[CASE REPORT]

ALEXANDER K. BRENNER, PT, MPT, OCS[1] • **NORMAN W. GILL,** PT, DSc, OCS, Cert. MDT, FAAOMPT[2]
CHRISTOPHER J. BUSCEMA, PT, DPT, MTC, Cert. MDT[3] • **KYLE KIESEL,** PT, PhD[4]

Improved Activation of Lumbar Multifidus Following Spinal Manipulation: A Case Report Applying Rehabilitative Ultrasound Imaging

Spinal manipulation is used frequently in the management of patients with spinal disorders.[3] The goal of treatment is to decrease pain, restore joint motion, and improve function. Although the biological mechanisms that explain why certain patients benefit from spinal manipulation are still not fully understood, there is an established association between spinal manipulation,

• **STUDY DESIGN:** Case report.

• **BACKGROUND:** The use of spinal manipulation as a treatment to facilitate neuromuscular control of the paraspinal musculature is not well described in the literature. The use of rehabilitative ultrasound imaging (RUSI) may offer a convenient way to investigate and document possible changes occurring in the lumbar multifidus associated with manipulation intervention.

• **CASE DESCRIPTION:** The patient was a 33-year-old male with a 21-year history of low back pain and left posterior thigh pain who presented with lumbar hypomobility and met a previously published clinical prediction rule for spinal manipulation. During examination, the patient was asked to perform a prone upper extremity lifting task to assess activation in the lumbar multifidus during an automatic task. Through palpation the examiner noted a decreased contraction of the left multifidus between L4-S1 compared to the right. To explore this further, a decision was made to assess the multifidus with RUSI, which confirmed the activation deficit noted during palpation. A lumbar regional manipulation was performed with the intention of reducing spinal hypomobility and of assessing changes in multifidus activation. Imaging of the multifidus muscles at the L4-5 and L5-S1 levels were obtained premanipulation, immediately postmanipulation, and 1 day after manipulation.

• **OUTCOMES:** An increased ability to thicken the multifidus during a prone upper extremity lifting task was noted immediately and 1 day after manipulation. Average percent change in thickness at the L4-5 and L5-S1 levels with the prone arm lift was 3.6% premanipulation, 17.2% immediately postmanipulation, and 20.6% approximately 24 hours postmanipulation. Improvements in the thickening of the multifidus muscle during the upper extremity lifting task were greater than 3 standard errors of the measurement. Other changes included immediate palpable improvement in the contraction of the multifidus during the upper extremity lifting task, along with the patient report of increased ease of lifting.

• **DISCUSSION:** In this case report we quantified the short-term influence of spinal manipulation on multifidus muscular activation using RUSI. No cause-and-effect claims can be made; however, the results provide preliminary evidence to suggest that spinal manipulation may influence multifidus muscle function. RUSI offers a convenient way to investigate and document these changes. *J Orthop Sports Phys Ther 2007;37(10):613-619. doi:10.2519/jospt.2007.2470*

• **KEY WORDS:** *motor control, reflexogenic, sonography*

or mobilization, and improved muscle function in the quadriceps,[15,45] the erector spinae,[24] and the deep neck flexors.[42] One possible mechanism by which spinal manipulation influences muscle function and activation is through a reflexogenic or neurophysiologic effect.[16,17,29,30,35] Specifically, the effect seen at the muscle (end organ) may be related to altered motor neuron pool excitability associated with spinal manipulation.[8,10,16,17,33] Murphy et al[33] proposed that spinal manipulation in the form of a high-velocity low-amplitude (HVLA) thrust activates mechanoreceptors and proprioceptors from structures in and around the manipulated joint. The altered afferent input arising from the stimulation of these receptors is thought to cause changes in motor neuron excitability, which then results in local or regional muscular changes around the manipulation site.[16,17,44,45]

