Immediate Effect of Lumbar Mobilization on Activity of Erector Spinae and Lumbar Multifidus Muscles

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ABSTRACT

Objective: The purpose of this study was to investigate the effect of grade IV lumbar mobilization on the activity/contraction of erector spinae (ES) and lumbar multifidus (LM) muscles in healthy people.

Methods: A randomized, repeated-measures design was used. Sixteen healthy subjects attended 3 testing sessions with a different intervention in each session (no intervention, grade IV central lumbar mobilization at L4, and placebo/light touch). Lying in a prone position, subjects lifted a light weight with their right arm while ultrasound images of LM and surface electromyography signals of ES were captured before and immediately after application of the intervention in the session. The contraction of LM was calculated from US images, and the root mean square was calculated from the electromyography signals of ES and used as outcome measures.

Results: A significant difference was found in LM contraction between the placebo and mobilization intervention (difference = 0.04, $P = .02$). There was no difference for the root mean square of electromyography signals between the interventions.

Conclusion: The significant difference in LM contraction was small and may not have clinical significance. Lumbar mobilization did not change the activity of ES in healthy people. Future studies with larger samples are needed to confirm our findings and to investigate the effect of mobilization on back muscles in people with low back pain. (J Chiropr Med 2017;16:271-278)

Key Indexing Terms: *Lumbar Vertebrae, Spine; Musculoskeletal Manipulations*

INTRODUCTION

Lumbar mobilization is a common manual therapy technique used to decrease low back pain (LBP) and increase lumbar spine range of motion.¹ During mobilization, the clinician's hands produce oscillatory movements of a specific

grade (grades I-IV) to a single vertebra of the lumbar spine.¹ The underlying mechanisms of joint mobilization are still unclear. Joint mobilization may induce several physiological responses including pain reduction, improved joint mobility, hypoalgesia, and change in muscle activity/contraction.² It has been proposed that joint mobilization stimulates mechanoreceptors in the joints and muscles, which may alter muscle activity by stimulating α -motor neurons at the spinal level³ and the neurons of the periaqueductal gray in the midbrain.²

The effect of spinal mobilization on muscle activity has an important clinical implication. Both LBP⁴⁻⁹ and neck pain¹⁰⁻¹² are associated with abnormally high activity of the superficial spinal muscles and low activity of the deep stabilizing spinal muscles. This abnormal activity of the spinal muscles might affect the patient's ability to move optimally and lead to further pain and functional limitation.^{12,13} For example, the lumbar multifidus (LM) is a primary stabilizing muscle of the lumbar spine, and LM dysfunction is associated with recurrent LBP.¹⁴ Similarly, increased activation of the superficial spinal muscles of the erector spinae (ES) may lead to increased intraarticular compression of spinal joints.¹³ Thus, normalization of the activity of spine muscles is important for pain reduction and optimal function.

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To our knowledge, there are no published studies on the effect of lumbar mobilization on the activity of back muscles in people with LBP. However, in people with neck pain, high grades of mobilization (grades III and IV) were found to decrease the impairment in cervical muscle activity.^{15,16} Grade III cervical mobilization increased activation of deep cervical flexor muscles, but decreased the activation of superficial cervical flexor muscles,¹⁶ and grade IV cervical mobilization increased contraction of the deep cervical flexor muscles.¹⁵ These findings suggest that spinal mobilization may correct the abnormal activity of spinal muscles in the presence of spinal pain. However, it is not clear if the reported changes are dependent on the hypoalgesic effect of spinal mobilization or have an independent effect on muscle activities. Studying the effect of mobilization on healthy subjects is 1 way to investigate the potential effects of spinal mobilization directly on the activity of spinal muscles in the absence of pain.

The effect of joint mobilization on the activity of spinal muscles in healthy subjects has been investigated in only a limited number of studies with contradicting findings. One study reported decreased activity of ES muscles after grade IV lumbar mobilization¹⁷ in healthy subjects. In contrast, another study reported no change in the activity of superficial neck flexor muscles after grade III cervical mobilization in healthy subjects.¹⁸ From these limited previous findings, it is unclear if mobilization can change muscle activity in the absence of pain.

The purpose of this study was to investigate the effect of lumbar mobilization on back muscle activity in healthy subjects. This study is the first to examine the effect of lumbar mobilization on both superficial muscles of the ES and deep muscles of the LM. Studying the effect of lumbar mobilization on the activity of back muscles in healthy subjects may lead to a better understanding of the underlying mechanism of mobilization, and will improve our knowledge about the effects of mobilization on lumbar muscle activity in the absence of pain.

