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Taking a Regional Interdependence Treatment Approach for a Patient with Upper Quarter Pain and Dysfunction: A Case Study

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Abstract

Background: Neck pain and shoulder pain are two classifications of diagnoses that are very prevalent in the general population. In the case of shoulder or neck pain, it may be important to take a regional interdependence view to the patient's presentation to ensure a comprehensive understanding of the patient's limitations. Regional interdependence is based on the thought process that dysfunction in one area of the body may manifest as further dysfunction or pain in a surrounding region. The purpose of this case report is to highlight a regional interdependence view of treatment decision-making in a case of upper quarter pain and dysfunction first diagnosed as three separate pathologies. **Case Description:** The patient is a 36-year-old senior gardener who presented to an occupational health clinic with neck and shoulder pain. She had significant limitations in cervical and shoulder range of motion in addition to impairments with scapular mechanics. **Intervention:** Interventions were directed at her primary areas of limitation, as well as further areas of limitation found via the regional interdependence approach of treatment, utilizing the 'test-treat-retest' model. The patient received a multimodal approach to her cervical and thoracic spine and shoulder girdle, incorporating manual therapy, therapeutic exercises and activity, and neuromuscular re-education. **Outcome Measures:** The outcome measures utilized with this patient were active range of motion, pain scale, return to work duties, and self-reported functional improvement. A limitation of this case study is the lack of use of standardized outcome measures, such as the Quick-Dash. **Discussion:** This case study provides support for a regional interdependence approach for treating patients with multiple chief complaints as a means to create a comprehensive treatment plan.

Keywords: Physical Therapy; Rehabilitation; Regional Interdependence; Neck-Shoulder Pain; Upper Quarter Dysfunction; Thoracic spine; Manual therapy

Background

Neck pain is a prevalent health condition that affects a large portion of the population at any given time. In a twelve month period, neck pain may influence up to 30-50% of the population (Celenay et al, 2016; Castelein et al, 2016). Notably, women often experience more neck pain for longer durations than men (Larsson et al, 2007). With the high prevalence of neck pain, it is important for clinicians to understand the economic burden associated with neck pain. When considering occupational health cases, like this case report, the overall cost of neck pain is second to only low back pain per year (Cleland et al, 2010). This overall cost considers not only the healthcare costs incurred during a patient's plan of care, but also the economic burden associated with decreased production at work due to diminished work capacity from the pain (Larsson et al, 2007).

Additionally, at any point in time, shoulder pain may influence up to 18-26% of adults (Linaker et al, 2015). Similarly to neck pain, women often experience more shoulder pain than males (Linaker et al, 2015; Larsson et al, 2007). When considering occupational health cases, "non-specific shoulder pain," or shoulder pain without a clear diagnostic feature, is up to six times more frequent than shoulder pain diagnoses with a clear pathologic feature, such as rotator cuff tear or impingement syndrome (Linaker et al, 2015). In the workforce, many exposures may increase the risk of shoulder pain. These exposures that increase the risk of shoulder pain are dependent on the positioning of the shoulder girdle during work activities, repetitive activities, and overall poor posturing during work duties (Linaker et al, 2015). When multiple of these exposures are manifested in one individual, the likelihood that that individual will experience shoulder pain increases four-fold (Linaker et al, 2015).

Importantly, neck-shoulder pain is frequently reported in the working age population (Sarquis et al, 2016). Workers with the highest prevalence of neck-shoulder pain are those who complete manual labor with their upper extremities at or above shoulder height, and those who spend the majority of their time in awkward postures (Sarquis et al, 2016). Additionally, with neck-shoulder pain, it has been found that both prolonged positioning and repetitive tasks can increase the pain symptoms the patient is experiencing (Andersen et al, 2011). In the case of worker's compensation, neck-shoulder pain can have vast economic repercussions, which can be as simple as decreased work capacity to as involved as progression to chronic pain and disability (Sarquis et al, 2016; Larsson et al, 2007; Andersen et al, 2011).

Regional Interdependence

Regional Interdependence is a model of assessment and treatment that is described as "seemingly unrelated impairments in remote anatomical regions of the body may contribute to and be associated with a patient's primary report of symptoms" (Sueki et al, 2013). While regional interdependence itself is a relatively new term, the underlying thought process behind it has been around for quite some time. This thought process began with the description of our body as a kinetic chain by Steindler (Sueki et al, 2013). The theory of regional interdependence has its basis on the understanding that a dysfunction in one area of the body will transfer atypical stresses to the surrounding area creating further dysfunction there as well (Sueki et al, 2013). Researchers have proposed that the regional interdependence model should be utilized during assessment and treatment of orthopedic conditions, so that clinicians have a comprehensive understanding of the patient's limitations (Sueki et al, 2013; Filipkowski et al, 2016; Dunning et al, 2015; Mintken et al, 2016). Importantly, regional interdependence expands outside the concept of the kinetic chain, but also incorporates ideas from the biopsychosocial model as well (Sueki et al, 2013). When utilizing the regional interdependence model of assessment and treatment, the clinician must take into account the patient's primary complaint, but also have further understanding about surrounding regions of the body and how their pain has impacted their life (psychosocial aspect) (Sueki et al, 2013).

