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Original Article

The effects of pelvic diagonal movements and resistance on the lumbar multifidus

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Abstract. [Purpose] The purpose of this study was to compare the effects of pelvic diagonal movements, made with and without resistance, on the thickness of lumbar multifidus muscles. [Subjects and Methods] Participants in this study were healthy subjects who had no musculoskeletal disorders or lumbar-related pain. Participants were positioned on their side and instructed to lie with their hip flexor at 40 degrees. Ultrasonography was used for measurement, and the values of two calculations were averaged. [Results] The thickness of ipsilateral lumbar multifidus muscles showed a significant difference following the exercise of pelvic diagonal movements. The results of anterior elevation movements and posterior depression movements also demonstrated significant difference. There was no significant difference in lumbar multifidus muscles thickness between movements made with and without resistance. [Conclusion] These findings suggest that pelvic diagonal movements can be an effective method to promote muscular activation of the ipsilateral multifidus. Furthermore, researchers have concluded that resistance is not required during pelvic diagonal movements to selectively activate the core muscles.

Key words: Lumbar multifidus, Pelvic diagonal movement, Resistance

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INTRODUCTION

In recent years, the importance of exercises to strengthen core stability has been stressed and such movements have increased in popularity. The term “core” is used to describe the lumbo-pelvic and abdominal regions of the body, and “core stability” refers to the ability to maintain body position stability by exercising muscular control over the lumbar and pelvic regions. Core stability is necessary to provide a basis for the movement of one’s upper and lower extremities[1–3)]. And it is highly dependent on the tension development of muscles originating in the lumbar vertebrae and pelvis.

Core muscles are classified into global and local muscle subsystems; these subsystems are important to help maintain body stabilization and consist of abdominal muscles, spinal and the diaphragm, and the pelvic floor. Of these muscles, especially those in the lower back region, the lumbar multifidus (LM) is particularly vital to stabilize the body while erect the trunk[3–5)].

Improving the strength and stability of the core muscles is a key component of clinical rehabilitation, competitive athletic training, and the improvement of individuals’ general and musculoskeletal health[6–8)]. Several studies have attempted to identify exercises that effectively activate core stabilizers[5, 9)]. Additionally, selective training is necessary for the proper recovery of the multifidus.

Prior to the movement of distal extremities, core stability should be feed-forward. Previous research has identified feed-forward activation of the multifidus associated with limb movements that challenge spine stability.[10)] Panjabi reported that the LM stabilizes the lumbar spine due to its position deep and segmentally near to the spine[11)]. It means that LM is expected to be a critical muscle for active movement of hip and extremity as it provides an essential source of torque and stability for

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the base of the spine.

In both sport and activities of daily living, functional patterns occur that mimic the spiral and diagonal movements of the body[12]. The muscles used in the spiral pattern having just about a diagonal line consist with a cortical array and this is focused in enhancing than weight training on one plane or one direction for performance[13]. This means that anatomical biarticular muscle is positioned in central line of the body diagonally. Jang reported that low extremity PNF diagonal pattern improve the standing balance ability and gait in stroke patients[14]. Some researchers have suggested that patterns of movement performed in combination with other facilitatory procedures may result in enhanced voluntary responses. These spiral and diagonal pattern movements are integrated and efficient and are similar to normal human movements[4, 15].

Many previous studies involving lumbar stabilization have been conducted with participants in a supine position; research on lumbar stabilization in a side-lying position is lacking[16, 17]. In addition, some study reported that different upright sitting postures result in different trunk muscle activation patterns and lumbo-pelvic upright sitting resulted in increased coactivation of superficial lumbar multifidus and internal oblique[18]. The musculature of abdominal and back tissue affects pelvic inclination and lumbar lordosis[19, 20]. Anatomically, these muscles, especially abdominal muscles connecting pelvic structures (pubis and crest) to ribs (xiphoid process and the fifth to seventh cartilages), can curve the lumbar spine and tilt the pelvis[20, 21]. However, no studies have examined the relationship between LM muscle thickness and kinematic pelvic movements using resistance.

