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Effects of Lumbar Mobilization on the Paravertebral Muscle Activity and Muscle Tone in Patients with Lumbar Spinal Stenosis

Background: Patients with lumbar spinal stenosis show abnormal changes in muscle activity due to pain and limited range of motion of the lumbar spine. Excessive increased muscle tone and decreased muscle activity patterns threaten the patients' quality of life. However, there have been a few studies showing how to improve muscle performance in patients with lumbar spinal stenosis. Among these, joint mobilization is one way of improving muscle performance through pain relief and increasing the range of motion.
Objectives: To investigate the effect of lumbar mobilization by orthopedic manual physical therapy on paravertebral muscle activity and tone in patients with lumbar spinal stenosis.
Design: A randomized controlled trial.
Methods: In this study, 24 patients with lumbar spinal stenosis were randomized (1:1 ratio) into two groups. The experimental group underwent lumbar posteroanterior mobilization, and the control group underwent conventional physical therapy (conventional transcutaneous electrical nerve stimulation) for 15 minutes each. For outcome measures, Myoton®PRO was used to evaluate muscle tone when resting of the paravertebral muscle in the pain area. For muscle activity evaluation, the reference voluntary contraction of the paravertebral muscle was evaluated using surface electromyography.
Results: Muscle tone and activity were significantly improved after intervention in both the experimental and control groups. In addition, the experimental group showed more significant decrease in muscle tone and activity than the control group.
Conclusion: These results suggest that lumbar mobilization improving muscle performance in patients with lumbar spinal stenosis.

Keywords: *Lumbar spinal stenosis, Joint mobilization, TENS, Muscle tone, Muscle activity*

Junhyeok Go, PT, PhD[a], Hojung An, Prof., PhD[b]

[a]Department of Physical Therapy, Kyungbok University, Namyangju, Republic of Korea
[b]Department of Physical Therapy, Dongnam University, Suwon, Republic of Korea

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Address for correspondence
Hojung An, Prof., PhD
Department of Physical Therapy, Dongnam Health University, 50, Cheoncheon-ro 74, Jangan-gu, Suwon-si, Gyeonggi-do, Republic of Korea
Tel: *** - **** - ****
E-mail: ans628@dongnam.ac.kr

INTRODUCTION

Lumbar spinal stenosis is a multifactorial condition with a prevalence of 27.2%, in which the nerves are encroached and compressed by the surrounding bones and soft tissues.[1] It is diagnosed using radiography and is characterized by muscle weakness in the lumbar and lower limb areas.[2,3] Core stability exercises are generally known to increase muscle activity,[4] and as the activity of the surrounding muscles has a critical role in the symptoms of lumbar spinal stenosis; the prevalence of the disease increases among individuals who don't practice core exercises.[5]

In the current clinical setting, the non-surgical treatments for the improvement of lumbar spinal stenosis symptoms include physical therapy, chiropractic, nonsteroidal anti-inflammatory drugs, epidural injection, and analgesics, and surgical methods include spinal decompression.[6] Among these options, the surgical treatment is more frequently used in

clinical practice for patients with lumbar spinal stenosis, but according to previous studies, 70% of patients after surgery showed no change in symptoms, while 15% showed improvement and 15% showed aggravation.[7] Thus, an approach based on physical therapy is necessary as a therapeutic option for stable functional recovery to avoid relying too much on surgical management.[8]

Such physical therapy approaches include joint mobilization and transcutaneous electrical nerve stimulation (TENS).[9] Joint mobilization is a method that can be applied through the patient's active performance of the lumbar area muscles within the range of motion and with the assistance of a therapist.[10] TENS, on the contrary, is a noninvasive peripheral nerve stimulation technique that activates the transcutaneous nerve.[11] Joint mobilization and TENS are both applied for improving pain, gait ability, daily activities, and physical functions in patients with lumbar spinal stenosis; however, only a few studies have investigated their effects on muscle tone or activity.[9,12]

Thus, this study aimed to compare the effects of joint mobilization and TENS on the muscle tone and activity in the lumbar area of patients with lumbar spinal stenosis to provide the clinical background for its management and treatment.