The regional interdependence model of thinking can be very easily applied to clinical practice. Clinicians can break down regional interdependence into a rather simplistic model of 'test-treat-retest,' when considering all patients (Sueki et al, 2013). This allows the clinician to be aware of all of the patient's limitations with every visit and allows for better outcome tracking. Comparably to the

understanding that dysfunction in one area may affect a surrounding area, researchers have shown that interventions may have similar impacts on neighboring regions (Sueki et al, 2013; Mintken et al, 2016). The theory of regional interdependence is thought to eliminate the need to choose between multiple different models of patient care, as it is an all-encompassing model (Sueki et al, 2013). Regional interdependence aims to look at not only the pathomechanical reason behind the patient's pain but also at the other factors, such as psychosocial, that may influence that pain. (Sueki et al, 2013).

Regional interdependence has been demonstrated in many studies connecting relationships between the axial and appendicular skeleton, in both the upper and lower quarters. Significant relationships have been found in the upper quarter between the cervical and thoracic spine, and in the lower quarter between the hip and knee (Sueki et al, 2013). Additionally, regional interdependence highlights relationships between the psychosocial and the biomechanical, or the mind and body (Sueki et al, 2013). Studies have shown that changes in the patient's psyche can influence musculoskeletal pain. Changes in the patient's psyche, as seemingly minute as negative emotion, can greatly affect the patient's pain; therefore, being aware of the psychological factors impacting the patient are very important (Tan et al, 2008). With this case being an occupational health case, the patient's psychosocial factors were something that we needed to be aware of throughout the plan of care. Psychosocial factors that we were keenly aware of throughout this case included overall emotion and employer pressure for return to duty.

Regional Interdependence in Neck and Shoulder Pain

The high incidence of neck and shoulder pain collectively, as well as their close approximation, makes these patient complaints strong candidates for consideration of the regional interdependence model. This has been confounded with further research that has demonstrated a significant connection between the cervical spine and the shoulder girdle. Mintken et al (2016) reported that almost half of patients that experience shoulder pain, have additional impairments in their cervical and thoracic spine, as well as the adjacent ribs. Those with cervicothoracic impairments have been found to have a three time increased risk for developing shoulder pain (Bergman et al, 2004; Mintken et al, 2016). Furthermore, it has been demonstrated that patients with shoulder pain and concomitant cervicothoracic dysfunction have poorer outcomes than those without a cervicothoracic dysfunction (Bergman et al, 2004; Mintken et al, 2016).

Castelein et al (2016) has demonstrated that alterations in function of scapular stabilization musculature produces changes in the loading of the cervical spine, which may create or maintain neck pain in patients with shoulder pain. However, other researchers have found that the correlation between neck and shoulder pain can happen the other direction as well. Dunning et al (2015) demonstrated positional dysfunctions in the upper thoracic vertebrae affect the corresponding rib's function, which can create further alterations in the way the scapulothoracic "joint" can move.

As regional interdependence is a relatively new theoretical approach to musculoskeletal assessment and treatment, there is relatively little definitive research that may guide clinical decision making when implementing this model into physical therapy practice. Therefore, the purpose of this case report is to highlight a regional interdependence view of treatment decision-making in a case of upper quarter pain and dysfunction first diagnosed as three separate pathologies.

Patient History

A 36-year-old female presented to an occupational health outpatient physical therapy clinic in early summer with upper quarter pain and dysfunction following increased work activities. Per this clinic's protocol for worker's compensation, the patient was evaluated by the physician first and then referred to physical therapy. The referral medical diagnoses were: strain of right shoulder, thoracic myofascial strain, and acute sprain of ligament of neck. The patient's chief complaints were the significant pain she was having through her neck and shoulder (8/10), and the increased difficulty with work duties and activities of daily living.

She reported that the pain throughout her neck-shoulder region began after multiple consecutive days of pulling thick and rugged weeds at work in late spring. It was on the 8th day of completing this task that she had diffuse stiffness and pain throughout her right upper quarter. However, she did not present to the occupational health clinic until early summer, when she was aware that her own attempts at pain management were unsuccessful. She noted that her previous methods of pain control included over-the-counter pain medications and ice.

The patient is a senior gardener at a local botanical center, where she completes a vast array of duties to ensure the beauty and health of the gardens. Her duties vary from being in multiple positions to pull weeds, to upright backpack spraying, to education and research with the botanical center. She reported moderate difficulties with her work duties, only being able to complete approximately 25% of the duties at initial evaluation. Additionally, outside of work she enjoys being an active individual. Prior to the onset of her neck-shoulder pain she was participating in home and studio yoga multiple times throughout the week for both exercise as well as stress relief. Of importance, the patient reports that she is right hand dominant and that she does tend to complete many of her tasks with her right upper extremity when at work and home.

Her past medical history was positive for a previous right shoulder injury. She reported that at that time she had localized impingement-like symptoms which were treated by both a medical doctor and a physical therapist. This too was a worker's compensation case, but with a previous employer. She stated that she had a full recovery from this shoulder pain and had been fully released from the worker's compensation case from both her physical therapist and her medical doctor. She also indicates that the pain and dysfunction she was currently experiencing was not the same as her previous impingement-like injury.

With initial presentation to this occupational health clinic, the physician prescribed her a muscle relaxant and anti-inflammatory medication and referred her to physical therapy. The physician chose to refer to physical therapy first, prior to the patient having any imaging done regarding her shoulder or cervical spine. The patient's goals regarding her physical therapy plan of care were to reduce her overall pain, improve her ability to complete all of her job duties, and to return to yoga at home for both exercise and stress relief.

