Immediate Effects of Thoracic Spine Thrust Manipulation on Neurodynamic Mobility

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Abstract

Objective: The purpose of this study was to investigate the immediate effects of thoracic spine thrust manipulation (TSM) on the upper limb provocation test (ULPT) and seated slump test (SST) in individuals with identified neurodynamic mobility impairments. A secondary aim was to determine if correlation existed between the perception of effect and improvements in neurodynamic mobility following a thrust manipulation compared with mobilization.
Methods: A pretest-posttest experimental design randomized 48 adults into 2 groups: TSM or mobilization. Participants with identified neurodynamic mobility impairment as assessed with the ULPT or SST received a pre-assigned intervention (TSM, n = 64 limbs; mobilization, n = 66 limbs). Perception of effect was assessed to determine its influence on outcome. Repeated-measures analysis of variance was used to examine the effects of intervention, and Fisher's exact test and independent *t* tests were used to determine the influence of perception.
Results: Both the ULPT ($P < .001$) and SST ($P < .001$) revealed improvements at posttest regardless of intervention. The ULPT effect sizes for TSM ($d = 0.70$) and mobilization ($d = 0.69$) groups were medium. For the SST, the effect size for the TSM group ($d = 0.53$) was medium, whereas that for the mobilization group ($d = 0.26$) was small. Participants in the mobilization group with positive perception had significantly greater ($P < .05$) mean neurodynamic mobility changes than those with a negative perception.
Conclusions: Neurodynamic mobility impairment improved regardless of intervention. The magnitude of change was greater in the ULPT than SST. Although both interventions appeared to yield similar outcomes, individuals who received mobilization and expressed a positive perception of effect exhibited significantly greater changes in neurodynamic mobility than those without a positive perception. (J Manipulative Physiol Ther 2018;xx:1-10)

Key Indexing Terms: *Manipulation, Spinal; Spine; Thoracic Vertebrae*

Introduction

The benefits of manual therapy intervention for a variety of musculoskeletal conditions have been widely reported in the literature.[1-8] Despite the high level of current evidence supporting its use, the specific mechanisms of action remain elusive.[9] The model proposed by Bialosky et al suggests that the interplay between biomechanical and neurophysiological effects of manual therapy may be responsible for changes seen clinically.[10] Additionally, in recent years, the literature has suggested that influences such as patient-therapist alliance and patient expectation may have an impact on the efficacy of manual therapy interventions.[11-17]

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Traditionally, both thrust joint manipulation and mobilization are considered manual therapy treatment techniques. However, although both are commonly used to reduce pain, eliminate impairment, and improve function, their relative efficacy is not entirely clear.[6,8,18] Thrust joint manipulation has been reported to be equally effective as mobilization in decreasing pain and improving function for mechanical low back pain.[19] Similarly, Izquierdo Pérez et al[20] reported no significant difference between cervical spine thrust manipulation and mobilization for chronic neck pain. Other authors, however, report superior outcomes when comparing thrust joint manipulation to mobilization procedures for mechanical neck pain,[21] cervicogenic headaches,[22] and low back pain.[23]

Variability in the evidence comparing thrust joint manipulation to mobilization is also noted for techniques directed at the thoracic spine. Thoracic spine thrust joint manipulation has been found to be more effective than mobilization for mechanical neck pain,[24] disability,[25,26] and lower trapezius muscle activation.[27] However, other authors have failed to establish a significant benefit of thoracic spine thrust joint manipulation over mobilization. When comparing thrust manipulation to mobilization, Sillevis et al noted no difference in autonomic nervous

Table 1. *Demographic Profile of Study Participants*

Group	Height (m)	Weight (kg)	Age (y)	BMI (kg/m^2)	Female (%)
TSM	1.70 (0.08)	70.86 (12.50)	25.73 (9.02)	24.27 (3.40)	63.64
Mobilization	1.69 (0.09)	67.16 (13.96)	23.33 (3.47)	23.35 (3.75)	76.19
P value	.62	.37	.26	.40	

Data are expressed as the mean (standard deviation), except where noted.
BMI, body mass index; *TSM*, thoracic spine thrust manipulation.

system activity in participants with chronic cervical spine pain.[28] Suvarnnato et al reported similar levels of improvement for participants who received thrust joint manipulation or mobilization for chronic neck pain.[29] Salom-Moreno et al reported similar improvements in pain-pressure threshold following thrust joint manipulation or mobilization in participants with mechanical neck pain.[24]

To determine why some individuals respond more favorably to thrust joint manipulation or mobilization, Lopez-Lopez et al considered psychological factors for participants with chronic neck pain who were exposed to different manual therapy techniques.[30] These authors noted that although thrust joint manipulation and mobilization both improved cervical spine pain, individuals with high anxiety responded more favorably to mobilization, whereas individuals with lower levels of anxiety were more likely to respond to thrust joint manipulation. Although evidence suggests that both mechanical and neurophysiological effects occur with manual therapy,[5,10,31,32] these findings indicate that psychological factors may also influence outcomes depending on the treatment received.

