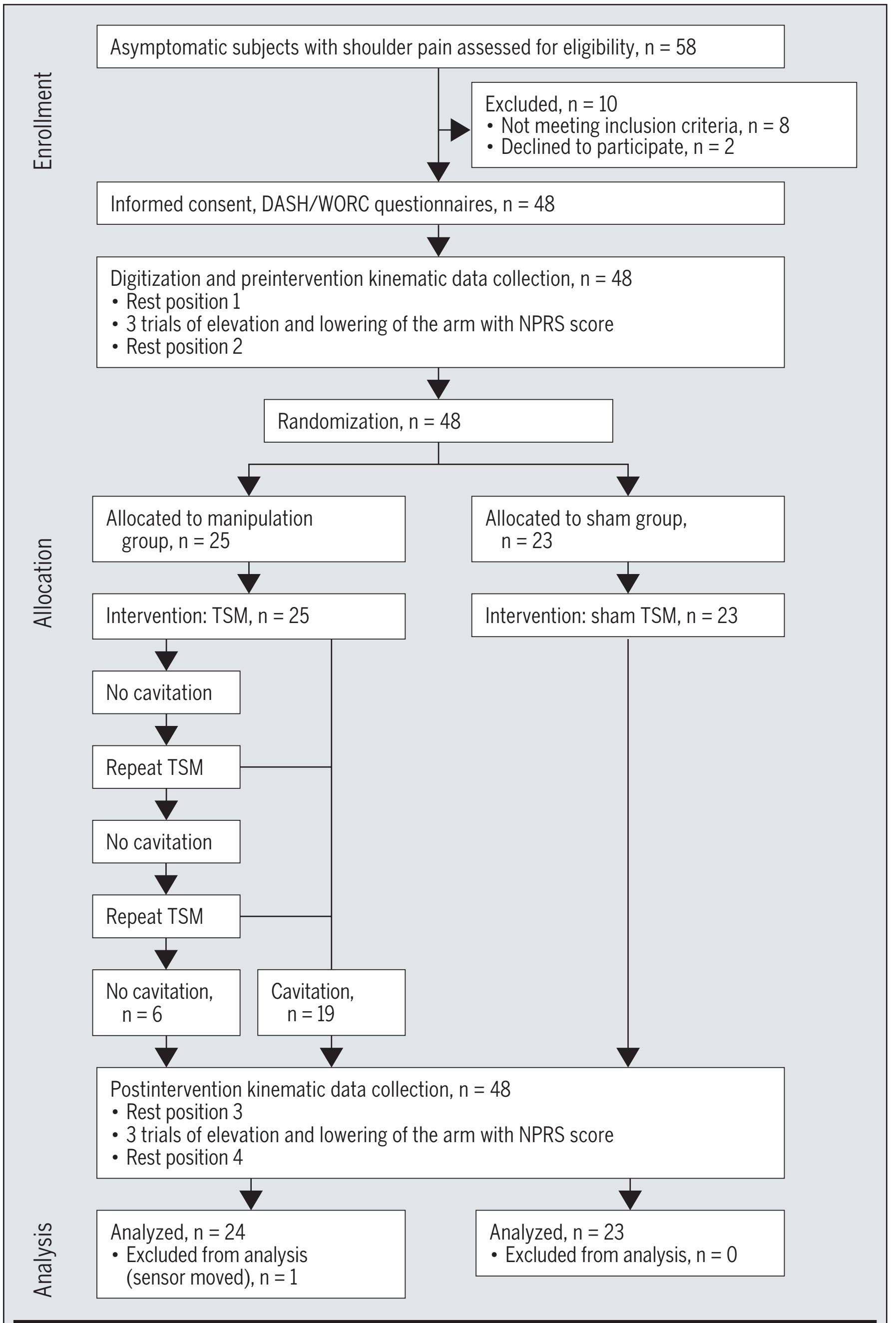

FIGURE 2. Flow diagram representing enrollment, allocation, procedures, and analysis for asymptomatic subjects. Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; NPRS, numeric pain rating scale; TSM, thoracic spine manipulation; WORC, Western Ontario Rotator Cuff index.

among clinical experts that regional interdependence is a valuable concept to consider as part of the clinical decision-making process.[65]

Although both physiological and biomechanical effects are believed to result from TSM, its contribution to shoulder rehabilitation is unclear, and additional studies evaluating the effectiveness of TSM to treat shoulder conditions are necessary. Based on regional interdependence and the neurophysiological effects of spine manipulation, the primary purpose of this study was to evaluate the immediate effects of TSM on shoulder pain and scapular kinematics in individuals with SIS. The secondary objective was to evaluate the immediate effects of TSM on scapular kinematics during elevation and lowering of the arm in subjects without symptoms. We hypothesized that TSM would reduce pain in subjects with SIS and cause changes in scapular kinematics in subjects with and without impingement symptoms.

METHODS

Subjects

Ninety-seven subjects, 47 asymptomatic and 50 with SIS, participated in the study. Using computer-randomized lists, one for the impingement group and the other for the asymptomatic group, subjects were randomly assigned to 1 of 4 groups: a TSM impingement group (n = 25), a sham impingement group (n = 25) (**FIGURE 1**), a TSM asymptomatic group (n = 24), and a sham asymptomatic group (n = 23) (**FIGURE 2**). Symptomatic participants were recruited using flyers posted in university buildings, orthopaedic clinics, and community public places, and asymptomatic participants (individuals without shoulder symptoms or impairments) were recruited from the university, the surrounding community, and personal contacts of the investigators. The basic descriptive characteristics of the subjects are presented in **TABLE 1**.