While electromyography (EMG) is considered to be the gold standard for assessment of muscle activation, surface electrodes only accurately record signals from superficial muscles. Indwelling electrodes, although capable of measuring deep musculature activation, are invasive and not appropriate in routine clinical practice.[32] Rehabilitative ultrasound imaging (RUSI) is gaining acceptance as a noninvasive method to assess and measure deep muscle function.[22,23] RUSI

[1]Company Commander, Physical Training and Rehabilitation Program, 46th Adjutant General Battalion (Reception), Fort Knox, KY. [2]Postdoctoral Research Fellow, Spine Research Center, Department of Orthopaedic and Rehabilitation, Walter Reed Army Medical Center, Washington, DC; Director and Assistant Professor, US Army-Baylor University Postprofessional Doctoral Program in Orthopaedic Manual Physical Therapy, Brook Army Medical Center, Fort Sam Houston, TX. [3]Chief of Physical Therapy, US Army Health Center, Vicenza, Italy. [4]Assistant Professor of Physical Therapy, University of Evansville, Evansville, IN. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Departments of the Army, or Defense. Address correspondence to Alexander K. Brenner, 403 Chestnut Street, Elizabethtown, KY 42701. E-mail: Alexander.brenner@us.army.mil

TABLE 1 Criteria for a Clinical Prediction Rule for Regional Lumbopelvic Manipulation[3,11]

Criteria	Present on Examination
Symptoms <16 d	No
FABQ-W score <19	Yes
No symptoms distal to knee	Yes
At least 1 level hypomobility in lumbar spine	Yes
At least 1 hip internal rotation >35°	No

Abbreviations: FABQ-W, Fear-Avoidance Behavior Questionnaire-Work Subscale.

refers to the rapid sequential display of ultrasound images, resulting in a moving presentation, and may also involve measurement of real-time images or static images at different points in time. Physical therapists can use RUSI to assess and measure muscle and related soft tissue structure and function during physical tasks.[46] Researchers have demonstrated the reliability of ultrasound measurements of the transversus abdominis (TrA) and multifidus muscles,[21,41,43,47] and RUSI has been shown to be a valid method of measuring various muscular attributes, including girth,[18-21] morphology,[43] and activation.[23,27,32]

The authors of a recent case report[14] using RUSI documented a patient's ability to improve muscle contraction and thickness in the TrA after spinal manipulation. It is then reasonable to expect that spinal manipulation, by a possible reflexogenic mechanism, may also improve the performance of the lumbar multifidus. Therefore, the purpose of this case report was to investigate and describe changes in multifidus activation using RUSI before and after lumbar spinal manipulation in a patient that presented with a long history of low back pain (LBP) and muscle dysfunction.

CASE DESCRIPTION

The patient was a healthy 33-year-old male (height, 1.83 m; body mass index, 26.4 kg/m^2), with a 21-year history of LBP and left posterior thigh pain. The patient provided verbal consent for treatment and publication of this care report and the rights of the patient were protected.

History

The initial episode occurred at age 12, with an insidious onset of debilitating low back and left posterior thigh pain that radiated to the ankle. The patient had a spontaneous resolution of the posterior thigh pain approximately 6 months after onset. Since that time, the patient reported recurrent, nondebilitating LBP and occasional left anterior thigh numbness on average twice per year.

Examination

At initial evaluation the patient reported being relatively pain free (between 0 and 1 on a numeric pain rating scale where 0 is "no pain" and 10 is "pain as bad as it can be"), but with a primary complaint of "stiffness" in the lower back. Other notable examination findings included a mild decreased lumbar lordosis in standing and lumbar hypomobility when assessed using central posterior-to-anterior spring testing over the L4 and L5 spinous processes.