In addition to psychological factors, Bialosky et al's proposed model of the mechanisms of manual therapy suggests that nonspecific features such as patient expectation can affect the delivery of manual therapy treatment and the patient experience.[10] Patient expectation is strongly correlated with outcomes in individuals experiencing neck pain, and matching expectation with treatment appears to dramatically increase efficacy of care.[12,13] Patient expectation can also be positively or negatively influenced by the instructions given by the practitioner.[14] Additionally, positive psychological reinforcement appears to improve patient outcomes.[15]

Although many studies have investigated thrust joint manipulation and/or mobilization for mechanical cervical spine or lumbar spine pain, range of motion (ROM), perceived disability, and pain-pressure threshold, few have investigated the effects of manual therapy on peripheral nervous system tissue and mechanosensitivity to testing with procedures such as neurodynamic tests. Szlezak et al[33] inferred a relationship between abnormal neurodynamic mobility and persistent peripheral dysfunctions such as hamstring strains. These authors also reported improved neurodynamic mobility via the straight leg raise test following unilateral lumbar spine mobilization.[33] A recent meta-analysis of peripheral responses to cervical or thoracic spinal manual therapy reported improvements in upper limb neurodynamic testing, thereby supporting the therapeutic effect of spinal manual therapy.[34] However, of the articles reviewed, only 4 used upper limb neurodynamic testing as an outcome measure, and all participants were treated with a cervical lateral glide mobilization.[5,35-37] Because of the anatomical relationship of the thoracic spine and the sympathetic chain ganglion, it appears plausible that intervention in this area may affect peripheral sympathetic outflow to both the upper and lower quarters.

Although previous studies have investigated the response of upper quarter neurodynamic mobility to cervical spine lateral glide mobilization,[5,35-37] no studies have investigated the effects of thoracic spine thrust manipulation (TSM) or mobilization on upper and lower quarter neurodynamic mobility. Additionally, no study has attempted to correlate perception of benefit from mobilization or thrust joint manipulation with improvement in neurodynamic mobility impairments. The purpose of this study was to investigate the immediate effects of TSM on the upper limb provocation test (ULPT) and seated slump test (SST) in participants with identified neurodynamic mobility impairments. An additional purpose was to determine if a difference in treatment effect was present between participants with positive and those with negative perceptions of effect.

Methods

Design

A randomized pretest-posttest experimental design was used to investigate the immediate effects of TSM on neurodynamic mobility. Shenandoah University's institutional review board, which approved this study for the Protection of Human Subjects, granted ethical approval. Prior to testing, examination procedures were explained and all participants provided informed consent. This trial was registered with ClinicalTrials.gov and made public via ID No. NCT02842918.

Participants

Based on a power analysis, to achieve a power of 0.80 and an effect size 0.5, a sample size of 126 limbs was recommended a priori. Forty-eight asymptomatic adults,