Examination

The patient presented to this occupational health outpatient physical therapy clinic as a "same-day evaluation," which indicates that the evaluation is often not a full traditional initial evaluation. The "same-day evaluation" is often limited to subjective, range of motion, and treatment based on the amount of time the patient is available prior to return to work. Upon examination, it was apparent that the patient was limited through her cervical spine and her shoulder girdle, consistent with her pain pattern. Table 1 provides the examination findings. She had diffuse range of motion limitations through the neck and shoulder region, as well as impaired scapular mechanics with the right scapula. She presented with right scapular winging and an elevated scapula at rest. With movement, she demonstrated more pronounced winging than at rest, and limited upward rotation during shoulder flexion and abduction. Observationally, on a scale from mild to severe, she presented with moderate forward head and moderate rounded shoulders, bilaterally. She also had significant muscular spasms throughout her right side in the upper and middle trapezius, supraspinatus, and infraspinatus.

Table 1. Initial and Final Cervical and Shoulder Range of Motion Values.

Cervical Motion	**Initial Evaluation**	**Final Re-Assessment**
Flexion	Limited 30%, Painful	Not limited or painful
Extension	Limited 50%, Painful	Not limited or painful
Right Sidebending	Limited 75%, Painful	Not limited, moderate "tightness"
Left Sidebending	Limited 25%, Painful	Not limited or painful
Right Rotation	Limited 50%, Painful	Not limited, mild "tightness"

Left Rotation	Limited 25%, Painful	Not limited or painful
Right Shoulder Motion	**Initial Evaluation**	**Final Re-Assessment**
Flexion	Limited 30%, painful	Not limited or painful
Abduction	Limited 30%, painful	Not limited or painful

Clinical Impression

At evaluation, the patient presented with both cervical spine and shoulder girdle limitations and pain. Regional interdependence as an approach to patient care seemed to be appropriate for this patient based on the vast number of studies that have demonstrated relationships between the cervical spine and the shoulder. Filipkowski et al (2006) states that the cervical spine should be considered a portion of the upper quarter's kinetic chain, and should therefore be involved in upper quarter treatment if necessary based on evaluation.

With regional interdependence in mind, further assessment of the thoracic spine was also warranted due to the functional scapulothoracic "joint" (Bergman et al, 2004). The musculature surrounding the functional scapulothoracic joint can be significantly altered during periods of shoulder pain in dysfunction; this alteration may produce widespread effects on both the cervical and thoracic spine (Castelein et al, 2016). Due to the many points of origin and insertion of musculature surrounding the scapulothoracic joint, alterations in activation may induce further dysfunction and mechanical strain to the structures in which they attach and support (Castelein et al, 2016). Again, this cause-effect relationship may not always function in a singular direction as Petersen and colleagues (2016) found an association between weakness through scapulothoracic musculature and increased incidence of neck pain. Studies have shown that patients with neck pain have increased pectoralis minor activity and decreased middle-lower trapezius activity during upper extremity movement (Castelein et al, 2016; Petersen et al, 2016). Over activity of pectoralis minor can lead to an anterior tilt and downward rotation of the scapula, which is counterproductive to the upward rotation needed for upper extremity elevation (Castelein et al, 2016). Additionally, the decreased activity of middle and lower trapezius proves to further contribute to the overall anterior tilt and downward rotation because they may no longer have the force generation to provide the necessary movement for elevation (neutral anterior-posterior positioning and upward rotation) (Castelein et al, 2016). These alterations in muscular activation were important for us to consider with our patient's presentation, as she demonstrated scapular winging and decreased upward rotation during shoulder elevation.

As previously discussed, the patient demonstrated a forward head, rounded shoulders posturing on initial evaluation. This posturing can increase the thoracic kyphosis, which has been found to be associated with decreased shoulder mobility in patients with and without pain (Barrett et al, 2016). Patients demonstrating this altered posturing, whether it is rigid or flexible, have shown decreased range of motion into both flexion and abduction (Barrett et al, 2016; Kebaetse et al 1999). Importantly, these were the two planes of motion that the patient demonstrated difficulty and pain with at initial evaluation. Studies have also shown that the slouched positioning may alter the appropriate length-tension relationship of the scapular musculature creating the inability to generate the appropriate forces for scapular control during shoulder movements (Kebaetse et al, 1999; Barrett et al, 2016).

Further evidence has continued to present itself that aligns with the underlying premise of regional interdependence. Therefore, it may be even more important to understand the relationships between force production and force alteration in neighboring body regions. A comprehensive assessment of these alterations allows the clinician to complete a thorough evaluation. Additionally, it is important to consider these remote regions if your initial treatments are not creating any relief or improvements in the patient (Kebaetse et al, 1999; Andrews et al, 2018, Crosbie et al, 2008). This has been demonstrated by Andrews et al (2018), who found that treatment at the thoracic spine generated improved results in shoulder pain and function without treatment at the glenohumeral joint at all.

The regional interdependence approach to decision making was appropriate with this patient due to her multiple pain points and medical diagnoses. Myofascial pain, similar to what she was experiencing, may be due to a combination of multiple factors; for example: metabolic deficiencies in the musculature, mechanical stress through the musculature and joints, and psychological influences (Hanney et al, 2017). With the production of symptoms from a combination of factors, it has been shown that neck-shoulder pain will benefit most from a multi-modal treatment approach in the long run (Larsson et al 2017). Therefore, the interventions selected for this patient were directed at not only improving mobility, but also stability and neuromuscular control at all three areas of limitation simultaneously.