The diagnosis for SIS was based on a clinical examination and self-reported orthopaedic history. To be classified as having SIS, potential subjects had to present with at least 3 of the following findings: positive Neer impingement test,[47] positive Hawkins impingement test,[21] positive Jobe test,[28] pain with passive[24] or isometric resisted[52,60] shoulder lateral rotation, pain with active shoulder elevation,[27] pain with palpation of rotator cuff tendons, and pain in the C5 or C6 dermatome region.[41] A recent review[22] has suggested that using a combination of shoulder tests may provide better di-

TABLE 1 DEMOGRAPHIC CHARACTERISTICS OF THE SUBJECTS*

	Impingement Groups		Asymptomatic Groups	
	Manipulation (n = 25)	Sham (n = 25)	Manipulation (n = 24)	Sham (n = 23)
Age, y	33.8 ± 12.2	29.7 ± 9.3	25.5 ± 5.2	26.1 ± 5.0
Gender, n				
Women	11	7	12	15
Men	14	18	12	8
Weight, kg	68.2 ± 15.0	77.0 ± 13.5	70.4 ± 10.9	63.5 ± 12.7
Height, m	1.69 ± 0.12	1.73 ± 0.10	1.71 ± 0.10	1.68 ± 0.10
Evaluated shoulder, n				
Dominant	16	16	16	9
Nondominant	9	9	8	14
Duration of pain, mo	49.0 ± 96.0	42.6 ± 66.0	...	...
DASH (0-100)	26.9 ±12.7	23.3 ± 16.5	1.2 ± 1.9	1.9 ± 2.7
Total WORC (0-2100)	786.4 ± 397.2	731.9 ± 504.5	13.4 ± 20.6	18.5 ± 26.2
Physical symptoms (0-600)	226.0 ± 118.6	218.1 ± 140.8	9.1 ± 14.8	11.2 ± 18.0
Sports/recreation (0-400)	178.2 ± 104.4	169.4 ± 113.9	0.7 ± 2.3	2.2 ± 5.7
Work (0-400)	168.4 ± 92.1	160.5 ± 124.2	2.5 ± 6.7	3.0 ± 6.3
Lifestyle (0-400)	108.2 ± 91.4	90.2 ± 91.1	0.7 ± 2.3	2.0 ± 5.9
Emotions (0-300)	105.6 ± 77.3	93.6 ± 81.6	0.4 ± 2.1	0.0 ± 0.0

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; WORC, Western Ontario Rotator Cuff index.
**Values are mean ± SD unless otherwise indicated.*

agnostic accuracy, and another study[44] has suggested that a combination of 3 positive tests may provide the best ability to confirm shoulder impingement. Additionally, all subjects had to be able to reach to at least 150° of arm elevation, as determined by visual observation.

For all 4 groups, potential subjects were excluded for the following: red flags for spinal manipulation[6] (eg, fracture, osteoporosis, malignancy, infection, and active inflammatory process), pregnancy, systemic illnesses, physical therapy or manual therapy treatment within 6 months prior to the evaluation, signs of complete rotator cuff tear or acute inflammation, cervicothoracic spine–related symptoms (positive cervical compression test[58] and excessive kyphosis), scoliosis, glenohumeral instability (positive apprehension, anterior drawer, or sulcus tests[41]), or previous upper extremity fracture or shoulder surgery. Asymptomatic subjects were also excluded if they tested positive for shoulder impingement.[21,28,47] This study was approved by the Research Ethics Committee of the Federal University of São Carlos (465/2011). The subjects gave written informed consent to participate in this study, which was conducted according to the Helsinki Declaration.

Only the symptomatic shoulder was evaluated in the impingement groups. In the asymptomatic groups, the side evaluated was randomly determined with a computer-randomized list.

Pain and Function Evaluation

Shoulder pain and function were assessed in all subjects at the beginning of the session using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire[50] and the Western Ontario Rotator Cuff (WORC) index.[32,33] Both questionnaires are valid and reliable for assessing health quality of life in individuals with upper-limb symptoms[50] and rotator cuff conditions.[32] The DASH questionnaire consists of 30 questions designed to measure physical function, symptoms, and social function. The score on the DASH questionnaire is calculated by applying an established formula,[26] and the total score on the questionnaire can range from 0 to 100, with 0 as the best and 100 as the worst possible score. The WORC index is a self-report questionnaire with 21 items covering 5 life and health domains (physical symptoms, sports/recreation, work, lifestyle, and emotions). Each question on the WORC index is scored on a 0-to-100-mm visual analog scale, and each domain can be scored separately or combined for a total score ranging from 0 to 2100.[32] **TABLE 1** shows the score on the questionnaires for all groups.

Pain during shoulder elevation and lowering was also assessed before and immediately after the intervention using a numeric pain rating scale (NPRS). The postintervention pain assessment was conducted about 3 minutes after the intervention. Scores on the NPRS range from 0 (no pain) to 10 (worst pain). The NPRS has been shown to be a valid and reliable tool for individuals with shoulder pain.[45] Different criteria have been used to determine the minimum clinically important difference (MCID) of the NPRS for individuals with chronic pain, including statistical significance, magnitude of improvement, percentages of responders, effect sizes, evaluation of secondary outcomes, and other factors.[17] Farrar et al[18] consider the MCID to be a change of 2 points, whereas Dworkin et al[17] reported an improvement of 15% to 20% as the MCID.

Three-Dimensional Kinematics

For 3-D measurements, data capture and analysis were completed using Flock of Birds hardware (miniBIRD; Ascension Technology Corporation, Shelburne, VT) integrated with MotionMonitor software (Innovative Sports Training, Inc, Chicago, IL). The Flock of Birds is a direct-current electromagnetic tracking device that locates multiple sensors relative to a source transmitter. The transmitter produces an electromagnetic field that induces current into the sensors with 3 embedded orthogonal coils. The 3-D position and orientation of each sensor were tracked simultaneously at a sampling rate of 100 Hz. The sensors are small and lightweight (1.8 × 0.8 × 0.8 cm). In a metal-free environment, within 76 cm of the transmitter, the root-mean-square accuracy of the system is 0.5° for orientation and 0.18 cm for position, as reported by the manufacturer. One of the sensors is attached to a stylus with known offsets to digitize anatomical landmarks for building the joint coordinate systems.