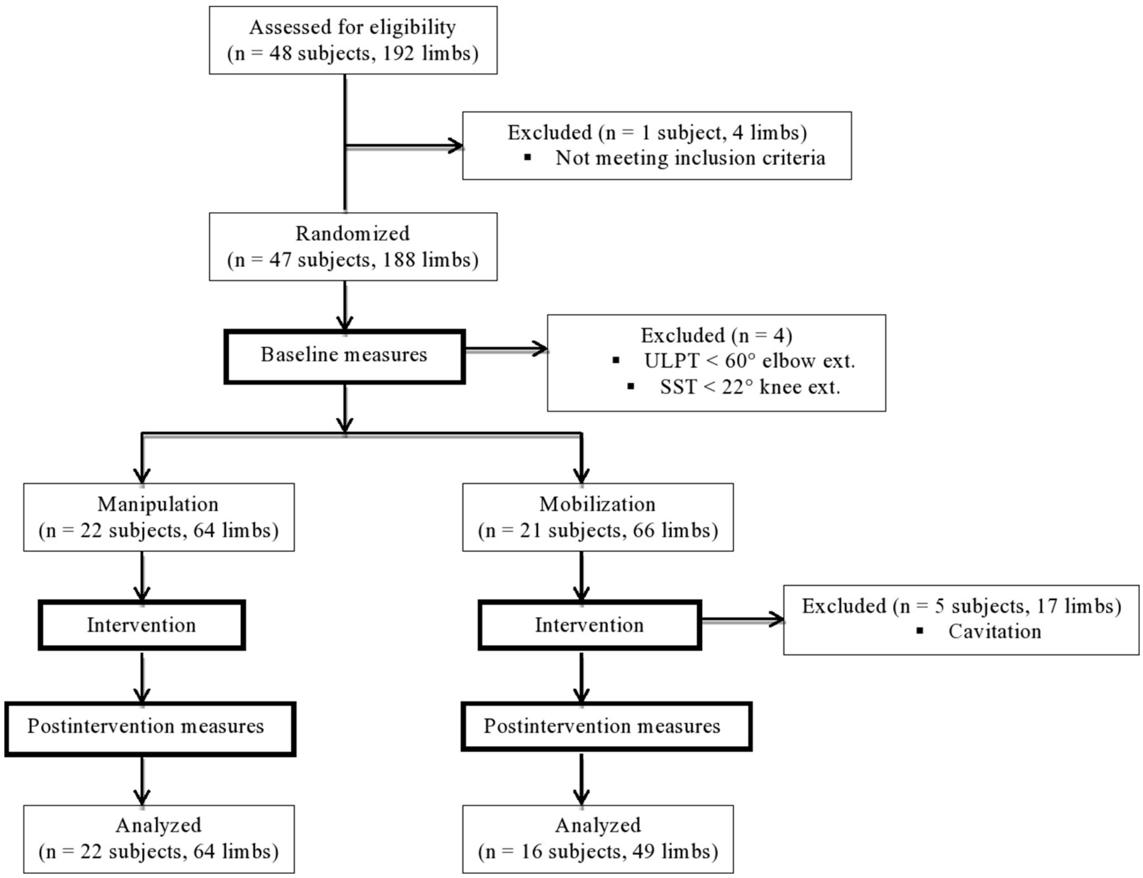

Fig 1. *CONSORT flowchart of the study.* SST, *seated slump test;* ULPT, *upper limb provocation test.*

aged 18 to 63 years (mean: 24.35 ± 6.61) (Table 1) with 192 limbs, were recruited through convenience sampling from Shenandoah University and the surrounding Shenandoah Valley. Exclusion criteria were a history of cervical or lumbar pain requiring medical intervention in the last 2 years; history of upper or lower extremity paresthesia or numbness; self-reported bone density disorders; previous spinal cord injury; diagnosed intervertebral disk herniation; previous diagnosis of spinal stenosis or disk pathology; history of circulatory or neurological disorders; history of spine and extremity fractures or dislocations in the last 2 years; and pregnancy.

A questionnaire containing exclusion criteria and demographic data was administered to participants prior to data collection.[38] One participant was excluded based on previous or current medical conditions identified by the questionnaire administered prior to testing, resulting in a sample size of 188 limbs (47 participants). For the purpose of this study, neurodynamic mobility impairment was operationally defined as a limitation in ULPT ≥60° of full elbow extension in 1 or both arms and/or limitation in SST ≥22° of full knee extension in 1 or both legs, whose symptoms successfully differentiated with movements of the cervical spine.[38] By use of these previously published[38] and recommended cutoff scores which represent the upper limit of the 75th percentile of individuals with neurodynamic limitations, an attempt at identifying participants with impaired ULPT and/or SST was made. Additionally, as these participants were not actively reporting upper quarter neurogenic symptoms, these methods allowed us to initially test our hypothesis under conditions that would not be impeded by possible nervous system tissue irritability. Upper or lower quarter limbs without impaired neurodynamic mobility were excluded. Figure 1 summarizes the stages of patient recruitment, testing, and analysis.

Procedures

By use of a random number generator, participants were randomized to 1 of 2 groups: TSM (n = 64 limbs) or mobilization (n = 66 limbs). Upper and lower quarter neurodynamic mobility was assessed with the ULPT and SST, respectively. The order of limbs assessed for each test was randomly allocated to limit order bias. Of the 47 participants (with 188 limbs) who met the inclusion criteria, 130 limbs exhibited impaired neurodynamic mobility and received their matched intervention.