SUBJECTS AND METHODS

Subjects

The patients in this study were the outpatients from the D-hospital and S-hospital in Seoul, South Korea, who had been diagnosed with lumbar spinal stenosis based on magnetic resonance imaging. A detailed explanation of the study purpose was given to the patients, and they provided a signed written consent for participation. The G power program was used to estimate the sample size with a total of 24 patients, at an effect size of .5, a significance level of α=.05, and a statistical power of .85. Using the Excel program, the 24 patients were randomized into two groups: the joint mobilization group (JMG, 12 patients) and the TENS group (TENSG, 12 patients). For both the groups, the pre-intervention muscle tone and activity were measured, and the post-intervention values were measured 15 minutes after intervention. The general characteristics of the patients are presented in Table 1. This study approved by the institutional review board of Yong-in University: No. 2-1040966-AB-N-01-20-1812-HSR-124-10.

Measurement Apparatus

Muscle tone

To assess the muscle tone in this study, the Myoton ®PRO was used as the tool to measure the frequency based on the repulsive force of the skin and muscle tissues through probe vibration.

The patients were guided to lie comfortably on a bed, and based on the spinous processes of the lumbar vertebrae, a mark was made on the erector spinae muscle belly at 3 cm to the area where the main symptoms were reported. The Myoton probe was held in a vertical position as the measurements were taken.[13] For accurate data collection, any pressure on the surrounding skin and muscle tissues was prevented, and the initial values were excluded as the tension could have increased at the first sensation of the probe vibration. All measurements were taken by one investigator to increase reliability, and only the data within 3% coefficient of variation were collected. For each patient, the mean of two sets of five measurements upon vibration was obtained.

Muscle activity

To assess the muscle activity in this study, the surface electromyography (EMG) (Telemyo 2400T G2, NORAXON USA Inc. UK) was used to collect the measured values.

The collected data was based on the root mean squared values, while the EMG sampling rate was set to 1,000 Hz. The frequency range for filtering and

Table 1. General characteristics of the patients

	JMG	TENSG	*P*
Age (years)	65.33 ± 6.12	64.91 ± 4.81	.855
Height (cm)	160.91 ± 6.63	161.33 ± 5.26	.866
Weight (kg)	60.16 ± 7.80	60.58 ± 5.19	.879

*P<.05, JMG: joint mobilization group, TENSG: transcutaneous electrical nerve stimulation group

notch filtering were 30 - 500 Hz and 60 Hz, respectively, using the Ag-AgCl adhesive electrode. The collected data was then analyzed by 5 second intervals for quantification. Based on the spinous processes of the lumbar vertebrae, a mark was made on the erector spinae muscle belly at 3 cm to the area where the main symptoms were reported, and to minimize the skin resistance for the collection of accurate data, the dermatomal hair were removed and the skin was sterilized with alcohol. The two active electrodes were attached to the area closest to the marked spots, while the reference electrodes were attached to the iliac crest without any relation to the erector spinae muscle.[14]

The patients in a standing posture were guided to have equal forces distributed through the left and right legs, and instructed to hold a 500 g dumbbell in each hand. The level of the activated erector spinae muscle was recorded as a reference, and the level was recorded once again when the patient was no longer holding anything. In analyzing the results, the %RVC (Reference Voluntary Contraction) method was used as the method of normalization that has been used in studies on patients who are unable to produce maximum contraction or perform repetitive contractions.[15]

Intervention

Joint mobilization

In this study, to ensure pain relief and joint range of motion in the lumbar area, the posteroanterior (PA) joint mobilization of Maitland Grade III was applied to the lumbar spinous process. This intervention was applied while the patient was guided to lie prone on the bed and have both arms relaxed on the sides so as to minimize the tension in the lumbar area. The investigator stood close to the lumbar area of the patient, and applied the joint mobilization by delivering the force in a vertical direction to the spinous process.