We hypothesized that lumbar mobilization would increase the activity of the LM and decrease the activity of the ES. This hypothesis is based on previous findings suggesting increased activity of the ES and decreased activity of the LM in LBP.^{9,19,20} The hypothesis is also based on findings from previous studies in people with neck pain, in which higher grades of mobilization (grades III and IV) increased the activation of deep cervical flexor muscles, but decreased the activation of superficial cervical flexor muscles.^{15,16} Both the cervical spine and lumbar spine have many anatomical and physiological similarities.

METHODS

Subjects between the ages of 18 and 50 years with no history of LBP in the last 6 months were included in the

study. Subjects with body mass index $>30 \text{ kg/m}^2$, any reported bony or joint pathology affecting lumbar spine (eg, osteoporosis), lumbar/sacral deformities (eg, spondylolisthesis), spinal surgery, and pregnancy were excluded. Before initiation of the study, approval was obtained from the internal review board at the University of Kansas Medical Center. All subjects consented prior to testing. Subjects' physical activity was assessed using the long version of the International Physical Activity Questionnaire.²¹

Each subject attended 3 sessions, which were 3–4 days apart. During the first session, no intervention was applied, which served as the control. During the second and third sessions, grade IV central lumbar mobilization and placebo (light touch) interventions were applied to lumbar segment 4 (L4) in random order. In each session, the subject lifted a light weight (1.5–2 lb) with the right arm before and immediately after each intervention (no intervention, placebo, or mobilization). Ultrasound (US) images of LM and surface electromyography (EMG) signals of ES were captured during the arm lift task. Muscle contraction from US images and root mean square (RMS) values of EMG signals were calculated and used as the outcome measures.

Arm Lift Task

Subjects were placed in prone position with the lower back exposed and legs shoulder width apart. An inclinometer was used to measure the lumbosacral angle. If the angle was greater than $>10^\circ$, 1 or 2 pillows were used under the abdomen to flatten the lumbar curve to $<10^\circ$, to standardize contact with the US transducer.²² Subjects' right elbows were flexed to approximately 90° , and right shoulders were abducted to approximately 120° .²³ A goniometer was used to measure the elbow and shoulder angles. Then, subjects were asked to lift a specific amount of weight (1.5–2 lb) with their right hand to elicit 30% of the maximal voluntary contraction of LM.²³ Subjects lifted the weight by raising their arm up until their right elbow touched the horizontal head piece of the stadiometer (at 5 cm height), and held their arms at that height, to induce isometric contraction, for 3 seconds. Subjects were instructed to keep their elbow and wrist at the same horizontal level during the arm lift. The subjects repeated the arm lift task 3 times before and immediately after each intervention.

Ultrasound Imaging

A Logiq P5 US (GE Healthcare, Milwaukee, Wisconsin) with a 60-mm curvilinear array transducer and a frequency of 5 MHz was used to capture the US images. Images of the LM were taken from the left side of the lower back at the L4–L5 level. The spinous process of L4 was palpated and marked. The US transducer was placed in sagittal orientation just lateral to the spinous process and angled medially to clearly visualize the sacrum and the left L4–L5

facet joint in the image. Ultrasound images were captured immediately before the arm lift task and during the isometric contraction of the arm lift task.

The same therapist captured and measured the US images for all subjects. The therapist had a rehabilitative US imaging training and conducted a reliability study on 15 subjects prior to this study, in which the therapist was found to have excellent intra-rater reliability in measuring US images (intraclass correlation coefficient = 0.85, standard error of measurement = 0.04, and minimal detectable change [MDC] = 0.10).²⁴

Electromyography

A Bagnoli Desktop EMG system was used. The system collects EMG signals at a bandwidth of 20-450 Hz. The EMG electrodes had 10-mm contact spacing and a 100-mm² detection area. The EMG procedures were performed by the same experimenter and followed SENIAM (Surface Electromyography for the Noninvasive Assessment of Muscles) standards.²⁵ The skin of each subject's back was cleaned with alcohol and allowed to dry before placing the EMG electrodes. These electrodes were placed 3.5 cm lateral from the lumbar spine spinous processes.¹⁷ Two electrodes were placed at the level of the first lumbar vertebra (L1) on each side (ES_L1_Left, ES_L1_Right), and 1 electrode was placed at the level of the fourth lumbar vertebra (L4) at the right side (ES_L4_Right). L1 and L4 spinous processes were palpated and marked using 2 landmarks, the iliac crest for identification of L4 spinous process, and the 12th rib for identification of L1 spinous process. The reference electrode was placed on the sacrum.²⁶ To collect and save the data from the EMG system, a data acquisition program was used (Labview 2012, National Instruments, Austin, Texas). The EMG data were collected at a frequency of 1000 Hz.