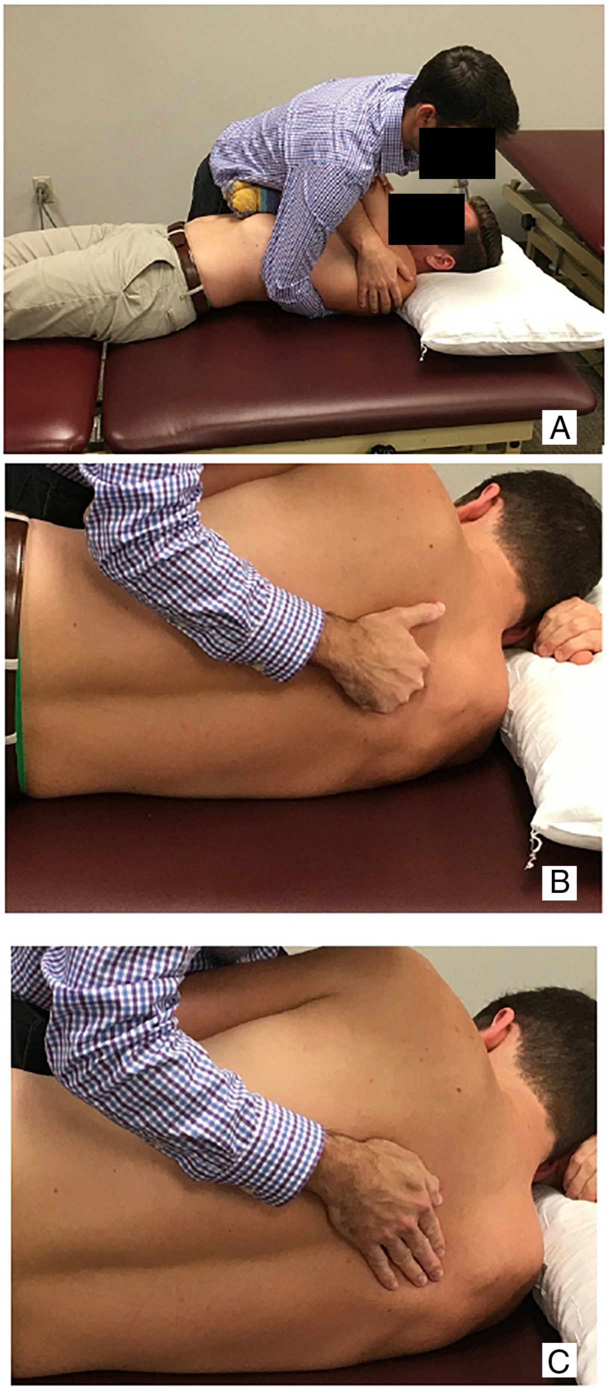

Fig 2. *Investigator and participant positioning for both thoracic spine thrust manipulation and mobilization procedures (A). Hand placement for thoracic spine thrust manipulation (B). Hand placement for mobilization technique (C).*

Randomly allocated treatment was then delivered to participants who had at least 1 limb with positive neurodynamic findings. Investigators involved in neurodynamic testing and measurements were blinded to the participant's group assignment. Posttreatment, participants were asked their perception of the effects of the treatment they received and posttest measurements with the ULPT and/or SST were performed. In all, 113 limbs were included in the final data analysis. Two licensed physical therapists, with a combined 27 years of experience as well as orthopedic board specialty and manual therapy certifications, delivered all of the treatment interventions. Investigators who delivered the intervention were blinded to the pre- and posttreatment measurements.

Measurements

Upper Limb Provocation Test. The ULPT was completed with participants in a supine position as described previously by Davis et al.[38] Cervical spine ipsilateral side bending was utilized to structurally differentiate a neurodynamic limitation from other upper quarter soft tissues. Results of structural differentiation were recorded and assisted in determining inclusion of that limb. A second investigator, blinded to the numbers on the goniometer, measured elbow extension with a standard goniometer. The goniometric measurement was read and recorded by another examiner. This procedure was conducted on both upper extremities during pretest measurements. Posttest measurements were assessed only on limbs lacking $\geq 60°$ of elbow extension. The ULPT has a sensitivity of 0.77 and a specificity of 0.94 in participants with neck pain.[39] Intrarater reliability in asymptomatic participants has been reported to be excellent, with an intraclass correlation coefficient of 0.98.[40,41] Previously, intertester reliability of the ULPT has been reported as poor when assessing resistance to movement as opposed to patient response to structural differentiation.[42] The minimal statistical meaningful change is 7.5° of elbow ROM.[41]

Seated Slump Test. The SST was completed as described previously by Davis et al.[38] To structurally differentiate limitation, passive cervical spine extension was introduced at the onset of symptoms. Results of structural differentiation were again recorded and determined inclusion of the limb. A blinded investigator measured knee extension with an inclinometer placed at the tibial tuberosity. This procedure was conducted on both lower extremities during pretest measurements. Posttest measurements were assessed only for limbs lacking $\geq 22°$ of knee extension. Urban and MacNeil reported a sensitivity of 0.91 and specificity of 0.70 for identifying neuropathic pain in the lower limb with the SST.[43] Excellent intrarater and interrater reliability has been reported, with intraclass correlation coefficients of 0.95 and 0.92, respectively.[44] There was strong agreement ($\kappa = 0.89$) among physical therapists when defining a positive SST as reduction of symptoms and increased knee ROM upon release of cervical flexion.[45] Currently, the minimal statistical meaningful change for the SST is unknown.