Approach and Interventions: Regional Interdependence in ACTION

A multimodal approach was used with this patient, utilizing the decision-making process of regional interdependence. Each day that the patient presented to therapy, she was quickly re-assessed through subjective report and some objective testing to guide the interventions (for example: range of motion). At initial evaluation, the patient was limited in mobility and limited by pain, therefore the initial treatments introduced were to help improve mobility. She additionally received education regarding her positioning throughout the day at work to assist with control of overall pain levels. As she continued to work at improving her mobility, progressions in treatments were made to focus on strengthening and re-education of control within the new ranges she had achieved.

Manual Therapy

Manual therapy was utilized throughout the patient's entire continuum of care, only being applied at the areas in which the patient exhibited hypomobility. Initially, manual therapy focused on the cervical spine and pain reduction, as the patient was experiencing the majority of her pain through this region. These cervical spine mobilizations focused on the areas with restriction and hypomobility, as well as gross improvement in facet joint separation. Various techniques were used to improve the patient's cervical spine mobility, with a quick re-assessment prior to each use of manual therapy to ensure utilization was only at the hypomobile segments and directions. Examples of the techniques utilized are: cervicothoracic joint seated mobilization, supine flexion and extension mobilizations, cervical axial traction, uncovertebral joint mobilizations, and seated flexion mobilizations. The patient commonly noted significant decreases in pain following seated flexion mobilizations and cervical axial traction. Figure 1 provides an example of cervical axial traction. Of note, the individual included in figures throughout this report is not the actual patient, and she provided consent to be photographed for the purpose of this paper.

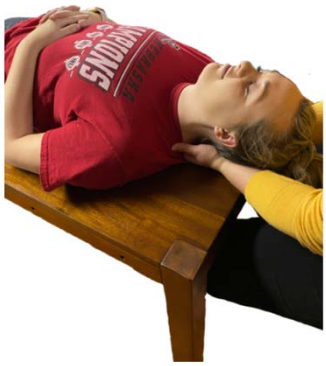

Figure 1. This image depicts an example of cervical axial traction.

The patient demonstrated gross hypomobility through her cervical spine. She demonstrated significant hypomobility through superoanterior facet movement bilaterally; however, with some assessments the hypomobility was with posteroinferior facet movement bilaterally. Hence, the importance of the continued re-assessments prior to mobilization. At the beginning of her plan of care, she received cervicothoracic seated grade 5 mobilizations, flexion and extension mobilizations bilaterally, uncovertebral joint mobilizations, and cervical axial traction. By visit five, she demonstrated improved cervical facet joint mechanics, however was still demonstrating difficulty with cervical range of motion. As will be discussed later, at this time is when an advancement to including thoracic mobilizations was included. Throughout the progression of her plan of care, she again demonstrated the need for flexion mobilizations to both the right and left from visit 11 to visit 17. Inclusion of these flexion mobilizations were added due to a period of regression of cervical range of motion and re-assessment of cervical joint mobility. With the addition of flexion mobilizations, she again demonstrated full range of motion through the cervical spine with minimal to no pain after manual therapy.

Multiple studies have found that cervical spine mobilizations create improvements not only at the location of mobilization, but also in nearby musculature and joints. Hanney et al (2017) found that high velocity low amplitude spinal mobilizations at the cervical spine produce reductions in pain and muscle sensitivity, as well as increases in range of motion. These mobilizations were included as the cervicothoracic grade 5 joint mobilizations during visits 2-10, which improved mobility through both the cervical spine and shoulder, which allowed for further progression of range of motion and stabilization exercises. Additionally, for patients that have shoulder pain, adding cervicothoracic mobilizations improves patient perceived success of treatment (Mintken et al, 2016). This patient commonly reported decreased pain after cervicothoracic mobilizations.

In regard to this case, it is important to note that studies have shown that cervical mobilizations with cervical range of motion exercises can produce apparent increases in strength of the scapulothoracic muscles (Petersen et al, 2016). These benefits, via either altered mechanical or neuromuscular outputs, have been found to last up to four days after mobilization (Petersen et al, 2016). Therefore, we utilized a multimodal approach with scapular strengthening and cervical and shoulder range of motion exercises to ensure maximum benefit from the apparent increase in strength. While there are benefits to cervical mobilization/manipulation, it is known that many risks are associated with these techniques, therefore it may be appropriate to seek other techniques that are less ‘risky’ (Peek et al, 2015).