Based on previous studies, varying the vibration did not show significant differences in the lumbar spinous process upon PA joint mobilization,[16] and based on this, the vibration in this study was administered at 60 Hz/min for the front-back joint mobilization in the lumbar neural spine. A single set consisted of 1 minute of joint mobilization, followed by 1 minute of rest to reduce the residual pain.[17] The treatment per day consisted of 8 sets for 15 minutes, where the last set no longer included the 1 minute of rest. The joint mobilization in this study was performed by a therapist with the certificate of Level 1 International Maitland Teacher's Association.

TENS

The therapeutic frequency of TENS (H-3000-P) used to reduce the lumbar pain was set at 3 - 1,000 Hz, and the input voltage and frequency were set at AC 220V and 60Hz, respectively. In reference to a previous study, the high-frequency high-intensity method was used in this study, where the frequency was set to 75 - 125 Hz, the intensity to 30 - 80 mA, the train duration to 30 - 200 μsec, and the pulsation frequency to 50 - 100 pps.[18] The intensity was set to the level right before the pain threshold, which induced a visible contraction in the patient's lumbar area. For the pad position, the cross arrangement that focuses the current to the most painful area was used; the electrodes were positioned on the left and right sides of the lumbar spinal segment, for the 15-minute interventions.

Data Analysis

All statistical analyses in this study were performed using the SPSS ver. 20.0 (SPSS Inc., Chicago, IL, USA). For normal distribution and homogeneity of the patients, the Shapiro-Wilk test and the t-test were performed, respectively, while the values of the descriptive statistics and frequency analysis were expressed as mean ± standard deviation. For the within-group differences between pre-intervention and post-intervention, the paired t-test was carried out. For the between-group differences, the independent t-test was performed. The level of significance for all statistical analyses in this study was set to α=.05.

RESULTS

Changes in the groups after intervention

Analyzing the effects on the muscle tone by comparing the pre- and post-intervention states in the JMG and TENSG showed that the post-intervention values decreased more than the pre-intervention values, showing a significant improvement in the muscle tone (P<.05). In addition, the muscle activity within each group between pre- and post-intervention was also shown to have significantly improved (P<.05) (Table 2).

Table 2. Changes in muscle tone and muscle activity in the groups after intervention

Variable	JMG		TENSG	
	pre	post	pre	post
Muscle tone	19.05 ± .81	16.20 ± 1.74*	19.05 ± .81	16.20 ± 1.74*
EMG	30.83 ± 2.68	21.41 ± 2.81*	30.83 ± 2.68	21.41 ± 2.81*

*P<.05, JMG: joint mobilization group, TENSG: transcutaneous electrical nerve stimulation group
EMG: electromyography

Changes between the groups after intervention

Analyzing the differences in pre- and post-intervention values between the JMG and TENSG showed that both muscle tone and muscle activity had improved to a higher degree in the JMG (P<.05) (Table 3).

Table 3. Changes in muscle tone and muscle activity between the groups after intervention

Variable	JMG diff	TENSG diff	P
Muscle tone	2.85 ± 1.66	.89 ± .59	.01*
EMG	9.42 ± .51	2.64 ± .27	.00*

*P<.05, JMG: joint mobilization group, TENSG: transcutaneous electrical nerve stimulation group
EMG: electromyography

DISCUSSION

According to previous studies, the prevalence of lumbar spinal stenosis decreased when core exercises were performed.[5] Other exercises, including cycling, treadmill, and core stability exercises also had a positive effect on the symptoms of lumbar spinal stenosis.[19] Based on these findings, the present study determined the immediate effects of joint mobilization and TENS on the muscle tone and activity of the lumbar spinal segment.

In this study, 24 patients with lumbar spinal stenosis were randomized into two groups: 12 patients in JMG to receive the PA joint mobilization intervention and 12 patients in TENSG to receive the TENS intervention. The results showed significant improvements in the muscle tone and activity in both the JMG and TENSG after intervention (P<.05), and for the between-group comparison, the JMG showed positive effects on both muscle tone and activity (P<.05).