Perceived Effects

To investigate the secondary purpose of this study, assessment of perceived effects was conducted using a method similar to that previously described by Michener et al.[46,47]

Table 2. *Pre-Post and Within-Intervention Differences for Both Groups*

Group	Preintervention (°)	Postintervention (°)	Within-Group Change (°)	*P* Value	Effect Size
Upper Limb Provocation Test					
TSM	75.30 (71.18-79.42)	66.63 (61.92-71.34)	8.67 (5.26-12.07)	<.001	.70
Mobilization	78.90 (71.99-85.81)	66.14 (57.21-75.07)	12.76 (6.23-19.30)		.69
Seated Slump Test					
TSM	37.18 (33.71-40.65)	32.24 (28.40-36.03)	4.94 (2.49-7.39)	<.001	.53
Mobilization	40.00 (36.03-43.97)	36.92 (32.53-41.31)	3.08 (0.62-5.53)		.26

Values are expressed as the mean (95% confidence interval) for preintervention, postintervention, and within-group change scores. *P* value indicates main effect of time.
TSM, thoracic spine thrust manipulation.

Posttreatment, participants were asked, “Do you think that the treatment you received will increase your (arm/leg) flexibility?” Each answer was assigned a point value: 0 = no, 1 = yes.

Interventions

Immediately following baseline assessment of neurodynamic mobility, participants received either a thoracic spine thrust joint manipulation or a mobilization intervention. TSM consisted of a high-velocity, low-amplitude (HVLA) supine thoracic anterior-to-posterior thrust manipulation between the vertebral segments of T4 and T7 (Fig 2).[48] If a cavitation did not occur on the first attempt, the participant was repositioned, and a second thrust was performed. No more than 2 HVLA thrusts were performed per participant. The principal investigator who performed the manipulation recorded the number of thrusts performed and the presence of a cavitation, including whether or not the cavitation occurred before or during the thrust. Participants assigned to the mobilization group received a procedure that was identical to that of the TSM group in setup, patient positioning, areas of vertebral contact, and duration. As described by previous authors,[27,28,49] hand positioning differed; a flat hand was used instead of a loose-fist grip (Fig 2) to reduce to the likelihood of cavitation. Similar to the procedure described by Cleland et al[27] and Sillevis et al,[28,49] light compression of the arms into the chest was applied, but no HVLA thrust was delivered.

Statistical Analysis

All data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 24 (IBM, Armonk, New York). Means, standard deviations, and significance values were calculated for all descriptive variables using independent *t* tests (Table 1). The underlying assumptions for parametric testing, including normality of distribution and homogeneity of variance, were tested using the Kolmogorov-Smirnov and Levene tests, respectively. All variables were normally distributed and had equal variances ($P > .05$). Additionally, Mauchly’s test indicated that the assumption of sphericity was not violated for within-participant effects. Separate 2 × 2 repeated-measures analyses of variance were also used to examine the effects of intervention between groups (TSM and mobilization) over time (pretreatment and posttreatment) on ULPT and SST measurements, with $\alpha = 0.05$. Within-group effect sizes were calculated using Cohen’s *d* coefficient for changes in ULPT and SST ROM for both TSM and mobilization groups.[50] An effect size >0.8 was considered large, 0.5 medium, and 0.2 small.[50] Perceived effects of treatment were assessed by comparing the TSM and mobilization groups posttreatment using Fisher’s exact test, with $\alpha = 0.05$. For the mobilization group, an independent *t* test was performed to examine the difference in treatment response between participants with positive perceptions and those with negative perceptions of effects. This analysis was not completed on the TSM group, as all but 1 participant within this group reported a positive perception of effect. Statistical analyses were conducted at a 95% confidence level. A *P* value $< .05$ was considered to indicate significance for all analyses.