Recently, there have been more contributions to evidence regarding the importance of thoracic spine mobilization with both cervical and shoulder pain patients. Within the last ten years, the Cochrane Review has suggested that thoracic spine manipulation may contribute to improved function and decreased pain in neck pain patients (Cleland et al, 2010). By visit 3, it was apparent that the patient was not having long term carryover from cervical mobilizations. Therefore, thoracic spine joint mobility assessment was completed to investigate further contributing factors, in an attempt to decrease pain and improve function. With initial assessment, the patient demonstrated hypomobility through her upper to mid thoracic facet joints and costotransverse joints. Engell et al (2019) found that the thoracic spine contributes to up to 25% of cervical mobility, therefore any improper mobility may lead to improper loading and dysfunction in the cervical spine. This finding by Engell supports the basis of regional interdependence. By the end of visit 3, she had a 50% improvement with cervical right sidebending, reduction in pain, and improvements in joint play through the costotransverse joints. Throughout each following session, as she was able to tolerate increased mobilization through the cervical and thoracic spine, she demonstrated improved mobility in both cervical and shoulder range of motion with less pain. With the addition of thoracic spine mobilizations, she began to demonstrate carryover of improved range of motion and decreased pain between sessions. The carryover seen has been supported by researchers that have observed accelerated neck pain recovery in those who receive thoracic mobilizations (Peek et al, 2015). With improved recovery, awareness of the mobility correlation, and knowledge of safety with thoracic mobilizations, these mobilizations may be a reasonable approach for patients with neck pain (Cleland et al, 2005). Additional studies have shown that patients with shoulder pain and concomitant hypomobile segments in the thoracic spine demonstrate improvement in shoulder symptoms, both pain and patient perceived disability, after thoracic spine mobilizations (Dunning et al, 2015; Barrett et al, 2016; Peek et al, 2015; Strunce et al, 2009; Haik et al, 2014). The findings of these studies help to support the theory of regional interdependence and our use of thoracic mobilization, as the mobilization outside of the area of primary complaint created improvements within the area of chief complaints (Strunce et al, 2009). While she had mobility gains within sessions, her overall hypomobility through the costovertebral joints and thoracic facet joints often returned between sessions. However, it is important to note that during her period of regression of cervical range of motion, she also demonstrated the need for rib mobilizations, posterior to anterior thoracic spine mobilizations, and the Jenkner mobilization. With the Jenkner mobilization promoting extension through her upper thoracic spine.

Examples of the techniques utilized throughout the plan of care in the thoracic spine are: prone costotransverse joint mobilizations, prone thoracic facet joint traction, muscle-energy technique of anterior glide of the posterior ribs, posterior-to-anterior of thoracic spinous processes, Jenkner mobilizations, and thoracic traction. The patient commonly reported benefits from the prone costotransverse joint mobilizations, prone thoracic facet joint traction, and the Jenkner mobilization; examples can be seen in Figure 2, Figure 3, and Figure 4.

Figure 2. This image depicts the prone costotransverse joint mobilization. In this image, the costotransverse joints of the right rib cage are being mobilized, with the line of force causing separation to the costotransverse joints. The left rib cage is being stabilized with the left hand of the student therapist.

Figure 3. This image depicts the prone facet joint traction. In this image, facet joints are being mobilized, with the line of force inducing separation.

Figure 4. This image depicts the Jenkner mobilization. The right hand is stabilizing the level just inferior to the "problematic level" and the left hand is providing axial traction. After the traction has been applied, then the right hand, adds a ventrally directed force to assist with extension.

Dunning et al (2015) found that after only two sessions of mobilizations through the facet joints and costotransverse joints, the subjects experienced a decrease in resting pain in the shoulder and improved 'Shoulder Pain and Disability Index' score. As noted before, the most commonly reported benefits were with the prone costotransverse joint mobilizations and the prone thoracic facet joint traction, which is in congruence with Dunning's 2015 study. Strunce et al (2009) also found that thoracic and rib mobilizations improve shoulder pain and range of motion. The subjects of that study had a 51% improvement in pain, a significant increase in shoulder range of motion, and a 4.2 point improvement in self-perceived health status (Strunce et al, 2009). Additionally, Haik et al (2014) found that immediately after thoracic spine mobilizations, subjects had improvements in scapular kinematics. This improvement in scapular kinematics is important to this patient as she demonstrated scapular winging and limited upward rotation through many of her early visits. Again, this presents another reason why it was important to take the multi-modal approach with this patient, as the thoracic mobilizations aided in the improvement in control of scapular motions.

While the patient presented with shoulder pain and impairments in shoulder range of motion, upon joint capsule assessment she demonstrated no areas of hypomobility through the glenohumeral joint. With no directions of hypomobility on assessment, joint mobilizations to the glenohumeral joint were not warranted in this patient's care. Additionally, as the patient received further cervical and thoracic mobilizations, she demonstrated improvements in her shoulder range of motion, indicating that the impairments of the shoulder were most significantly related to thoracic and cervical spine mobility.

Mobility

Exercises to promote mobility were most heavily needed at the beginning of patient sessions to improve the mobility through the cervical spine and the shoulder, as the patient was limited in both areas. These exercises consisted of active and active-assisted range of motion up to and through pain,

as tolerable. For the shoulder, she completed pulleys and dowel range of motion; and for the neck, she completed active range of motion. Not only were these exercises important for improving her range of motion, they were also important to reassure the patient that she could use the affected upper extremity to prevent progression to more significant shoulder pathologies, such as adhesive capsulitis. With each visit, the patient was asked to complete active range of motion of both the cervical spine and the shoulder. This assessment allowed us to understand her current limits of range of motion as well as pain's impact on her mobility, guiding our treatment decision making for that day. For example, when the patient demonstrated full active shoulder flexion and abduction, the use of active assisted range of motion was no longer utilized in her care plan.

As the patient continued to progress, she again received exercises targeted at mobility at the end of her sessions, in the form of stretching. Near the end of her plan of care, she was experiencing tightness rather than pain during cervical range of motion, and again had areas of increased muscular spasm. Therefore, we chose to complete stretching exercises with mild manual therapy to promote and encourage the patient to continue the stretching as part of her home program. Hanney et al (2017) demonstrated that manual static stretching of the upper trapezius can decrease pain and improve range of motion, when stretching at a moderate to vigorous intensity. When completing at a moderate to vigorous intensity, the patient is able to take advantage of the creep phenomenon (Hanney et al, 2017). The patient had increased muscular spasm through her bilateral upper trapezius and bilateral levator scapulae, so she was instructed on stretching for these muscles. With implementation of stretching, at patient return after final physician visit, she reported no feelings of tightness during cervical range of motion.