A direct association is yet to be verified due to the lack of studies regarding the immediate effects of TENS or joint mobilization on the muscle tone and activity in patients with lumbar spinal stenosis. Nevertheless, previous studies reported that core stability exercises including elbow-toes, back bridges, hand-knees, side bridges, and curl-ups increased the muscle activity, which had a positive effect on patients with lumbar spinal stenosis. Thus, it was reasonable to assume that the interventions in this study led to a positive effect based on the improved muscle tone and activity in the lumbar spinal segment.[4,19]

Applying PA joint mobilization to the lumbar area causes physiological extension.[20] As the core extension exercise has been reported to exert a positive effect on pain relief in lumbar spinal stenosis, the PA joint mobilization applied to the lumbar area was likely to be a positive intervention as part of the manual physical therapies for these patients.[21] In addition, joint mobilization applied to the lumbar area has been reported to improve the muscle tone and stiffness,[22] and the muscle activity upon flexion,[23] thus lending support to the results in this study.[23] The pathological symptoms of lumbar spinal stenosis arise from the narrowed nerve spaces caused by the nearby bones and soft tissues, and since joint mobilization acts to broaden the spinal canal and the interverterbral foramen, the intervention was thought to have led to the positive effects in this study.[1,24]

In lumbar spinal stenosis, the narrowed space in the spine obstructs the flow of the cerebrospinal fluid in the epidural space, which ultimately causes hypoxia and claudication in the spinal nerve.[25] The use of hot packs, ultrasound, and TENS have been reported to significantly improve the pain and Roland Morris

Disability Index,[26] and applying TENS, in particular, had a positive effect on decreasing the muscle tone and increasing the spinal blood flow in patients with lumbar spinal stenosis.[27,28]

In this study, joint mobilization was shown to be a more effective intervention than TENS. This may be attributed to the broadened spinal canal and intervertebral foramen, passive lumbar extension after joint mobilization, and further advantages of increased blood flow.

CONCLUSION

This study investigated the changes in the muscle tone and muscle activity in 24 patients with lumbar spinal stenosis after two different interventions: joint mobilization and TENS. Each patient was provided 15-minute interventions, in which the improvements in muscle tone and activity were higher in the JMG than TENSG. Both the groups showed significant improvements, indicating a need for further studies performing the two interventions simultaneously on a greater number of patients.