Results

Forty-three persons with 130 limbs determined to have impaired neurodynamic mobility participated in this study and were randomly allocated to the 2 treatment groups (TSM, n = 64 limbs; mobilization, n = 66 limbs). No significant differences were found between treatment groups for any of the baseline demographics of the participants (Table 1). Participants allocated to the mobilization group who experienced a cavitation during the procedure were not included in the final data analysis; these included 5 participants and 17 limbs (9 ULPT and 8 SST). A total of 113 limbs were included in the final analysis. No participants reported pain or residual

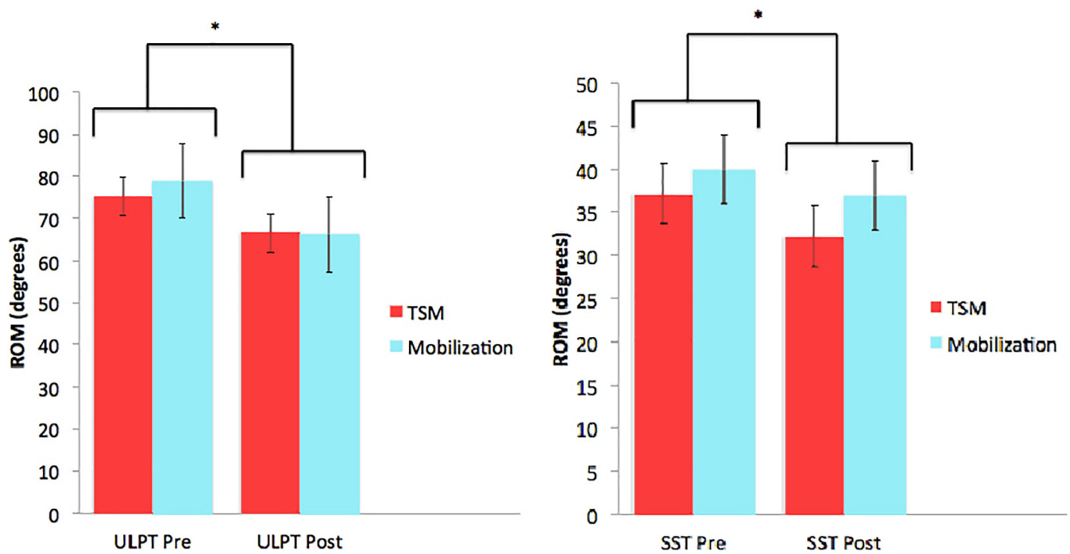

Fig 3. *Comparison of preintervention and postintervention means for the ULPT and SST. *Significant, P < .001.* ROM, *range of motion;* SST, *seated slump test;* TSM, *thoracic spine thrust manipulation;* ULPT, *upper limb provocation test.*

Table 3. *Perceived Effects for TSM and Mobilization Groups*

Perception of Effect	TSM Group (n = 22)	Mobilization Group (n = 16)
Positive	21 (95.45)	12 (75)
Negative	1 (4.55)	4 (25)

Values are expressed as the number (%). Fisher's exact test (P = .14).
TSM, thoracic spine thrust manipulation.

posttreatment symptoms, indicating no adverse effects from the treatment provided.

Upper Limb Provocation Test

Descriptive data for ULPT measurements are summarized in Table 2. Fifty-one limbs were considered positive for upper quarter neurodynamic impairment via the ULPT and included in the analysis (TSM, n = 30; mobilization, n = 21). Figure 3 illustrates the comparison between groups over time for the ULPT. Analysis of variance revealed a significant effect ($F_{1,49}$ = 42.56, $P < .001$), but there was no significant interaction between groups ($F_{1,49}$ = 1.55, P = .218). Both groups had significant improvements in neurodynamic mobility, and the effect of treatment did not depend on group allocation. ULPT effect size for both the TSM (d = 0.70) and mobilization (d = 0.69) groups was medium.

Seated Slump Test

Descriptive data for SST measurements are summarized in Table 2. Sixty-two limbs were considered positive for lower quarter neurodynamic impairment via the SST and included in the analysis (TSM, n = 34; mobilization, n = 28). As seen in Figure 3, comparison between groups over time for the SST revealed a significant effect ($F_{1,59}$ = 21.56, $P < .001$), but, no significant interaction was noted between groups ($F_{1,59}$ = 1.17, P = .285). Similar to the ULPT findings, both groups exhibited significant improvements in neurodynamic mobility, but the effect observed did not depend on the group assignment. Seated slump test effect size for the TSM group (d = 0.53) was medium, whereas that for the mobilization group (d = 0.26) was small.

Table 4. *Mean Neurodynamic Change Comparison for Positive and Negative Perception of Effect Within the Mobilization Group*

Group	Mean Neurodynamic Change (°)	P Value	Effect Size
Positive perception (n = 20)[a]	10.8° (0.62-20.63)	<.05	0.46
Negative perception (n = 8)[a]	3.12° (−3.59 to 9.83)	<.05	0.17

Values are expressed as the mean (95% confidence interval).
[a] n indicates number of limbs.