The electromagnetic sensors were attached with double-sided adhesive tape to the sternum, to the acromion of the scapula, and to a thermoplastic cuff secured to the distal humerus to track humeral motion, as in previous studies.[7,34,36,41,62] The subject stood with the arms relaxed at the side in a neutral position, with the transmitter directly behind the shoulder to be tested, while bony landmarks on the thorax, scapula, and humerus were palpated and digitized to allow transformation of the sensor data to local anatomically based coordinate systems. Thoracic landmarks included the sternal notch, C7 spinous process, T8 spinous process, and xiphoid process. Scapular landmarks included the root of the spine, posterolateral acromion, and the inferior angle. Humeral landmarks included the lateral and medial epicondyles. The center of the humeral head was estimated by moving the arm passively through short arcs of motion (less than 45°) to define the pivot point.[2] Local coordinate systems were established for the trunk, scapula, and humerus using digitized landmarks according to the recommended protocol of the International Society of Biomechanics.[69]

The *y-x-z* sequence was used to describe the scapular motions relative to the trunk. For the scapula, the rotations were described in the order of internal/external rotation, upward/downward rotation, and anterior/posterior tilt. The humeral position with reference to the trunk was determined using the y'-x-y'' sequence. The first rotation defined the plane of elevation, the second the humeral elevation angle, and the third the internal/external rotation.

Previous studies have generally found a difference of 2° to 5° in scapular kinematics between those with and without shoulder impingement to be clinically relevant.[36,41] As such, changes in motion within or greater than this range of values were considered to be of clinical relevance in the present study.

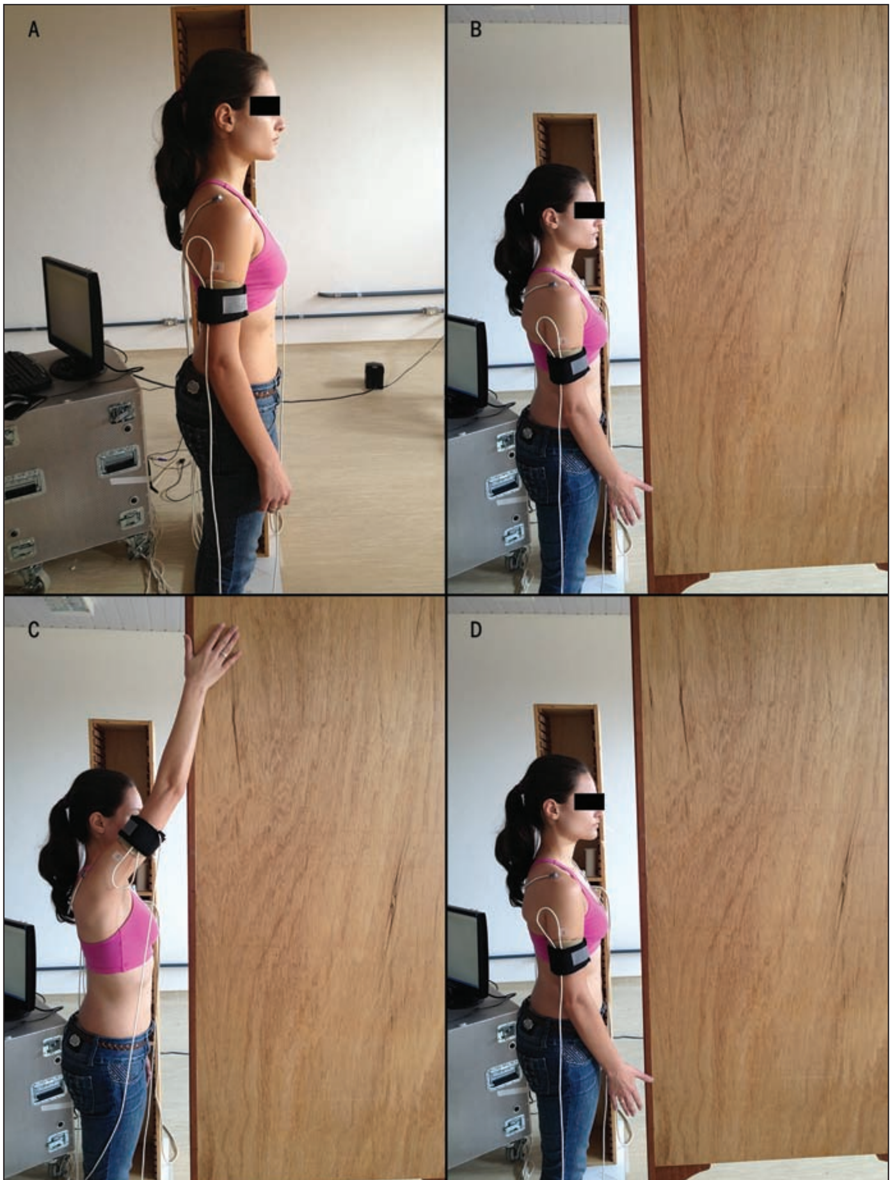

FIGURE 3. Data collection. (A) Rest position, (B) start position of arm elevation, (C) maximal position of arm elevation, (D) final position of lowering of the arm.