During examination in the prone position, the patient was asked to unilaterally elevate the upper extremity with the intention of activating the contralateral lumbar paraspinal musculature.[28] During the prone upper extremity lifting task the patient complained of increased pain in the lower lumbar region and difficulty in completing the task. The examiner noted through palpation and visual observation that the left paraspinal musculature, in the L4-5 region, did not show the same amount of activation when compared to the right paraspinal musculature. Palpation was performed just lateral to the spinous processes of L4 and L5 over the multifidus and medial to the longissimus paraspinal musculature. Additionally, the patient met 3 of the 5 clinical predictors for short-term success with regional lumbopelvic manipulation: a Fear-Avoidance Behavior Questionnaire-Work Subscale (FABQ-W) score of less than 19, no symptoms distal to the knee, and lumbar hypomobility (**TABLE 1**).[11]

Because the patient had complaints of stiffness and met the clinical prediction rule suggesting success with spinal manipulation, our selected primary intervention was spinal manipulation to help determine if it would reduce the patient's complaints of stiffness at the lower lumbar levels.[3,4] To investigate and document potential changes, RUSI was used to observe the lumbar multifidus at L4-5 and L5-S1 both premanipulation and postmanipulation.

Ultrasound Instrumentation and Measurement Technique

Ultrasound images of the lumbar multifidus were obtained using the Sonosite 180 Plus (Sonosite Inc, Bothell, WA) in brightness mode, with a 60-mm, 5-MHz curvilinear array transducer. All measurements were taken by the same investigator, who demonstrated good intrarater reliability ($ICC_{3,3}$ = 0.98; SEM, 0.094 cm)[28,39] for this technique in a symptomatic population.

To measure muscle recruitment, we utilized the prone upper extremity lifting task (**FIGURE 1**). This task was chosen because it allows for an objective measurement of multifidus thickness change and is not dependent on an individual's ability to volitionally contract the deep muscle system, which is known to vary in asymptomatic subjects.[40] The patient was positioned in prone with a pillow under his abdomen to slightly flex the lumbar spine for better imaging, and his shoulders were abducted to approximately 120°. The transducer was placed

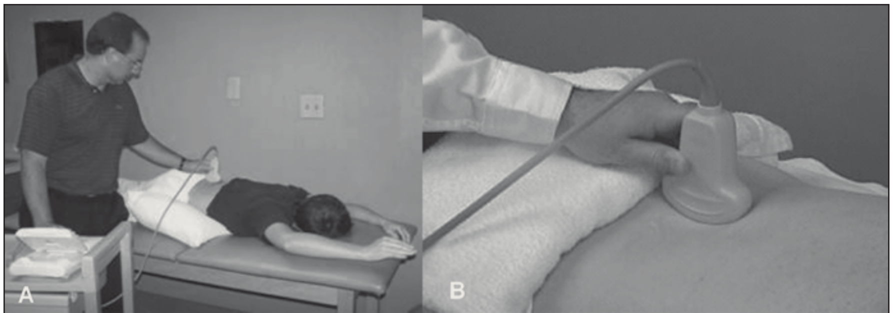

FIGURE 1. Measuring muscle thickness change of the lumbar multifidus with ultrasound imaging during a prone upper extremity lifting task (A), and the transducer orientation (B) used to generate the parasagittal view.

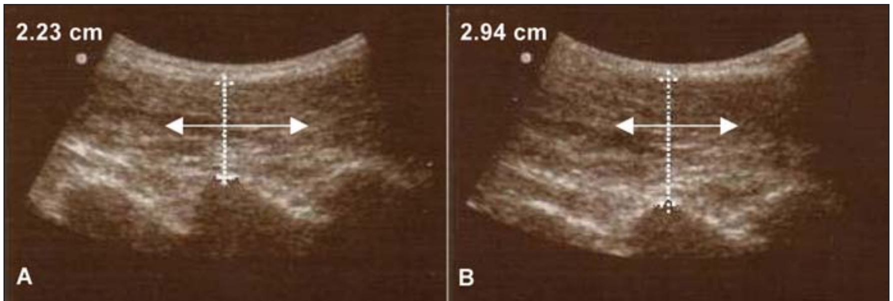

FIGURE 2. Sonogram of a parasagittal view of lumbar spine with the L4-5 facet joint in the center. The dotted line is the on-screen caliper measurement of the multifidus at rest (A) and during activation (B) during the contralateral arm-lifting task. The arrow indicates the direction of the multifidus muscle fibers.

just lateral to midline on the left side over the lower lumbar segments in the sagittal plane (parasagittal view of the lumbar multifidus[47]) and adjusted until an adequate view of the lumbar facet joints was obtained. The patient was then asked to perform the upper extremity lifting task by gently lifting the right arm off the table to induce a contraction of the left lumbar paraspinals.