Therefore, the purpose of this study was to examine the effects of pelvic diagonal movement patterns, made with and without resistance, on the LM.

SUBJECTS AND METHODS

Researchers recruited 21 subjects, including 10 males and 11 females, from S University. Subject age, height, and weight (mean ± standard deviation) were 22.2 ± 2.1 years, 167.5 ± 9.5 cm, 63.0 ± 10.3 kg, respectively. The inclusion criteria for participation in this study were as follows: participants must have (1) no neuromuscular problems and (2) not undergone physical therapy in the one year preceding this study. All included patients understood the purpose of this study and provided written informed consent prior to their participation in accordance with the ethical standards of the Declaration of Helsinki.

When the subjects adopted a side-lying position with a pillow, their right side was lowered onto the bed as a result of gravity and they do two diagonal pattern of left side pelvic with hip joint flexion at an angle of 40 degrees. One movement, anterior elevation (AE), is the combination of slight pelvic posterior tilting, up and forward movement, and lateral side-bending of the trunk. And the other movement, posterior depression (PD) is combination of slight pelvic anterior tilt and down and backward movement. Static resistance and traction were applied in opposition to the pattern.

The examiner's two hands were placed against the anterior superior iliac spine (ASIS) of the participant during the front upper pelvic diagonal pattern, and the examiner's hands were placed against the ischial tuberosity during the posterior lower pelvic diagonal pattern. The resistance maintained in the end range of each diagonal pelvic movement and the level of resistance was about 50% of the maximal static contraction optimally.

While the participants performed the movements, researchers measured the thickness of the subjects' LM. An ultrasound (eZono 3000, Germany, 2011) and U.S. transducer at 7–10 MHz with a 50 mm penetration depth was utilized to calculate this measurement. To measure LM thickness, the transducer was located longitudinally between the L4 and L5 on the left side of the spinous process. Thickness measurements of the multifidus muscle were conducted from the tip of the zygapophyseal joint for L4–5 level to the inferior edge of the superior border of the multifidus.

Statistical analysis was performed using SPSS version 22.0 software for Windows (SPSS Inc., Chicago, IL, USA). The mean and standard deviation of the variables were calculated using descriptive statistics, and one-way repeated ANOVA was used to compare the thickness of LM in accordance with the pattern movements. For a normality check, the Shapiro-Wilk test was conducted and the Bonferroni method was applied for a post-hoc test. The level of statistical significance was set at $p<0.05$.

RESULTS

Results showed a difference in LM activation across the various movement positions ($p<0.05$). There was a significant difference between the pelvic anterior elevation and posterior depression movements ($p<0.05$). However, no significant difference ($p>0.05$) was found when the results of pelvic diagonal patterns exercised with and without the resistance were compared (Table 1).

Table 1. A comparison of average thickness in various positions (Unit: mm)

	Resting[a]	AE[b]	PD[c]	AE with resistance[d]	PD with resistance[e]	Post-hoc
LM*	25.0 ± 4.1	30.2 ± 5.8	27.7 ± 4.1	31.6 ± 5.7	27.4 ± 4.0	a<e,c<b,d

*p<0.05, LM: lumbar multifidus; AE: anterior elevation; PD: posterior depression
All variables are mean ± standard deviation.

DISCUSSION

This study examined the thickness of the lumbar multifidus muscle (LM) using sonography while performing two pelvic diagonal movements, both with and without resistance, in a side-lying position. Previous study has suggested that lumbar stabilization during hip abduction in side-lying can reduce quadratus lumborum activity and ipsilateral pelvic tilt and can recruit the gluteus medius and internal oblique[19]. And it reported that lumbar stabilization with relaxation to decrease the activity of quadratus lumborum is a useful treatment protocol[19].