Procedures

Data were collected with the subjects in a relaxed standing position in front of the transmitter (**FIGURE 3**). Kinematic motion analysis was based on scapular orientation data measured at the humerothoracic angles of 30°, 60°, 90°, and 120° during arm elevation and lowering. The sagittal plane was defined by a flat surface to ensure the proper plane of elevation during active flexion. During elevation, subjects were instructed to keep their thumb pointing toward the ceiling, to slide their hand on the board, and to elevate their arm at a rate such that full elevation was accomplished over approximately 3 seconds (**FIGURE 3**). Lowering was performed at the same rate. Three complete cycles of the movement were performed. This procedure has been shown to be reliable during elevation and lowering of the arm in asymptomatic subjects and subjects with SIS.[20] Sensors were not removed or replaced between trials and between preintervention and postintervention testing. Care was taken during the procedures to not alter the location of any of the sensors. In a pilot study, the therapist was trained to position her hands and body in a manner that would not change the orientation of the sensors during the intervention. Also, data for a standing relaxed position were recorded immediately before and after the intervention to verify any possible sensor movement. A difference of more than 5° in more than 1 scapular motion in the relaxed position between the preintervention and postintervention was attributed to sensor movement, as a change of 5° would be larger than any expected measurement error, based on a previous study[20] that found measurement error to vary from 2.7° to 4.9° in asymptomatic subjects and from 3.1° to 3.8° in subjects with SIS.

Interventions

A physiotherapist with 4 years of experience in manual therapy administered the TSM or sham intervention, targeting the midthoracic spine of the subjects. For the TSM intervention, the subject assumed a seated position and the therapist performed a thrust technique (**FIGURE 4**). If no cavitation was detected with the manipulation, the thrust was repeated up to 3 times.

For the sham intervention, the subject assumed the same seated position and the therapist held the subject in the same

FIGURE 4. Positioning of the subject and therapist during both manipulation and sham interventions.

position as that of the thrust manipulation intervention. The therapist applied the same forces as those of a thrust manipulation, while holding the position for a few seconds, without actually performing a thrust manipulation. The subjects were given only general information about the purpose of the study to control expectations and to conduct an effective sham intervention. The same instructions were given to all subjects before and after both interventions. There was no communication between the evaluator and the therapist who performed the intervention. The therapist knew the condition of the subject and the intervention received, whereas the evaluator did not know if the subject had shoulder pain or had received the intervention (blinded-assessor study). This was achieved by having the clinician who was collecting the kinematic data on the computer leave the room while the therapist applied the assigned intervention.

Data Analysis

Statistical analysis was performed for all subjects with a complete data set in SPSS Version 17.0 (SPSS Inc, Chicago, IL). The mean of the 3 trials performed preintervention and postintervention was used for statistical analysis. Descriptive statistics (mean and standard deviation) were calculated for all scapular orientation data (internal/external rotation, upward/downward rotation, and posterior/anterior tilt) and pain scores. The Kolmogorov-Smirnov test was used to evaluate the distribution of data, and all variables showed $P>.05$. The Student *t* test was performed to compare function scores (DASH questionnaire and WORC index) between TSM and sham groups for both the subjects with SIS and asymptomatic subjects. For the primary purpose of this study, a 2-factor analysis of variance, with time (preintervention and postintervention) as the within-subject factor and intervention (TSM and sham) as the between-subject factor, was performed to identify possible differences in pain scores between interventions for the subjects with SIS. Also, for the primary purpose, separate 3-factor analyses of variance for each scapular kinematic movement were conducted for arm elevation and lowering in the subjects with SIS. For each analysis, time (preintervention and postintervention) and angle (30°, 60°, 90°, and 120°) were within-subject factors and intervention (TSM and sham) was the between-subject factor. If no interactions (time by angle by intervention, intervention by time, angle by time, angle by intervention) were observed, the main effect of time was analyzed. The main effect of angle was not of interest, given the known differences between angles, and the main effect of intervention was not of interest, as it would have simply reflected inherent group selection differences. For the secondary objective, the same analyses for kinematic data described for subjects with SIS were performed for asymptomatic subjects. The Tukey test was used for post hoc analysis when necessary. The level of significance was set at .05 for all statistical analyses.

Intragroup effect sizes for all variables across elevation and lowering of the arm were calculated using the Cohen *d* coefficient[13] for both the TSM and sham intervention groups. An effect size of greater than 0.8 was considered large, of approximately 0.5 moderate, and of less than 0.2 small.[13]

The reliability for measurements of each scapular motion was determined by calculating intraclass correlation coefficients (model 3,1) using the kinematic data from 3 trials of shoulder elevation and lowering.[57] For all analyses, the intraclass correlation coefficient values below 0.20 were considered poor, from 0.21 to 0.40 fair, from 0.41 to 0.60 moderate, from 0.61 to 0.80 good, and from 0.81 to 1.00 very good.[1] Absolute reliability was defined as the standard error of measurement (SEM), and the minimum detectable change (MDC) at the 95% confidence level[67] was calculated for each scapular motion separately for the impingement and asymptomatic groups. The SEM was calculated with the square root of the mean-square error term from the 1-way analysis of variance,[31] and the MDC was calculated by multiplying the SEM value by 1.96 and by the square root of 2.[67] The SEM data estimate the average error of the measurement for any given trial,[31] and the MDC data are the difference needed between repeated measures on a subject to be considered larger than random variation attributed to measurement errors.[67]

RESULTS

Pain and Function Scores

The groups were considered relatively similar across all baseline demographics (**TABLE 1**). For the 2 impingement groups, the 2-factor interaction of intervention by time (preintervention and postintervention) for the NPRS was not significant (F = 2.63, P = .11), but the main effect of time showed a significant decrease (0.6 points) in pain score at postintervention, independent of the intervention applied (F = 8.96, P = .004) (**TABLE 2**). The Cohen d coefficient showed a small effect (d = 0.22) of interventions on self-reported shoulder pain (**TABLE 2**).