Measurements from the hyperechogenic "tip" of the facet to the fascial plane between the muscle and subcutaneous tissue were obtained at rest and during the arm-lifting task (**FIGURE 2**) at the L4-5 and L5-S1 levels. Thickness change of the multifidus measured with RUSI during this prone upper extremity lifting task has been shown to correlate ($r = 0.79$) with muscle activation as measured on EMG.[28] Measurements were taken on 3 occasions: premanipulation, immediately postmanipulation, and 1 day later (approximately 24 hours). An average of 3 trials for each testing occasion for the resting and arm-lifting conditions was calculated and expressed as a percent change from rest, using the following equation: $[(activation - rest) \div rest] \times 100$.

The initial measurements confirmed a poor activation of the muscle at the L4-5 level, showing only a 5.7% change in thickness (**TABLE 2**). This is well below the 22% average increase noted by Kiesel et al[28] in asymptomatic subjects performing the same task. The finding of poor activation was even more pronounced at the L5-S1 level, with only a 2.3% change in thickness when lifting the arm.

TABLE 2 Ultrasound Measurements of Lumbar Multifidus Thickness at Rest and During the Upper Extremity Arm-Lifting Task

	At Rest (cm)	During Arm-Lifting Task (cm)	Change (cm)	Change (%)
L4-5				
Premanipulation	2.65	2.80	0.15	5.7
Postmanipulation	2.68	3.23	0.55*	20.5
1 day postmanipulation	2.53	3.19	0.66*	26.1
L5-S1				
Premanipulation	2.65	2.71	0.06	2.3
Postmanipulation	2.56	2.95	0.39*	15.2
1 day postmanipulation	2.51	2.88	0.37*	14.7

** Difference greater than the minimal detectable change (MDC) calculated on previously published data establishing the standard error of measurement for multifidus muscle thickness at 0.09 cm and the MDC at 0.26 cm.*

Intervention

Following confirmation of poor activation of the lumbar multifidus with RUSI, the patient was treated with spinal manipulation. Clinical decision making was guided or assisted by the consideration that the patient met 3 of the 5 clinical predictors for short-term success with regional lumbopelvic manipulation (**TABLE 1**).[11] The initial manipulation performed was a regional lumbopelvic manipulation. This technique was selected because this was the technique used to develop[11] and validate[3] the clinical prediction rule criteria that matched our patient. This technique is also believed to have more of an effect on the lower lumbar and sacral regions of the spine, which is where the patient complained of the lumbar stiffness.

The patient assumed a supine position on the plinth. The patient was then placed into left side bending with right rotation of the torso. Grasping the patient's left scapula while maintaining the side bending, the patient was then rotated towards the therapist. When the pelvis lifted from the table, a HVLA thrust was introduced through the anterior superior iliac spine in an anterior-to-

FIGURE 3. Lumbosacral region manipulation. (Adapted with permission from *Orthopaedic Manual Physical Therapy Management of the Lumbar Spine, Pelvis, and Hip Region* [CD-ROM]. Louisville, KY: Evidence in Motion, LLC; 2002.)

FIGURE 4. Side-lying lumbar manipulation. (Adapted with permission from *Orthopaedic Manual Physical Therapy Management of the Lumbar Spine, Pelvis, and Hip Region* [CD-ROM]. Louisville, KY: Evidence in Motion, LLC; 2002.)

posterior direction (**FIGURE 3**). An audible pop was heard by both the therapist and the patient; but the cavitation may have occurred caudal to the targeted hypomobile vertebral segments, perhaps at the sacroiliac joint.