Perceived Effects of Treatment

Table 3 contains the frequencies of the responses provided by the participants regarding perceived effects of the technique received. There were no significant differences in perceived effects between the TSM and mobilization groups posttreatment (P = .14). An independent t test (Table 4) was used to compare the amount of change in neurodynamic mobility between those with positive and those with negative perceptions of effect. This analysis revealed a significant difference ($P < .05$) in mean neurodynamic mobility change between individuals with a positive (10.80°) and those with negative (3.12°) perception of effect. The effect size for those with a positive perception approached medium (*d* = 0.46), and for those with a negative perception, the effect size approached small (*d* = 0.17) (Table 4).

Discussion

The results of our study suggest that improvements in both upper and lower quarter neurodynamic mobility occurred following both interventions (TSM and mobilization) in individuals with identified impairments. Although the effect size was medium for ULPT improvements for both groups, the SST improved to a greater magnitude following thrust manipulation than it did with mobilization. Improvement in outcome measures regardless of the technique provided is consistent with other studies that have compared thoracic spine thrust joint manipulation with mobilization,[24,28,29] as well as with studies that have compared local specific thrust manipulation techniques with more general and indirect techniques[51,52] or placebo interventions involving the thoracic spine.[51,53]

Increases in ULPT mobility of 8.67° following TSM and 12.76° following thoracic spine mobilization (Table 2) are similar to the results of previous studies investigating changes in neurodynamic mobility following manual therapy treatment. Additionally, changes in both intervention groups are greater than the previously reported minimal statistical meaningful change of 7.5°.[41] Saranga et al reported a 7° increase in elbow extension following cervical lateral glide mobilizations in asymptomatic participants.[35] Vicenzino et al also reported a 7° increase in radial nerve biased neurodynamic testing following cervical lateral glide mobilization in symptomatic participants[5] and later described ROM improvement >20% greater than that provided by a placebo following cervical lateral glide treatment.[36] Coppieters et al reported improvement of 19° following cervical lateral glide treatment in participants with cervicobrachial symptoms.[37] Few studies are available for comparison of the changes we noted in SST mobility (4.94° following TSM and 3.08° following mobilization) (Table 2). Szlezak et al reported an increase in SLR of 8.5° following unilateral PA mobilization to the lumbar spine.[33] Because of the similar improvements noted with TSM as previously reported with cervical spine techniques, TSM or thoracic spine mobilization may be a potential intervention for identified peripheral neurodynamic limitations. Additionally, TSM or mobilization may provide an indirect approach to treatment, allowing for the avoidance of locally irritable tissues. However, these hypotheses would need to be assessed in a clinical setting prior to generalizing to participants with subjective complaints of symptoms in addition to identified neurodynamic impairments.

An explanation of the observed improvement in neurodynamic mobility impairment is likely multifactorial. Because of its anatomical location, TSM or mobilization may impact the sympathetic chain ganglion. Given the supply of the sympathetic neurons, it has been theorized that adverse neurodynamic mobility and mechanical hypomobility of the thoracic spine and rib cage are related to widespread somatic musculoskeletal complaints. In a recent review, the thoracic spine was referred to as the “Cinderella region” of the spine, perhaps a reflection of its relationship to regions distant to its osteology.[54]

Mean changes in the ULPT were greater in the mobilization group than in the TSM group. This small difference between groups was not significant (P = .46). However, when perception of effect was considered, a significant difference ($P < .05$) in mean neurodynamic mobility improvement was noted within the mobilization group between those who reported positive and negative perceptions (Table 4). Participants who received mobilization and had a positive perception of effect had an average improvement in neurodynamic mobility of 10.80°, whereas those with a negative perception of effect had 3.12° of improvement in neurodynamic mobility (Table 4). Previous studies reported the positive effect of expectation on soft tissue mobilization[12] and thrust manipulation[13] and the supraspinal mechanisms that occur following TSM.[55] These findings suggest that belief in the mobilization intervention may result in similar changes found with thrust manipulation and may be a significant factor in treatment effectiveness; another possibility is that the improvements typically associated with manual therapy procedures are, at least in part, related to positive expectation and belief held by the recipient.

Awareness of the biopsychosocial model in the management of musculoskeletal disorders has grown, and recent research has investigated patient-therapist interactions[16] and contextual factors[17] as they relate to outcomes. Although difficult to quantify, it is clear from these analyses that environmental factors, such as the context of the intervention, features of both the treating clinician and the participant, and the specific interaction between the two, play a significant role in the effectiveness of the treatment. It is possible that the language used to describe the mobilization intervention, the context and environment of our data collection lab, the wording on our flyer used to advertise for participants, and even the specific rapport that was developed with the primary investigators during the intervention could have had an impact on peripheral neurodynamic mobility and the improvements identified.