For normalization purposes, EMG signals were collected during a back-lift task that induced submaximal contraction of ES. At the beginning of each session, the subjects lifted their back from a prone position until the spine of their scapulae touched the horizontal piece of the stadiometer (approximately 5 cm away from their thorax) and held their back at that height for 3 seconds. The EMG signals from both tasks (back lift and arm lift) were recorded from rest to the end of the contraction.

Interventions (No Intervention, Placebo, and Mobilization)

All interventions were applied for 5 minutes. During the first session (no intervention), no contact was made with the subject's back. During the second and third sessions, the placebo and grade IV lumbar mobilization interventions were applied in random order. The placebo (light touch) was performed by the therapist's placing his or her hand at the L4 vertebra. Manual therapy techniques including

mobilization had been shown to have a placebo effect, and thus, it is recommended that a placebo group/intervention be included in manual therapy studies.²⁷ Therefore, we included a placebo intervention in the form of light touch to distinguish any true changes in muscle activity after mobilization. To our knowledge, no previous studies have investigated the effect of touch/light pressure placebo on muscle activity. However, Kinesio Tape, another type of light contact pressure, was found to have no effect on muscle strength/activity.²⁸ Grade IV mobilization was used because previous studies had shown some effect of higher grades of mobilization (grades III and IV) on spinal muscle activity.^{15,16}

The mobilization included grade IV mobilization using the pisiform grip and was applied 4 times, each with 60 seconds of oscillation and 20 seconds of rest in between, to match the standard dose of mobilization in clinical settings. A force plate (Bertec Force Plate, Columbus, Ohio) was used to standardize the amount of force by providing live visual feedback to the therapist on the amount of mobilization force applied. The therapist who applied the mobilization has 13 years of experience as a physical therapist in clinical and academic settings. The therapist also captured and measured the ultrasound images during the study. While applying mobilization, the therapist stood on the force plate and applied consistent mobilization oscillating forces with a maximum force of 180 N, amplitude of 30 N, and frequency of 1 Hz. The mobilization was applied consistently at 1-Hz frequency using a metronome. The sampling frequency of the force plate was 100 Hz. The collection, display, and storage of the force plate data were implemented by using a second Labview program (Labview 2012).

Data Analysis

The LM muscle thickness from the US images was measured with ImageJ software.²⁹ The thickness of the LM was measured as the distance between the most posterior portion of the facet joint and the fascial plane, as visualized by the hyperechoic line between the muscle and subcutaneous tissue³⁰ (Fig 1). The percentage thickness change (contraction) in the LM was calculated using the following equation²³: % thickness change of LM = (LM thickness at contraction – LM thickness at rest)/LM thickness at rest × 100.

A MATLAB program was used to analyze the EMG signals from both the back lift and arm lift tasks. First, the EMG signals were filtered using a bandpass filter of 30-400 Hz (Butterworth, second order). Second, the signals were filtered with a notch filter (Butterworth) at frequencies of 60, 120, and 180 Hz to eliminate electrical noise. Third, the signals were smoothed using RMS with an RMS window size of 20 ms. Fourth, the contraction onset was identified only for the ES_L1_Right electrode. The contraction onset was considered the time when the signal exceeded a

Fig 1. Measurement of lumbar multifidus muscle thickness from ultrasound images. The yellow line represents the measurement (lumbar multifidus muscle thickness) from the ultrasound image.

threshold of the mean plus 2 standard deviations away from its baseline for more than 25 consecutive samples.³¹ Fifth, the RMS for the EMG signals was selected for the middle second of the 3-second isometric contraction (1 second after the onset of muscle contraction). Finally, the RMS values from the arm lift task were normalized to the RMS from the back lift task and used for statistical analysis.

Statistical Analysis

The normalized RMS of the ES and the contraction of the LM were averaged across the 3 trials of the arm lift task in each session. Then, the averaged values for the ES at L1 on both sides (left and right) were averaged. As a result, 3 outcomes emerged: the normalized RMS at L1, the normalized RMS at L4, and the contraction of LM. The change in outcomes (outcome at the end of the session –outcome at the beginning of the session) within the session was used in the final analysis.