Because this manipulation technique did not appear to affect the targeted vertebral levels, it was then decided that a different technique would be used to introduce a local manipulative effect at the L4-5 vertebral segment. The patient was placed in the right side-lying position on the plinth. The left hip was flexed until motion was palpated at the interspinous space at L4-5. The torso of the patient was then rotated left until motion was again felt at the same space. With the patient in proper position, the therapist provided a HVLA rotational thrust of the pelvis anteriorly and inferiorly (**FIGURE 4**). An audible pop was heard by both the therapist and patient; however, the cavitation may have occurred higher on the lumbar spine than was intended. No further manipulation was performed.

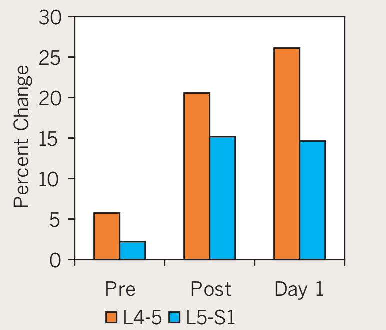

FIGURE 5. Percent change in multifidus thickness. Graph represents the percent change for the lumbar multifidus at the L4-5 and L5-S1 levels before the manipulation was performed (Pre), immediately after the manipulation (Post), and approximately 24 hours after the manipulation (Day 1).

Following the second manipulation, the patient was immediately repositioned prone on the table and the postmanipulation measurements with ultrasound imaging were captured using the previously described protocol. Care was taken to place the transducer head in the exact location that was used to capture the premanipulation images. The patient was sent home without a home exercise program, though instructed to remain active. The following day, approximately 24 hours from the first RUSI measurements, the patient was reassessed using the same protocol described above.

OUTCOMES

A change in the multifidus thickness at rest and during the upper extremity lifting task at both the L4-5 and L5-S1 levels was noted immediately postmanipulation and maintained when measured approximately 24 hours later. A summary of the thickness measurements and rest-to-activation differences are provided in **TABLE 2**. The percent change values for premanipulation, postmanipulation, and 1 day postmanipulation are compared in **FIGURE 5**.

Based on a previously reported standard error of the measurement (SEM) for measurements of multifidus muscle thickness with ultrasound imaging of 0.094 cm, the minimal detectable change (MDC_{95}) was calculated as follows: $SEM \times \sqrt{2} \times 1.96 = 0.26\ cm$. This value indicates that one would be 95% confident that any difference greater than 0.26 cm would reflect true difference or change (ie, treatment effect).[1,9]

Our patient demonstrated changes greater than the MDC at both L4-5 and L5-S1 on both postmanipulation measurements. The change was most pronounced at L4-5. An additional observation was a decreased resting thickness of 0.12 cm at the L4-5 level and 0.14 cm at L5-S1 level 1 day postmanipulation; however, these changes did not exceed the threshold to ensure the changes were not secondary to measurement error.

The changes in muscular function noted after manipulation were also accompanied by clinically relevant improvements. An immediate visual and palpable improvement was noted in the contraction of the multifidus during the upper extremity lifting task, along with the patient report of increased ease of lifting. Further, the patient's primary complaint of stiffness was resolved.

DISCUSSION

The patient in this case report demonstrated a dramatic change in the ability to activate the multifidus during a prone upper extremity lifting task immediately following spinal manipulation. Further, this improvement in multifidus activation was associated with improvements in other clinical exam findings. These results are similar to those reported by Gill et al,[14] who found improvements for activation of the TrA muscle immediately following spinal manipulation, and reaffirms the value of using RUSI to investigate and document in vivo neuromuscular changes in spinal muscle activation following manipulation.