Strengthening, Stabilization, and Neuromuscular Re-Education

Starting at visit one, the patient began working to improve her overall strength, stabilization, and neuromuscular control through her scapular stabilizers and deep neck flexors. These exercises were warranted as at initial evaluation, she demonstrated improper scapular mechanics with overhead movements and the forward head, rounded shoulder posturing. With the initial visits, the exercises were focused on proper muscular activation and control of motion in the deep neck flexors and scapular stabilizers. These exercises consisted of scapular retraction, chin tucks and nuccal nodding, progressing quickly to scapular pull downs and rows with simultaneous deep neck flexion.

By visit seven, the patient demonstrated improved range through the shoulder and improved control with scapular stabilizer musculature. At this visit, she was progressed to further glenohumeral neuromuscular re-education with proprioceptive training utilizing the UE Ranger, and she demonstrated improved ability to complete postural training exercises against the wall without a breakdown in form. She completed the exercises to promote the proprioceptive feedback through the glenohumeral joint, but she also completed exercises to promote kinesthetic awareness through the scapula via scapular clocks in sidelying that progressed from assisted to manually resisted by the physical therapist. Moezy et al (2014) found that scapular stabilization exercises, similar to the those we started her with, are effective at improving shoulder range of motion and improving posturing of the shoulders and cervicothoracic spine.

As discussed earlier, patients with neck pain often demonstrate dysfunction and improper activation of the middle and lower trapezius (Castelein et al, 2016). In the case of this patient, she demonstrated significant weakness through her middle and lower trapezius. Exercises were put in place specifically targeting the middle and lower trapezius to improve not only strength but also scapular stabilization. By visit eight, she was able to complete minimal repetitions without resistance of middle and lower trapezius exercises with proper form. With each visit, the patient worked to progress repetitions and resistance as she had improved strength and control.

As her mobility continued to improve, she demonstrated the ability to complete further strengthening and stabilization exercises. This was completed through focus on the force through these muscles once proper mobility through the spinal segments and shoulder girdle had returned. By visit 10, she was able to progress to weight bearing scapular stabilization exercises that were more similar to the types of

activities and positioning that she would complete at work. The initial weight bearing exercises completed consisted of weight bearing against the wall completing scapular clocks in which she had fair control but struggled with endurance. Importantly, she demonstrated the ability to self-identify with minimal cueing when she lost scapular control with the initial exercises. She was able to quickly progress to quadruped and half-plank weight bearing exercises completing static and dynamic movements. Examples of these exercises include: heel of hand digs, contralateral scapular clocks, and scapular retraction and protraction. As she demonstrated improved control in the increased weight bearing positions she progressed to half bear crawls, push-ups on the swiss ball, and eventually full bear crawls. Scapular stabilization exercise protocols, similar to the exercise progression that the patient advanced through, have been shown to demonstrate improvements in strength and motor control over periods of eight weeks after the protocol was completed (Hotta et al, 2018). She was seen for a total of 8 weeks, with all weeks including scapular stabilization exercises both in therapy and at home.

When the patient finally regained the majority of her cervical range of motion near the end of her therapy sessions, we again worked more specifically on neuromuscular re-education of both cervical flexion and extension by completing the range of motion with segmental guidance. Yang et al (2015) found that completing cervical stability training with upper thoracic mobilizations provided more improvement in proprioception and pain than only completing cervical stability training. These findings have been further verified by Lee et al (2016) and Celenay et al (2016) who both found that craniocervical flexor training with thoracic mobilization was more effective at improving muscular function, range of motion, and perceived disability of patients with neck pain than completing one approach alone. As we took a multimodal approach with our patient, we completed the upper thoracic mobilization alongside the cervical stability training to provide the maximum benefits for the patient.

The patient demonstrated many areas of deficits in strength and neuromuscular control through her cervicothoracic spine and shoulder girdle. With the implementation of the regional interdependence approach, we were able to quickly assess the patient's ability to complete exercises with first attempts in session, which allowed for continued progression or maintenance of the exercise. Through the progression of her plan of care, the focus shifted from ensuring neuromuscular control but to improving functional activity tolerance with maintenance of control. She started at very minimal repetitions, many exercises only able to complete 5 prior to breakdown in form, and was able to progress by the end of the plan of care to up to 20 repetitions.

Strength and Mobility

Finally, we incorporated exercises that addressed both strength and mobility simultaneously. These exercises were initially biased to promote mobility through the thoracic spine and shoulder girdle, but once she demonstrated improved mobility we worked to improve strength through her re-found range. These exercises were completed over a foam roller and worked into horizontal abduction/adduction, elevation with contralateral extension, and scapular protraction and retraction. Images of examples of these exercises can be found in Figure 4, Figure 5, and Figure 6.

Figure 5. This image is an example of the horizontal adduction (left) and horizontal abduction (right) that the patient completed on a foam roller.

All of these exercises focused on thoracic spine extension with superimposition of upper extremity movements. Improving thoracic mobility during upper extremity movements is important, as it has been found that full upper extremity movement requires some thoracic extension. Barrett et al (2016) found that for full bilateral shoulder elevation, a person must have approximately 15 degrees of thoracic extension. It was also found that when completing unilateral upper extremity elevation, a person must have approximately 9 degrees of thoracic extension (Barrett et al, 2016). However, other researchers have found that side-bending and rotation of the thoracic spine are more predominant than extension during unilateral upper extremity movement (Crosbie et al, 2008). Therefore, thoracic mobility as a whole is important during any upper extremity movement, whether unilateral or bilateral.