TABLE 2 Pain Scores for Elevation and Lowering of the Arm in Both Impingement Groups

	Preintervention NPRS Score*	Postintervention NPRS Score*	Mean Difference†	P Value	Pooled SD	Effect Size, Cohen d
Manipulation (n = 25)	3.3 ± 2.6	2.4 ± 2.7	−0.8 (−1.2, −0.5)	.11	2.7	−0.31
Sham (n = 25)	2.4 ± 2.4	2.2 ± 2.3	−0.2 (−0.6, 0.1)		2.3	−0.10
Main effect of time	2.9 ± 2.5	2.3 ± 2.5	−0.6 (−0.9, −0.2)	.004‡	2.5	−0.22

Abbreviation: NPRS, numeric pain rating scale.
**Scores are an average of 3 trials. NPRS possible score range is 0 to 10. Values are mean ± SD.*
†Values in parentheses are 95% confidence interval.
‡Main effect of time was significant within impingement group for the NPRS scores (P<.05).

The majority of subjects in the asymptomatic group reported no pain before or after the intervention. One subject in the TSM asymptomatic group and 1 subject in the sham asymptomatic group experienced pain (NPRS score, 1/10) during 1 trial of elevation and lowering of the arm after the intervention. These data were not analyzed further.

Three-Dimensional Scapular Kinematics

Impingement Group For scapular internal rotation, the 3-factor interaction for elevation and lowering of the arm and the 2-factor interactions (intervention by time, angle by time, and angle by intervention) were not significant. The main effect of time was significant only during elevation of the arm (F = 4.36, P = .04) (**FIGURE 5**), in which internal rotation increased 0.5° after the interventions.

For scapular upward rotation, the 3-factor interaction for elevation and lowering of the arm, as well as the 2-factor interactions of time by angle and intervention by angle, was not significant; however, there was a significant 2-factor interaction of intervention by time (preintervention and postintervention) during elevation (F = 6.28, P = .01) and lowering (F = 3.73, P = .04) of the arm (**FIGURE 5**). Post hoc analysis demonstrated that those in the TSM impingement group experienced a significant increase of less than 2° in upward rotation during both elevation (P<.01) and lowering (P = .02) of the arm postintervention (**TABLE 3**).

For scapular tilt, the 3-factor interaction for elevation and lowering of the arm, the 2-factor interactions (intervention by time, angle by time, and angle by intervention), and the main effect of time were not significant (**FIGURE 5**).

The Cohen d coefficient showed limited effect of TSM on internal rotation, upward rotation, and scapular tilt for the impingement groups (d ranged from less than 0.01 to 0.10).

Asymptomatic Group For scapular internal rotation, the 3-factor interaction for elevation and lowering of the arm, the 2-factor interactions (intervention by time, angle by time, and angle by intervention), and the main effect of time were not significant (**FIGURE 6**).

For scapular upward rotation, the 3-factor interaction for elevation and lowering of the arm was not significant, nor were the 2-factor interactions of time by angle and intervention by angle; however, a significant intervention-by-time (preintervention and postintervention) interaction was found for both elevation (F = 6.52, P = .01) and lowering (F = 5.93, P = .02) of the arm (**FIGURE 6**). Post hoc analysis for arm elevation demonstrated that the TSM asymptomatic group experienced a significant increase of 2.2° in upward rotation at postintervention, whereas the sham asymptomatic group showed an increase of only 1.0° (**TABLE 3**). Post hoc analysis for the lowering of the arm revealed that the TSM asymptomatic group experienced a significant increase of 1.9° in upward rotation at postintervention, whereas the sham asymptomatic group showed an increase of only 0.7° (**TABLE 3**).