Limitations

The use of young, healthy participants who had objective neurodynamic impairment without subjective complaints is a primary limitation of our study, and makes clinical generalization difficult at this time. However, as this study appears to be the first to assess the effects of TSM on peripheral neurodynamic mobility, participation of persons who presented with an impaired ULPT or SST, but without subjective complaints of symptoms, was intentionally sought. Previous studies indicate that most, if not all, individuals will exhibit some degree of sensitivity to nervous system tissue upon neurodynamic testing procedures.[56] However, reports of normal responses to the assessment of neural tissue mechanosensitivity vary widely.[38,56-59] Davis et al reported that nearly 87% of healthy individuals reported symptoms prior to full elbow extension and noted a mean elbow extension angle of 49.4° for these participants.[38] Pullos noted as much as 60° of elbow extension ROM limitation in some asymptomatic participants when exposed to median nerve-biased ULPT procedures.[60] Davis et al also reported that one-third of healthy individuals described symptoms with the SST prior to full knee extension, with a mean knee extension angle of 15.1° for participants considered to have a positive test.[38] As a result of the inherent variability and these findings, the authors utilized previously established cutoff scores to determine which participants would receive intervention.

Contralateral cervical spine side bending and posterior pelvic tilt positioning were added to the standard testing sequence for the ULPT and SST, respectively, in an attempt to increase the likelihood of neurodynamic impairments. Because of the aims of this investigation, the definition of a positive test deviates from what is classically considered positive.[40,61] Assessment of sensitization, however, was monitored, considered in testing interpretation, and measured. The intent of our study was not to investigate psychometric properties of these previously described neurodynamic tests, but rather to identify neurodynamic impairment for the purpose of monitoring its possible change with the application of TSM compared with mobilization. The population studied may consequently limit the ability to generalize these findings to patients with subjective reports of upper or lower quarter neurodynamic mechanosensitivity. Further investigations should include a heterogenous sample of older individuals and those who are subjectively symptomatic. Although within-session changes may be clinically useful for individual patient management strategies, long-term effects were not examined in this study. Further study is needed to determine whether the effects identified in this initial trial would reduce perceived disability and pain and improve function to a greater extent than current multimodal treatment approaches in a clinical setting.

Despite statistical significance being met upon data analysis, wider confidence intervals in mean differences for the mobilization procedure for both the ULPT and SST were noted. These wide confidence intervals may in part be explained by the negative perception of some (25%) participants in the mobilization group. This may also explain the smaller effect size and magnitude of change in the SST for those who received the mobilization intervention. Additional investigations are needed to confirm these findings to ensure generalizability. Confidence intervals that were wider than initially anticipated may have affected sample size calculation. Future studies should consider a larger sample size because of the variability in response. Last, considering the lack of a control group and no significant difference in neurodynamic mobility improvements between groups, we cannot rule out the possibility that treatment effects were influenced by pre-intervention measurements.

Conclusion

This study investigated the immediate effects of TSM and mobilization on the ULPT and SST in participants with identified neurodynamic impairment. The results of this study indicate that peripheral neurodynamic mobility improved regardless of intervention (TSM or mobilization). Although the magnitude of change in lower quarter neurodynamic mobility favored participants who received manipulation, the magnitude of change in upper quarter neurodynamic mobility was similar for both groups. However, when perception of effect was considered, those who perceived positive benefit from thoracic spine mobilization exhibited significantly greater improvement in neurodynamic impairment than individuals with a negative perception. These findings support previous research that thrust joint manipulation or mobilization may yield similar outcomes but, at times, may be influenced by perception or expectation.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): A.J.H., A.J.L.

Design (planned the methods to generate the results): A.J.H., A.J.L.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): A.J.H., S.A.H.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): A.J.H., A.J.L.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.J.H., A.J.L., J.K.G., S.A.H.

Literature search (performed the literature search): A.J.H., A.J.L.

Writing (responsible for writing a substantive part of the manuscript): A.J.H.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): A.J.L., J.K.G., S.A.H.

Practical Applications

- Thoracic spine manipulation and mobilization both improved neurodynamic mobility impairment in the upper and lower quarters.
- Magnitude of change was similar in the upper quarter and greater in the lower quarter for those who received thrust manipulation as opposed to a mobilization.
- Participants who reported a positive perception of mobilization exhibited significantly greater improvement in neurodynamic mobility than those with a negative perception.

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