Figure 6. This image is an example of the shoulder elevation with contralateral extension that was completed over a foam roller.

Figure 7. This image is an example of the shoulder protraction (left) and retraction (right) that was completed over a foam roller.

Outcomes

After 19 visits, the patient had fully returned to her home yoga program with no increase in pain. By visit 23, she demonstrated vast improvements in her overall cervical range of motion, shoulder range of motion, scapular mechanics, and her functional goals to return to work. She was having intermittent pain, maximum of 1/10 dependent on the amount of work completed in a day. Her improved range of motion values can be found in Table 1. At this time, she was released from physical therapy care, but continued to follow with the physician for the following two-weeks with once per week appointments and instruction to continue with the home exercise program.

In order for the patient to return to full-duty at work, she was required to lift 50 pounds from floor to overhead, carry 50 pounds at waist height for 40 feet, and push/pull 180 pounds for 40 feet occasionally, all with proper body mechanics. She demonstrated the ability to lift 50 pounds from floor to waist with mild pain, carry 45 pounds 50 feet, and push/pull 70 pounds 50 feet with mild pain on the push. The physician decided that at this point she was close to meeting her work requirements, therefore he would allow her to return to full duty with the home exercise program to finalize her strength. The patient returned to the physical therapy side of the clinic after her full release from physician care reporting that she had returned to full duty including lifting the heavier weights, with no increase in pain or symptoms.

Clinical Impression

The patient benefited from our approach utilizing the regional interdependence treatment scheme of ‘test-treat-retest.’ This was observed by within session re-assessments and by end of plan of care outcomes. An example of within session re-assessments is seen in Table 2. Within visit 7, the patient received manual therapy for both the cervical and thoracic spine, completed exercises that emphasize mobility of the cervical spine and shoulder, and completed strengthening exercises focusing on scapular stabilization musculature and deep neck flexors. With the multimodal approach targeting the cervical and thoracic spine, as well as the musculature surrounding the cervical and thoracic spine, the patient reported benefit as seen by improvements in range of motion outcomes and decreased pain.

Table 2. Within session comparison of cervical and shoulder range of motion before/after manual therapy.

Visit 7	*Prior to Manual Therapy*	*After Manual Therapy*
Cervical Right Rotation	Not limited but painful	Not limited, pain at end-range
Cervical Right Sidebending	Limited 50% with moderate pain	Limited 25% with mild pain

R Shoulder Flexion & Abduction	Full, mildly painful with eccentric control	Full, minimally painful with eccentric control

By the end of the plan of care, the patient had made great strides toward her goals. At her 23rd visit, she reported that she felt that she was 90% improved, with the remaining 10% being in regards to the not full attainment of lifting goals for work. Additionally, the patient had made lifestyle changes at home regarding her plan of care, including attention to posture and purchase of a foam roller to continue with the home exercise program after discharge. At discharge from physical therapy, she had met 5 of the 8 goals; with the only goals not attained being the lifting, carrying, and pushing/pulling for work. At discharge from the occupational health doctor's care, she had met 8 of 8 goals, with no difficulties with lifting, carrying, and pushing/pulling at work.

Patients presenting with multiple "diagnoses" may benefit from a regional interdependence approach to treatment, in order to target all possible pain and limitation generators. In this case, as she progressed through her plan of care after the initial promotion of mobility and pain control, it was apparent that her most significant limitations were through her thoracic spine. If the regional interdependence model of assessment and treatment had not been considered and utilized within her plan of care, the patient may have had a slower recovery and slower return to work.

Discussion

Regional Interdependence

As introduced earlier, regional interdependence is a model that allows clinicians to draw relationships between multiple regions of the body related to the patient's primary complaint to create a comprehensive treatment plan for the patient. In the case of this patient, she had primary complaints of dysfunction and pain in the cervical spine and the shoulder, which led to further investigation of the thoracic spine through physical therapy sessions.

The medical doctor initially diagnosed this patient with three separate pathologies of: acute sprain of ligament of neck, strain of right shoulder, and thoracic myofascial strain. When evaluating the patient at each session, it was apparent that these three seemingly 'separate' pathologies were all interconnected, needing to be addressed simultaneously. In this case, the model of regional interdependence was appropriate to use, as the dysfunction in one area was producing symptoms locally, but may have also contributed to further dysfunction and symptoms in surrounding areas. In this case, it is not fully clear which came first: the cervical spine dysfunction creating further thoracic spine and shoulder dysfunction, the thoracic spine dysfunction that created cervical spine and shoulder dysfunction and pain, or even shoulder pain and dysfunction that creates cervical and thoracic spine pain and dysfunction. Nevertheless, when treating with the regional interdependence model of 'test-treat-retest' through the multiple affected regions of her body, she experienced improvements in pain, range of motion, and strength to allow for the full return to work and leisure activities.

What about referred pain?