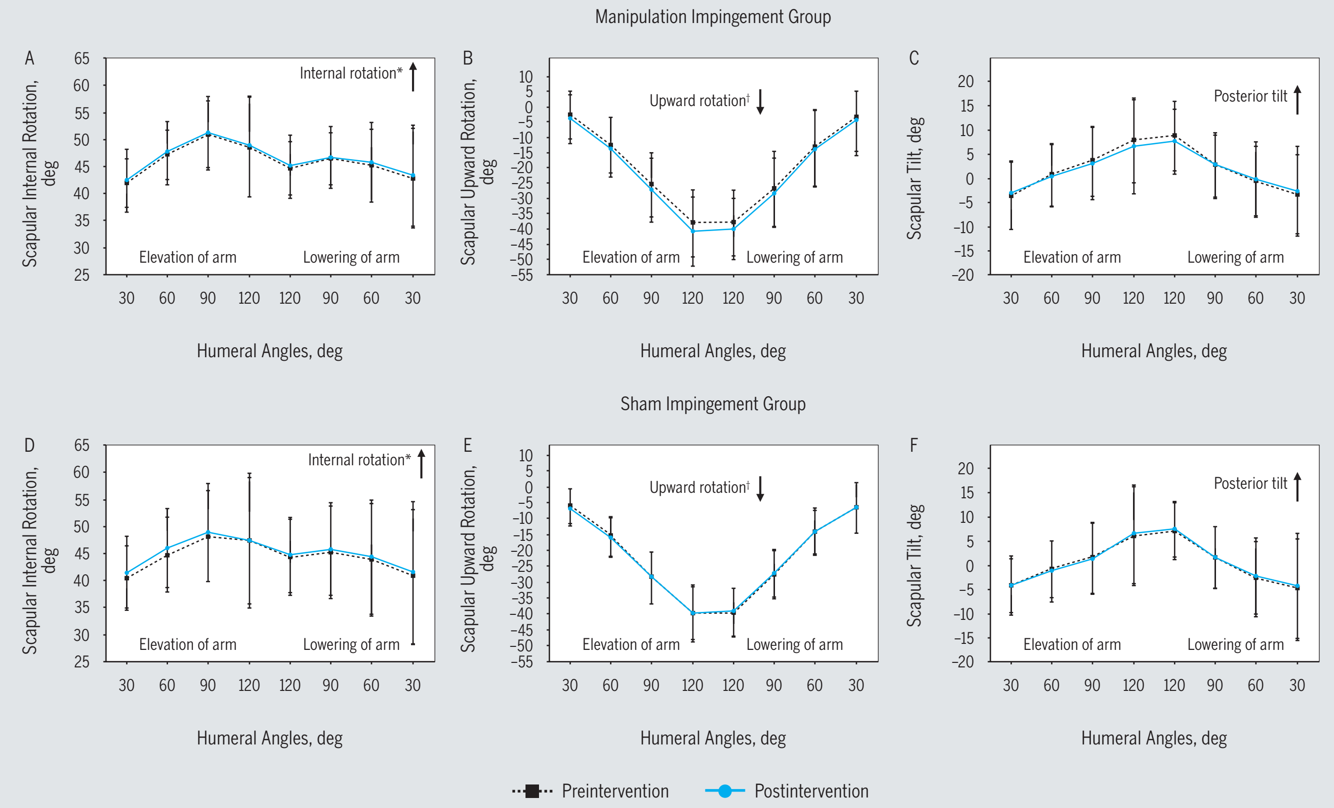

FIGURE 5. Mean ± SD for scapular internal/external rotation, upward/downward rotation, and posterior/anterior tilt for the manipulation impingement group (top) and sham impingement group (bottom) preintervention and postintervention. *Statistically significant effect of time (F = 4.36, *P* = .04) for internal rotation during elevation of the arm for impingement groups. †Statistically significant 2-way interaction (intervention by time) for upward rotation during elevation (F = 6.28, *P* = .01) and lowering (F = 3.73, *P* = .04) of the arm for impingement groups.

For scapular tilt, the 3-factor interaction for elevation and lowering of the arm, as well as 2-factor interactions of time by angle and intervention by angle, was not significant; however, there was a significant interaction of intervention by time (preintervention and postintervention) during both elevation (F = 12.10, *P*<.01) and lowering (F = 13.00, *P*<.01) of the arm (**FIGURE 6**). Post hoc analysis demonstrated that the TSM group experienced a significant decrease of 0.9° in posterior tilt during elevation and a significant increase of 1.1° in anterior tilt during lowering of the arm at postintervention (**TABLE 3**).

The Cohen *d* coefficient showed limited effect of TSM on scapular internal rotation, upward rotation, and tilt for asymptomatic groups (*d* ranged from 0.04 to 0.17).

Three-Dimensional Scapular Kinematics Reliability

There was very good intrarater reliability for assessing scapular internal rotation, upward rotation, and tilt during elevation and lowering of the arm (**TABLE 4**).

DISCUSSION

To our knowledge, this is the first randomized controlled clinical trial to directly compare the effectiveness of TSM and sham intervention on pain and scapular kinematics in subjects with SIS. The findings of the current study suggest that shoulder pain during elevation and lowering of the arm decreases immediately after a single session of TSM or sham TSM directed to the midthoracic spine in subjects with SIS. However, more studies are necessary to determine whether the pain relief is clinically relevant. Although a few changes were also observed in scapular kinematics after the TSM, these were not considered to be clinically relevant.

Self-reported shoulder pain in the symptomatic individuals seemed to decrease independently of the intervention applied (TSM or sham), and the reduction of 0.6 points in the NPRS was under the MCID of 2 points, as suggested by Farrar et al.[18] That group mean differences may obscure meaningful individual patient improvements and other benefits and risks should be considered.[17] Information about percentages of responders and evaluation of secondary outcomes, safety and tolerability, and other factors must all be considered to adequately understand the therapeutic benefit associated with a treatment for chronic pain.[17]

TABLE 3	**Difference Preintervention to Postintervention in Kinematic Data During Elevation and Lowering of the Arm***

Measure/Group/Treatment	Humeral Phase	Mean Difference, deg†	*P* Value	Pooled SD, deg	Effect Size, Cohen *d*
Scapular upward rotation					
Impingement group					
Manipulation	Elevation	–1.7 (–2.6, –0.8)‡	<.001	16.7	0.10
	Lowering	–1.1 (–2.1, –0.2)‡	.019	17.6	0.06
Sham	Elevation	–0.1 (–1.0, 0.7)	.749	14.6	<0.01
	Lowering	0.2 (–0.8, 1.1)	.681	14.6	0.01
Asymptomatic group					
Manipulation	Elevation	–2.2 (–2.9, –1.6)‡	<.001	14.6	0.15
	Lowering	–1.9 (–2.6, –1.2)‡	<.001	15.4	0.12
Sham	Elevation	–1.0 (–1.7, –0.3)‡	.005	14.1	0.07
	Lowering	–0.7 (–1.4, 0.7)	.078	13.5	0.04
Scapular tilt					
Asymptomatic group					
Manipulation	Elevation	–0.9 (–1.5, –0.3)‡	.002	5.1	0.17
	Lowering	–1.1 (–1.8, –0.4)‡	.002	8.8	0.12
Sham	Elevation	0.6 (0.0, 1.2)	.063	7.6	0.07
	Lowering	0.7 (0.0, 1.4)	.057	8.2	0.08

**Post hoc results for significant intervention-by-time interactions for upward rotation and scapular tilt. Negative numbers mean increased upward rotation and anterior tilt during elevation phase and decreased downward rotation and posterior tilt during lowering phase at postintervention.*
†Values in parentheses are 95% confidence interval.
‡Significant difference between postmanipulation and premanipulation (P<.05).

It is also important to highlight that a descriptive analysis of the data shows a greater number of subjects who reported pain relief after TSM (60%) than after the sham intervention (36%). The percentage of mean change in NPRS for the TSM impingement group was 25.5%, whereas in the sham impingement group it was 10.3%. According to Dworkin et al,[17] raw score changes of 1 point or percentage changes of approximately 15% to 20% represent the MCID for the NPRS in subjects with chronic pain. This suggests that a change in pain score may be clinically important in subjects who received the TSM intervention.