SAS statistical software was used for statistical analysis. Wilcoxon signed-rank tests were carried out for the 3 outcomes to test the null hypothesis of zero median difference. Because

of the pilot nature of the study, no correction was made for conducting Wilcoxon tests several times.

RESULTS

Sixteen subjects (9 males and 7 females, age 26.8 ± 4.8 years, body mass index 23.4 ± 3.2) participated in the study. Most subjects had a high activity level as measured by the International Physical Activity Questionnaire (12 high, 3 moderate, and 1 low activity level). The EMG system had malfunctioned and failed to collect data for 1 subject. The US data for that subject were included in the analysis.

The mean and standard deviation for each outcome are presented in Table 1. Median differences between placebo and mobilization for the ES L1, ES L4, and LM US were 0.029, 0.061, and 0.041, respectively. In terms of standard deviations (SD) (computed from placebo measurements), these median differences represent increases of 0.39, 0.58, and 1.05 SDs. Wilcoxon signed-rank tests revealed that the effects on the activity of the ES at L1 and L4 were not statistically significant

Table 1. Differences in the Outcomes in Each Session^a

	EMG_L1 (n = 15)				EMG_L4 (n = 15)				LM contraction (n = 16)			
	After		Δ	Mean $\pm$ SD (CI)	After		Δ	Mean $\pm$ SD (CI)	After		Δ	Mean $\pm$ SD (CI)
	Baseline	Intervention			Baseline	Intervention			Baseline	Intervention		
No treatment (control)	0.59 $\pm$ 0.20	0.60 $\pm$ 0.23	0.01 $\pm$ 0.06 (−0.02 to 0.05)	0.58 $\pm$ 0.26	0.61 $\pm$ 0.30	0.03 $\pm$ 0.07 (−0.01 to −0.07)	0.17 $\pm$ 0.06	0.18 $\pm$ 0.08	0.01 $\pm$ 0.05 (−0.02 to −0.03)			
Placebo	0.65 $\pm$ 0.38	0.66 $\pm$ 0.36	0.01 $\pm$ 0.07 (−0.03 to 0.05)	0.63 $\pm$ 0.49	0.63 $\pm$ 0.48	<0.01 $\pm$ 0.11 (−0.06 to 0.06)	0.19 $\pm$ 0.08	0.16 $\pm$ 0.07	−0.03 $\pm$ 0.06 (−0.07 to −0.00)			
Mobilization	0.65 $\pm$ 0.33	0.65 $\pm$ 0.33	<0.01 $\pm$ 0.18 (−0.10 to −0.10)	0.57 $\pm$ 0.33	0.58 $\pm$ 0.37	0.01 $\pm$ 0.16 (−0.08 to 0.10)	0.16 $\pm$ 0.06	0.17 $\pm$ 0.08	0.01 $\pm$ 0.05 (−0.01 to −0.04)			

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Δ , difference in outcome between baseline and after intervention; CI, 95% confidence interval of mean difference in outcome between baseline and after intervention; EMG, electromyography; LM, lumbar multifidus; SD, standard deviation.

^a The EMG outcomes represent the normalized root mean square of the EMG signals (normalized to submaximal contraction). The LM contraction represents the percentage change in muscle thickness between rest and contraction states.

($P = .45$ and $.28$, respectively), whereas the effect on the LM contraction was ($P = .02$). We also tested differences between the no-intervention and mobilization conditions, and none was statistically significant.

DISCUSSION

The purpose of the study was to investigate the effect of grade IV lumbar mobilization on back muscle activity in healthy people to gain a better understanding of physiological effects of mobilization in the absence of pain. Ultrasound imaging of the LM muscle and EMG of the ES muscles were used to investigate this effect. A significant difference in LM contraction was found between the placebo and the mobilization.

This is the first study to investigate the effects of lumbar mobilization on both deep (LM) and superficial (ES) back muscles in healthy subjects. Our results suggest that grade IV mobilization may be used to improve LM contraction, although the effect was small. These results also improve our knowledge of the mechanism underlying mobilization, adding to a wider application of lumbar mobilization. The LM muscle is a primary stabilizer muscle of the lumbar spine and has been found to have altered activation in LBP; many manual and therapeutic interventions are targeted to decreasing the risk of LBP and improving spinal stability in people with LBP.