According to the leading article discussing regional interdependence, referred pain by definition is "pain that is perceived in a location other than the actual site of painful stimulus or source of symptoms" (Sueki et al, 2013). This article goes on to discuss referred pain as a component of regional interdependence (Sueki et al, 2013). In the article, it is discussed in the premise of a lower extremity disfunction; however, it is easily transferable to an upper extremity dysfunction as well. For example, pain starting at the cervicothoracic spine can influence surrounding regions of the body, such as the shoulder, and vice versa; both of which fall into the umbrella of the regional interdependence theory definition. This means that referred pain in this context would have been very likely with our patient; however, in her case, we do not know which dysfunction led to the other. Therefore, when a patient is experiencing pain and they are not making progress with the current treatment, it may be important to be aware of further contributing factors and referral patterns.

What about radicular pain?

According to the leading article discussing regional interdependence, radicular pain is “pain that originates from the spinal nerve roots and is experienced remotely from the site of the nerve root lesion” (Sueki et al, 2013). Sueki et al (2013) recognizes radicular pain as a “special case” of regional interdependence. When a patient has radicular pain, the nerve root is cause of the pain; however, this does not mean that the patient may not have other symptoms remotely that contribute to their overall pain and disability, making the ‘radiculopathy’ fall into regional interdependence (Sueki et al, 2013). Sueki et al (2013) describes the additional symptoms that contribute to, but are separate from, the nerve root pain as: altered motor control and impaired nerve root mobility.

Clinical Utility

As discussed throughout, the evidence suggests that dysfunction in one area may lead to further dysfunction in surrounding area. In some cases, the place of initial dysfunction may not even be a chief complaint of the patient. A thorough evaluation allowed us to make connections between this patient’s “3 diagnoses” from the medical doctor, which led to a more comprehensive treatment plan, utilizing the ‘test-treat-retest’ method. Many studies have pointed towards the importance of a cervical spine assessment for shoulder pain, but there has been increased evidence within the last few years that shoulder pain assessments should also include the thoracic spine. While it may not be feasible to evaluate all of these areas at the initial visit, the nature of reassessment that is central to a regional interdependence approach gives the clinician additional options to pursue later if progress is not made with initial interventions.

The more time spent with the patient and continued work in all aspects of her treatment: manual therapy, therapeutic exercise, neuromuscular re-education, therapeutic activity; it was more apparent that she may have had a longstanding cervicothoracic dysfunction. The longstanding cervicothoracic dysfunction coupled with the upper quarter overuse in a flexed posture may have caused the widespread pain and dysfunction through the neck and shoulder. Therefore, it was most advantageous for the utilization of the regional interdependence approach to treatment by completing the ‘test-treat-retest’ method. The patient was able to demonstrate improvement within session, which aided in patient buy-in and adherence to home exercise programs.

Outcomes Compared to Literature Findings

In this case, the patient had multiple areas of limitation and multiple areas of pain. This brought the physical therapist and student physical therapist to utilization of the regional interdependence approach to simultaneously work for improvements in all areas of the patient’s pain and limitations. As described earlier, there have been more studies that have demonstrated the importance of cervical mobilizations for patients with shoulder pain, thoracic mobilization for patients with shoulder pain, and thoracic mobilization for patients with cervical pain. In this case, the patient presented with pain in the neck and shoulder with limitations in range of motion at both regions as well.

As discussed earlier cervical spine mobilizations have been found to improve shoulder pain, scapulothoracic muscle activity, and patient perceived disability of shoulder pain (Mintken et al, 2016; Hanney et al, 2017; Petersen et al, 2016). Therefore, cervical mobilizations were utilized throughout the continuum of care for this patient, not only for improvements locally at the cervical spine, but also for regional interdependence improvements that have been found at the shoulder.

Relatively new to research is the consideration of the thoracic spine in relation to neck and shoulder pain. Within the last ten years, research has greatly expanded regarding the importance of thoracic spine assessment in patients with not only shoulder pain, but also those with cervical pain. As briefly discussed earlier, in patients with shoulder pain thoracic mobilizations have been found to improve pain, patient-perceived disability, and range of motion (McDevitt et al, 2015; Dunning et al, 2015, Peek et al, 2015; Strunce et al, 2009; Haik et al, 2014). Additionally, thoracic mobilizations have been found to directly affect middle and lower trapezius activity, which when this activity is inappropriate it may further contribute to scapular dysfunction and pain (McDevitt et al, 2015). When looking at the impact of

thoracic mobilization on cervical pain, it has been found that patients who receive thoracic mobilization have greater improvements in neck pain and perceived disability (McDevitt et al, 2015; Peek et al, 2015; Cleland et al, 2005). McDevitt et al (2015) does concede that thoracic mobilizations are not the end-all-be-all for treatment of patient's pain, but should be used as an adjunct to the already established multi-modal approach to see the greatest improvement in clinically meaningful changes in pain and disability.

Conclusion

Patients presenting with multiple diagnoses and pain points may need a closer look to demonstrate the relationship between their impairments. The purpose of this case report was to highlight a regional interdependence view of treatment decision-making in a case of upper quarter pain and dysfunction first diagnosed as three separate pathologies. This case provides support that patients with multiple complaints may need further assessment away from their major pain generators to create a comprehensive treatment plan. Additionally, this case is in agreement with the up-and-coming research regarding regional interdependence and the upper quarter's inclusion of the cervical and thoracic spine. The case utilized a multi-modal approach to address each of the patient's limitations and pain generators through manual therapy, therapeutic exercise and activity, and neuromuscular re-education. In this case, the patient described achieved complete resolution of symptoms with the utilization of the 'test-treat-retest' approach from the regional interdependence model. Future studies that continue to investigate regional interdependence of the upper quarter and the efficacy of multi-modal treatments in these patients are warranted.

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