Other studies have also evaluated immediate effects of TSM on shoulder impingement and showed reduced pain scores in subjects symptomatic for shoulder impingement after TSM techniques.[8,46,59] However, these studies did not include a comparison with a control group of symptomatic subjects receiving a common or sham intervention. As such, the placebo effect of manual therapy could not be eliminated in these previous investigations.

A possible reason for the lack of significance in pain score reduction in the TSM impingement group in the present study is that some of the patients were not seeking care for their symptoms.[46] This may explain the relatively low NPRS scores, which could have resulted in a floor effect.

Neurophysiological mechanisms underlying spinal manipulation are not completely understood, but there are theories that explain how hypoalgesia could occur as a result of spinal manipulation. Evidence indicates that the sudden stretching produced by mechanical thrust could impact primary afferent neurons from the paraspinal tissues, motor control system, and pain-processing mechanism.[39,53] These neural inputs may activate the diffuse descending pain-inhibitory system and influence the pain-processing mechanism and other physiological mechanisms controlled by the nervous system.[39,53]

Although a significant increase in scapular upward rotation was observed in subjects with SIS following TSM during elevation and lowering of the arm, it was below the clinically relevant threshold (2°-5°), according to previous investigations.[36,41] Also, TSM produced a small effect size, because the Cohen *d* index for the TSM impingement group was 0.10 and 0.06 for elevation and lowering of the arm, respectively. According to Armijo-Olivo et al,[3] significant differences without relevant effect sizes may not be considered clinically relevant.

Individuals with SIS presented a significant but not clinically relevant increase in scapular internal rotation after both the TSM and sham intervention. This increase was about 0.5° and, therefore, was not considered to be harmful to the individuals. Moreover, the effect size was very small for both interventions, because the Cohen *d* index was 0.03 for the TSM and 0.08 for the sham intervention impingement groups.

The secondary purpose of this study was to verify whether similar effects might occur in the scapular kinematics of asymptomatic individuals. Based on the findings for scapular upward rotation, TSM may immediately improve scapular upward rotation independently of shoulder symptoms. Sham intervention seems to be equally effective as TSM in asymptomatic subjects. TSM improved upward rotation by approximately 2.2°, which exceeded the MCID, whereas improvement with the sham intervention was 1.0°. Considering that the lower trapezius is an important upward rotator,[51] these findings are consistent with findings of Cleland et al,[10] who showed that TSM applied to the lower thoracic segments (T6-T12) improved lower trapezius strength in asymptomatic subjects. Furthermore, spinal manipulation

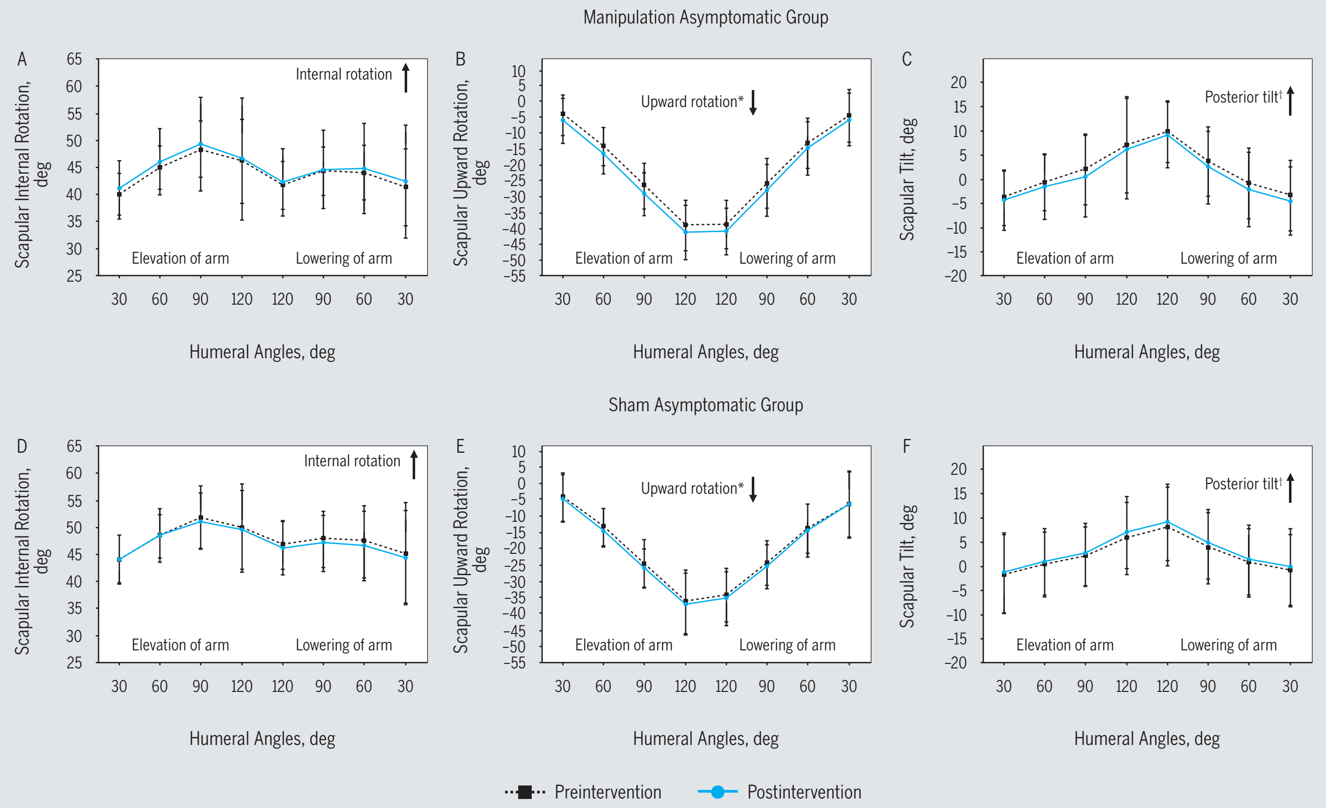

FIGURE 6. Mean ± SD for scapular internal/external rotation, upward/downward rotation, and posterior/anterior tilt for the manipulation asymptomatic group (top) and sham asymptomatic group (bottom) preintervention and postintervention. *Statistically significant 2-way interaction (intervention by time) for upward rotation during elevation ($F = 6.52$, $P = .01$) and lowering ($F = 5.93$, $P = .02$) of the arm for asymptomatic groups. †Statistically significant 2-way interaction (intervention by time) for scapular tilt during elevation ($F = 12.10$, $P<.01$) and lowering ($F = 13.00$, $P<.01$) of the arm for asymptomatic groups.