Normative data on multifidus thickness change as a result of specific tasks is lacking. But in our previous work[28] we have found an average thickness change of 22% at the L4-5 level in asymptomatic subjects during the same prone arm-lifting task used with this patient. The small thickness change averages across both L4-5 and L5-S1 levels noted in our patient premanipulation (3.6%) represents gross muscle dysfunction, with the postmanipulation changes approximating normal activation (17.2% immediately after manipulation and 20.6% approximately 24 hours later [**FIGURE 5**]). Our case report adds value to the literature in describing the application of RUSI to measure changes in muscle size of the posterior spinal musculature postmanipulation and documenting changes up to 24 hours postmanipulation.

There are a number of proposed mechanisms of action for spinal manipulation and the investigation of these biological underpinnings is important to the overall acceptance of this treatment approach among other healthcare professionals, policy makers, and the public.[25,35] Presently, the major mechanisms considered to have biologic potential to provide a treatment effect include biomechanical changes,[25] neurophysiologic[35] or reflexogenic changes,[16] neuroendocrine changes,[35] circulatory changes,[17] and immune system responses.[35] In this case report we investigated the potential of RUSI to document possible neurophysiologic effects on the multifidus muscle after spinal manipulation. Our efforts directly support the research guidelines developed in the 2005 Conference on Biology of Manual Therapies, specifically to "develop imaging techniques that can be used to capture dynamic in vivo responses to biomechanical signals in healthy and nonhealthy tissues."[25] We believe that RUSI offers a unique imaging modality to investigate these in vivo changes and further our knowledge of the underlying mechanisms involved in spinal manipulation.

Neurophysiological and Reflexogenic Mechanisms

Neurophysiologic degradation in muscle performance most likely stems from pain-mediated inhibition and/or reflexogenic (reflex-mediated) inhibition.[35] Spinal manipulation is thought to exert an effect on the inflow of sensory information to the central nervous system.[35] It is theorized that spinal manipulation reduces input from receptive nerve endings in innervated paraspinal tissues, including skin, muscle, tendons, ligaments, facet joints, and innervated disc, influencing pain-producing mechanisms as well as other physiological systems controlled or influenced by the nervous system. Researchers have found that spinal manipulation increases pain tolerance and/or pain thresholds[8,30,35]; however, because this patient had minimal complaints of pain, we did not consider the resolution of pain inhibition to be the primary explanation for improved muscle activation.

Alternatively, the reflexogenic effect might best explain the positive results observed in muscle activation for our patient. The reflexogenic effect via spinal manipulation refers to the evoking of paraspinal muscle reflexes (likely from muscle spindles), which alters central or peripheral neural pathways.[6,35] These changes have been shown to either increase or depress motoneuron excitability.[8,10,33] Our case may demonstrate an increase in excitability at the end organ. Similar to improved muscle activity in our investigation, Herzog et al[17] showed that posterior-to-anterior spinal manipulation treatments aimed at the cervical, thoracic, lumbar, and sacroiliac regions resulted in increased or excitatory paraspinal EMG activity in the region that was manipulated. It is unknown how long an effect may last, but it is generally considered to be very short term. Interestingly, in our case, evidence of increased activity was observed almost 24 hours later. In addition to the excitatory effect, further research should investigate if the possible trend noted in decreased resting thickness of the TrA postmanipulation represents an overall attenuation of signals, which may represent a decrease in baseline muscle activity. The same observation has been made in other studies.[14,29] It is important to stress that the theories behind neurophysiologic mechanisms are complex and the reader is guided to an in-depth review for further information.[35] Though a cause-and-effect relationship cannot be suggested in our findings, we propose that a reflexogenic effect offers the most reasonable explanation for the changes in muscle thickness observed with RUSI.