REFERENCES

1. Kalichman L, Cole R, Kim DH, et al. Spinal stenosis prevalence and association with symptoms: the Framingham Study. *Spine*. 2009;9:545-550.
2. Binder DK, Schmidt MH. Weinstein PR. Lumbar spinal stenosis. *Semin Neurol*. 2002;22(2):157-166.
3. Kasukawa Y, Miyakoshi N, Hongo M, et al. Lumbar spinal stenosis associated with progression of locomotive syndrome and lower extremity muscle weakness. *Clin Interv Aging*. 2019;14:1399-1405.
4. Atsushi I, Koji K, Yu O, et al. Trunk muscle activity during lumbar stabilization exercises on both a stable and unstable surface. *J Orthop Sports Phys Ther*. 2010;40(6):369-375.
5. Lee SR. Factors related to lumbar spinal stenosis incidence over middle-aged adults. *Asia-pa J Multimed Serv Converge Art Hum Soc*. 2017;7(8):863-870.
6. Sharif F, Ahmad A, Gilani SA. The operative versus conservative approaches in the management and treatment of lumbar spinal stenosis. *Pak J Med Dent*. 2021;10(1):30-36.
7. Johnsson KE, Rosen I, Uden A. The natural course of lumbar spinal stenosis. *Clin Orthop Relat Res*. 1992;6(279):82-86.
8. Mazanec DJ, Podichetty VK, Hsia A. Lumbar canal stenosis: start with nonsurgical therapy. *Cleve Clin J Med*. 2002;69(11):909-917.
9. Tomkins CC, Dimoff KH, Forman HS, et al. Physical therapy treatment options for lumbar spinal stenosis. *J Back Musculoskelet Rehabil*. 2010;23(1):31-38.
10. Godges JJ, Mattson-Bell M, Thorpe D, Shah D. The immediate effects of soft tissue mobilization with proprioceptive neuromuscular facilitation on glenohumeral external rotation and overhead reach. *J Orthop Sports Phys Ther*. 2003;33(12):713-718.
11. Johnson M. Transcutaneous electrical nerve stimulation: mechanisms, clinical application and evidence. *Rev Pain*. 2007;1(1):7-11.
12. Carlo A, Pierre C, Rampersaud YR, et al. Effect of active TENS versus de-tuned TENS on walking capacity in patients with lumbar spinal stenosis: a randomized controlled trial. *Chiropr Man Therap*. 2019;27(1):1-10.
13. Nair K, Masi AT, Andonian BJ, et al. Stiffness of resting lumbar myofascia in healthy young subjects quantified using a handheld myotonometer and concurrently with surface electromyography monitoring. *J Bodywork and Movement Ther*. 2016;20(2):388-396.
14. Stegeman DF, Hermens HJ. Standards for surface electromyography: the European project "Surface EMG for non-invasive assessment of muscles (SENIAM). Enschede: Roessingh Research and Development. 2007.
15. Sousa ASP, Tavares JMRS. Surface electromyographic amplitude normalization methods: a review. Electromyography: New Developments, procedures and Applications. 2012
16. Willett E, Hebron C, Krouwel O. The initial effects of different rates of lumbar mobilisations on pressure pain thresholds in asymptomatic subjects. *Manual ther*. 2009;15(2):173-178.
17. Shum GL, Tsung BY, Lee RY. The immediate effect of posteroanterior mobilization on reducing back pain and the stiffness of the lumbar spine. *Arch Phys Med Rehabil*. 2013;94(4):673-679.
18. Park JH, Song BB. Effect of frequency and intensity of transcutaneous electrical nerve stimulation on patients with chronic low back pain. *The Korea Contents Association*. 2012;12(6):361-370.
19. Jarrett S, Morey JK, Kristen CS, et al. The influence of exercise on perceived pain and disability

in patients with lumbar spinal stenosis: a systematic review of randomized controlled trials. *Am J Lifestyle Med*. 2016;10(2):136-147.
20. Christopher MP, Kornelia K, James H, Gabrielle B. Segmental mobility of the lumbar spine during a posterior to anterior mobilization: assessment using dynamic MRI. *Clin Biomech*. 2003;18(1):80-83.
21. Fang Y. Treating lumbar spinal stenosis using lumbar and abdominal muscle training. *J New Chin Med*. 2015;47(11):113-114.
22. Yang DJ, Uhm YH. The effect of the lumbar segmental mobilization technique on chronic low back pain patients' the characteristics of the muscles, and limited of stability. *J Korean Soc Integr Med*. 2020;8(4):191-202.
23. Chesterton P, Payton S. Effects of spinal mobilisations on lumbar and hamstring ROM and sEMG: A randomised control trial. *Physiother Pract Res*. 2017;38(1):17-26.
24. Irene R. Manual therapy for lumbar spinal stenosis: a comprehensive physical therapy approach. *Phys Med Rehabil Clin N Am*. 2003;14(1):103-110.
25. Kobayashi S. Pathophysiology, diagnosis and treatment of intermittent claudication in patients with lumbar canal stenosis. *Orthop*. 2014;5(2):134-145.
26. Zarife K, Suheda O, Koncuy S, Alp G, Selcuk K. Effectiveness of physical therapy and epidural steroid injections in lumbar spinal stenosis. *Spine*. 2009;34(10):985-989.
27. Wang JS. Therapeutic effects of massage and electrotherapy on muscle tone, stiffness and muscle contraction following gastrocnemius muscle fatigue. *J Phys Ther Sci*. 2017;29(1):144-147.
28. Carlo A, Pierre C, Raja R, et al. Effect of TENS versus placebo on walking capacity in patients with lumbar spinal stenosis: a protocol for a randomized controlled trial. *J Chiropr Med*. 2016;15(3):197-203.