TABLE 4 Reliability Data for Measurements of Scapular Motion Based on 3 Trials of Elevation and Lowering of the Arm

	Impingement Groups (n = 50)			Asymptomatic Groups (n = 47)		
Measure/Humeral Phase	**ICC†**	**SEM***	**MDC_{95}***	**ICC†**	**SEM***	**MDC_{95}***
Scapular internal rotation						
Elevation	0.96 (0.93, 0.97)	1.6	4.4	0.95 (0.92, 0.97)	1.5	4.1
Lowering	0.97 (0.93, 0.97)	1.6	4.4	0.95 (0.92, 0.97)	1.5	4.0
Scapular upward rotation						
Elevation	0.96 (0.93, 0.98)	2.0	5.7	0.95 (0.91, 0.97)	1.6	4.5
Lowering	0.96 (0.94, 0.98)	2.1	5.9	0.95 (0.93, 0.97)	2.0	5.5
Scapular tilt						
Elevation	0.98 (0.96, 0.98)	1.1	3.1	0.98 (0.96, 0.98)	1.1	3.0
Lowering	0.97 (0.95, 0.98)	1.4	3.8	0.97 (0.96, 0.98)	1.3	3.5

Abbreviations: ICC, intraclass correlation coefficient; MDC, minimum detectable change; SEM, standard error of measurement.
**Values are deg.*
†Values in parentheses are 95% confidence interval.

seems to alter central sensory processing[15,53] and to improve motor control.[20,61] Although the physiological mechanisms underlying spinal manipulation were not directly evaluated in our investigation, it is important to consider that TSM was applied only once, which might not have been sufficient to cause greater changes in scapular upward rotation.

TSM seems to increase anterior tilt in asymptomatic subjects during both elevation and lowering of the arm; however, this increase was not considered clinically relevant because the effect size was small and was below the MCID considered in this study. Our findings are in agreement with the only study that has evaluated the effects of the same TSM technique in this population. Rosa et al[55] showed that TSM did not affect 3-D scapular kinematics during arm flexion in young, asymptomatic individuals. However, more studies are necessary to provide a more definitive conclusion on the effects of TSM on scapular kinematics in asymptomatic individuals, as only young individuals were assessed in the current study.

The aim of the present study was to assess the effects of TSM separately from other interventions, such as other manual therapy techniques or exercises of the shoulder girdle complex. These other interventions are often combined with TSM and included in an overall plan of care for patients with SIS.[4,5,68] While the relative contribution of specific manual therapy procedures is of interest, it has been demonstrated in patients with shoulder complaints that a combination of manual therapy and exercises or usual medical care is superior to either intervention alone.[5,60]

Despite evidence of the neurophysiological effects of spinal manipulation, a placebo effect must also be considered. If a subject in a study is informed of the potential benefits of spinal manipulation, the expectation of the benefits could contribute to placebo analgesia from the treatment.[54] The inclusion of a sham group of symptomatic subjects was intended to minimize placebo effects from the manipulation technique, because incomplete information about the purpose of the study was provided to all subjects. However, the Hawthorne effect, in which the subjects improved or modified an aspect of the experimentally measured behavior in response to the awareness that they were being studied, might have occurred.[40] A blinded evaluator was also used to minimize expectation bias in the study, and we suggest the use of an asymptomatic group to further blind participants to data collection and the therapist providing the TSM.

Though spinal manipulation usually targets a single vertebral level, the TSM technique chosen for this study was directed to the midthoracic (T3-T7) region. Studies have shown that several levels are simultaneously affected by this technique, even when a single vertebral level is targeted.[30,39] The choice of this TSM technique for this study was based on the presence of the cables for the electromagnetic sensors. No adverse effects or worsening of shoulder symptoms following TSM or the sham intervention were reported by the participants.

This randomized controlled trial has some limitations. In the kinematic data, the mean differences between preintervention and postintervention conditions were close to the SEM values, thus caution should be taken when interpreting these results. Also, the results of this study are only generalizable to asymptomatic individuals and those with shoulder impingement symptoms, but not to individuals with other shoulder pathologies. The effects of other spinal manipulation techniques applied to the thoracic spine and other spinal levels should be evaluated in subjects with shoulder impingement. Future investigations should compare the effects of manipulation in subjects with shoulder impingement who have thoracic pain or hypomobility compared to those with no thoracic problems. Future studies should also include long-term follow-up periods.

CONCLUSION

This study evaluated the immediate effects of a TSM on pain and scapular kinematics. The results suggest that shoulder pain immediately decreases in subjects with SIS after TSM. Some changes were observed in scapular kinematics after the TSM; however, these were small in magnitude and were not considered clinically meaningful. Future studies should continue investigating the effects of other spinal manipulation techniques in subjects with shoulder impingement symptoms. ◉

KEY POINTS

FINDINGS: Shoulder pain immediately decreased in subjects with SIS after a TSM. Some changes were observed in scapular kinematics after TSM that were not considered clinically meaningful.

IMPLICATIONS: The results suggest that TSM may be used to manage pain in patients with SIS as part of the rehabilitation plan.

CAUTION: These results are not generalizable to other shoulder conditions or other manual techniques. Subjects in this study had low levels of pain.

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