RUSI Considerations

RUSI has been shown to be a reliable and valid method to measure muscle size and architectural change of pelvic floor,[7] TrA,[26,32] rectus abdominis,[37] and tibialis anterior.[23] The majority of the RUSI literature to date related to the lumbar multifidus has been focused on measuring cross-sectional area.[5,18,20] The parasagittal view used in this case has been described in the literature as being used for real-time biofeedback to augment learning of volitional contraction of the lumbar multifidus.[20,40] Kiesel et al[28] reported the reliability of the parasagittal measurement ($ICC_{3,1}$ = 0.85) and ($ICC_{3,1}$ = 0.80) in asymptomatic subjects, but the SEM was not reported. The reliability results reported earlier ($ICC_{3,3}$ = 0.98; SEM, 0.094 cm) are from an ongoing clinical trial on patients with acute LBP where the average of 3 measures is being utilized.[27] Averaging 3 measures has been shown to decrease the SEM when RUSI was used to measure lateral abdominal wall muscular thickness change.[49] Further study is needed to establish the reliability of this measure among raters.

In addition to established reliability, muscle thickness change as measured by RUSI has been validated as a measure of muscle performance for the pelvic floor,[7] TrA,[26,32] rectus abdominis,[37] and lumbar multifidus using the same prone upper extremity lifting task[25] used in this case. Although an increase in the ability to thicken the muscle has been associated with increased muscle activation, there are other factors that may have influenced our observations. It is possible that the multifidus thickness observed following manipulation could have been secondary to forces applied by the surrounding musculature on the multifidus during the upper extremity lifting task. These changes may not have been recognized when measured with an anterior-to-posterior measurement; however, this problem could potentially be eliminated by including medial-to-lateral measurements in future investigations.

A limitation in assessing muscle activation with RUSI is that only morphologic changes are observed; information about the potential altered timing of the paraspinal activation is not readily available with conventional RUSI. However, researchers using specialized high-frequency ultrasound imaging have been able to investigate the timing of muscle contraction in the paraspinals.[48] Though we did not investigate any potential timing changes in multifidus contraction postmanipulation, a recent EMG study has demonstrated altered timing in muscle contraction of the TrA following manipulation of the sacroiliac joint.[31]

Manipulation Considerations

In this patient, the perceived location of cavitations following manipulation (above and below the targeted area) by both patient and therapist seemed to have no bearing on the improved activation of the lumbar multifidus. In fact, recent studies have questioned the accuracy and relevance of cavitations with lumbar manipulations.[2,40] Ross et al,[40] utilizing accelerometers secured to the skin, reported an accuracy rate of only 46% when attempting to target a specific lumbar segment with manipulation. He also reported an average error from target of 1 vertebral segment and concluded that manipulation in the lumbar spine is generally not accurate. Additionally, several authors[2,12,13] found no statistical or clinically important differences in outcomes between patients who experienced an audible pop and those who did not with a specific lumbar manipulation technique. As we observed in our patient, changes at the targeted level were noted, irrespective of where the cavitations were thought to have occurred.

In this case report, the patient described an immediate improvement in the ease of movement during the upper extremity lifting task following manipulation. These findings may be similar to those reported by O'Sullivan et al,[34] who found that providing pelvis stability via manual compression through the ilia improved motor control and ultimately improved performance during an active straight-leg-raise test. It is possible that improved motor control following manipulation aided our patient during the upper extremity lifting task.[38] The results of this study, however, do not suggest that manipulation definitively restores motor control. Future research should address if manipulation has an initial influence that may assist in achieving long-term rehabilitation goals and resolving long-standing dysfunction.

Further research is indicated to compare the influence of spinal manipulation on lumbar multifidus function in those with and without lumbopelvic dysfunction. Additional research into alternate manipulation techniques, the effects of nonthrust mobilization versus thrust manipulation, and the effects of manipulation on the activation of other muscles in the lumbopelvic region is needed.

CONCLUSION

In this patient with a history of chronic LBP, lumbar stiffness, and difficulty in activating the lumbar multifidus an increase ability to activate the lumbar multifidus at the L4-5 and L5-S1 levels was found immediately following spinal manipulation. Further, this improvement was maintained over a 24-hour period. No cause-and-effect claims can be made. However, this case report provides preliminary evidence to suggest that spinal manipulation may influence multifidus muscle function. RUSI offers a convenient way to investigate and document these changes. ◉

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