The pelvic diagonal movement was exercised using both anterior elevation (AE) and posterior depression (PD). Proprioceptive neuromuscular facilitation (PNF) is a treatment method that can be applied in a specific diagonal movement pattern to facilitate one's ability to promote function and increase muscle coordination[16, 22, 23]. Within the PNF concept, pelvic AE motion is a combination of pelvic posterior tilting, lateral side-bending, and forward movement. The pelvic PD motion is a combination of pelvic anterior tilt and downward and backward movement. These PNF pelvic movements were similar to the pelvic diagonal movements applied in this experiment. Results indicated that LM thickness varied significantly between each movement. In previous studies, when core muscles are called upon to provide stability to the lower back, the LM is the first muscle to activate prior to a limb's movement, thus preparing for the disturbance produced by the movement[3, 24]. Due to its strong connection to the pelvis and to the ligaments surrounding the sacroiliac joint, the multifidus may have an influence on the activities of the pelvic muscles during functional activities[24–26]. The LM activates tonically while maintaining pelvic motion and supports inter-segmental lumbo-pelvic stability.

Results showed that LM muscle thickness was higher during pelvic AE movements than during PD movements. The LM reacts to ipsilateral lumbar side-bending, originates from the posterior superior iliac spine of the pelvis and sacrum, and inserts onto the transverse processes of vertebrae. If we check the muscle activity according to the direction of the tilt of the pelvis only, the muscle activity of the LM muscle will be larger in the anterior tilting. However, we have combined various motions to perform diagonal movements. AE motion causes ipsilateral lumbar side-bending and it was more affected by the side bending of the trunk than by the tilt, although the pelvic posterior tilt occurred slightly during the AE and anterior tilt during the PD.

Previous studies reported that lumbo-pelvic instability caused by insufficient action of the deep core muscles may result in muscle imbalance between the global and local muscles[27, 28]. Global muscles produce movement and phasically respond to loads; local muscles, however, work tonically and are able to generate only a moderate stabilizing force[27, 28]. In this study, LM muscle thickness increased during pelvic diagonal movements with added resistance; however, no significant difference was seen between movements conducted with and without resistance. The LM activated proactively for stabilization as the tonic muscle and the activation of phasic muscles that can produce greater power. Therefore, the contraction of phasic muscle around the pelvis would increase with resistance, with corresponding increases in tonic muscles such as the LM[19].

There are some limitations of this study. First, the subjects consisted of healthy and pain-free individuals; thus, the movements cannot be applied to unhealthy patients in the same manner. Second, researchers could not conduct a more detailed analysis of LM muscle activation or look beyond the superficial layer into the deep layers of the muscle. And researchers did not measure phasic muscles or investigate the correlation between tonic and phasic muscles. In this experiment, we conducted only diagonal movement. Therefore, further research is needed to compare with other stabilization maneuvers for demonstration the effect of the diagonal movement.

In conclusion, these findings suggest that pelvic diagonal movements can be an effective method to promote the muscular activation of the LM. Furthermore, it is not necessarily required that resistance be applied to achieve the selective recruitment of the LM.