No significant differences were found in EMG activity between the 3 interventions in healthy subjects. These findings are in line with the findings of Soon et al,¹⁸ who found no significant changes in the EMG activity of cervical muscles after grade III cervical mobilization in subjects with no neck pain. However, this result contradicts other previous studies reporting effects of hip, thoracic, and lumbar mobilization on subjects with no pain.^{17,32-34} These studies suggested that mobilization can alter the firing of mechanoreceptors, which can change muscle activity through arthrokinetic reflex.³²⁻³⁴ The discrepancy in findings may be explained by the differences in the protocols and the joints tested. Most of the previous studies³²⁻³⁴ tested the maximum torque/strength of the muscles, whereas our study tested the activity of the muscles at submaximal contraction. The submaximal contraction used in this study might not challenge the muscles sufficiently, and therefore no change in muscle activity was observed after mobilization.

Only 1 previous study¹⁷ detected significant changes in EMG activity of the ES muscle at submaximal contraction in healthy subjects after lumbar mobilization. In that study,¹⁷ ES muscle activity was tested at quiet standing (standing still with no movement). The discrepancy in the findings between the previous study and our study might come from the different sites of mobilization application and different testing tasks. The previous study¹⁷ found that the mobilization effect on muscle activity is larger at the mobilized segment than at other segments of lumbar spine. It is possible that changes in EMG

at the L1 level were not detected in this study because the L1 is far from the mobilized segment (L4), and that a change could not be detected at the L4 level because of the low activity level of the task. Furthermore, the testing task in the previous study¹⁷ was quiet standing, whereas in our study we used the arm lift task while the subject was lying prone. The quiet standing task is a slow postural task, whereas the arm lift task in our study is a faster active task. The arm lift task was more suitable for our study design as we collected US imaging to detect contraction of the LM; the arm lift task is considered a standard task with reported validity and reliability for capturing US images of the LM muscle.^{23,24} The different testing positions and tasks might have contributed to the discrepancy in the findings between the 2 studies.

A statistically significant difference in LM contraction between the placebo and mobilization sessions was found. However, the difference was very small; only a 4% median difference was found. Such a small difference may not have clinical significance. Despite the fact that US imaging is a reliable method for indirectly measuring LM contraction, the relative MDC of US imaging for LM muscle contraction has been reported to be 10%-13%.^{24,30,35}

There was no significant difference in LM contraction between the no intervention and mobilization sessions. This result is consistent with a dissertation project conducted by Lim,³⁶ in which neither mobilization nor manipulation changed LM contraction in healthy subjects. Several factors could have contributed to this negative finding. First, the subjects did not have LBP, and 15 of 16 subjects had a moderate to high physical activity level. Unlike people with LBP, healthy subjects do not have muscle inhibition from pain or weakness in their LM muscle.^{5,6,9,20,37} It might be that an effect of mobilization on activity/contraction of back muscles is not possible when motor function is intact or in the absence of pain. Second, US imaging may not be sensitive enough to detect small changes in LM contraction because of the large MDC of US imaging. Third, a single session of mobilization may not be enough to elicit changes in the activity of back muscles in a healthy population.

Limitations

The sample size for this study was small, and most of our subjects were active and young, which limits generalization of the results. The arm lift task used in this study may have not sufficiently challenged the subjects' back muscles. However, the arm lift task is considered the standard task and has consistently been used in previous US imaging for examination of the LM. Furthermore, US imaging may not be sensitive enough to detect small changes in LM contraction because of relatively large MDC for LM (10%). Therefore, the finding of small (4%) differences in

LM contraction between the mobilization and placebo interventions should be considered with caution.

Future studies may investigate the effect of lumbar mobilization on back muscles at maximal isometric contraction in healthy people and at either maximal or submaximal contraction in people with LBP. Furthermore, future studies may investigate the effect of several sessions of mobilizations on the activity of back muscles, as restoration of ES and LM muscle activity is important for optimal function and pain control. Needle EMG has higher sensitivity than US imaging and may be used to detect the activity of the LM muscle. Lumbar mobilization might have the potential to increase LM activity and strength, which may be beneficial in decreasing the risk of LBP in healthy subjects and increasing the stability of the spine in people with LBP.

CONCLUSION

This study suggests that lumbar mobilization may not result in clinically significant changes in the activity of back muscles at submaximal contractions in healthy people. Future studies should consider more sensitive methods to detect the activity of back muscles or exertions that require higher submaximal or maximal contractions.

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

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Practical Applications

- Lumbar mobilization may decrease pain and stiffness but not increase muscle activity in the back region.

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