REFERENCES

1) Borghuis J, Hof AL, Lemmink KA: The importance of sensory-motor control in providing core stability: implications for measurement and training. Sports Med, 2008, 38: 893–916. [Medline] [CrossRef]
2) Willardson JM, Fontana FE, Bressel E: Effect of surface stability on core muscle activity for dynamic resistance exercises. Int J Sports Physiol Perform, 2009, 4: 97–109. [Medline] [CrossRef]
3) Saeterbakken AH, Fimland MS: Muscle activity of the core during bilateral, unilateral, seated and standing resistance exercise. Eur J Appl Physiol, 2012, 112: 1671–1678. [Medline] [CrossRef]
4) Cholewicki J, VanVliet JJ 4th: Relative contribution of trunk muscles to the stability of the lumbar spine during isometric exertions. Clin Biomech (Bristol, Avon), 2002, 17: 99–105. [Medline] [CrossRef]
5) Arokoski JP, Valta T, Airaksinen O, et al.: Back and abdominal muscle function during stabilization exercises. Arch Phys Med Rehabil, 2001, 82: 1089–1098. [Medline] [CrossRef]
6) Stuge B, Laerum E, Kirkesola G, et al.: The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy: a randomized controlled trial. Spine, 2004, 29: 351–359. [Medline] [CrossRef]
7) Liemohn W, Pariser G: Core strength: implications for fitness and low back pain. ACSM's Health Fit J, 2002, 6: 10–16.
8) Cho HY, Kim EH, Kim J: Effects of the CORE exercise program on pain and active range of motion in patients with chronic low back pain. J Phys Ther Sci,

2014, 26: 1237–1240. [Medline] [CrossRef]
9) Souza GM, Baker LL, Powers CM: Electromyographic activity of selected trunk muscles during dynamic spine stabilization exercises. Arch Phys Med Rehabil, 2001, 82: 1551–1557. [Medline] [CrossRef]
10) Masaki M, Ikezoe T, Fukumoto Y, et al.: Association of sagittal spinal alignment with thickness and echo intensity of lumbar back muscles in middle-aged and elderly women. Arch Gerontol Geriatr, 2015, 61: 197–201. [Medline] [CrossRef]
11) Panjabi MM: The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. J Spinal Disord, 1992, 5: 383–389, discussion 397. [Medline] [CrossRef]
12) Voight ML, Hoogenboom BJ, Cook G: The chop and lift reconsidered: integrating neuromuscular principles into orthopedic and sports rehabilitation. N Am J Sports Phys Ther, 2008, 3: 151–159. [Medline]
13) Kofotolis N, Verbas I, Kalogeropoulou E: Proprioceptive neuro muscular facilitation versus isokinetic training for strength endurance and jumping performance. J Hum Mov Stud, 2002, 42: 155–165.
14) Jang EJ: The effects of PNF low extremity pattern on standing balance and gait in stroke patients by ramp and stairs. Graduate School of Rehabilitation Science, Daegu University, 2013.
15) Voss DE, Ionta MK, Myers BJ: Proprioceptive neuromuscular facilitation. Patterns and techniques. Philadelphia: Harper & Row Publishers, 1985.
16) Yoo B, Park H, Heo K, et al.: The effects of abdominal hollowing in lower-limb PNF pattern training on the activation of contralateral muscles. J Phys Ther Sci, 2013, 25: 1335–1338. [Medline] [CrossRef]
17) Kim CR, Park DK, Lee ST, et al.: Electromyographic changes in trunk muscles during graded lumbar stabilization exercises. PM R, 2016, 8: 979–989. [Medline] [CrossRef]
18) O'Sullivan PB, Dankaerts W, Burnett AF, et al.: Effect of different upright sitting postures on spinal-pelvic curvature and trunk muscle activation in a pain-free population. Spine, 2006, 31: E707–E712. [Medline] [CrossRef]
19) Cynn HS, Oh JS, Kwon OY, et al.: Effects of lumbar stabilization using a pressure biofeedback unit on muscle activity and lateral pelvic tilt during hip abduction in sidelying. Arch Phys Med Rehabil, 2006, 87: 1454–1458. [Medline] [CrossRef]
20) Kim HJ, Chung S, Kim S, et al.: Influences of trunk muscles on lumbar lordosis and sacral angle. Eur Spine J, 2006, 15: 409–414. [Medline] [CrossRef]
21) Heino JG, Godges JJ, Carter CL: Relationship between hip extension range of motion and postural alignment. J Orthop Sports Phys Ther, 1990, 12: 243–247. [Medline] [CrossRef]
22) Huo M: Neuromuscular joint facilitation. Tokyo: Ipec Press, 2010, p 3.
23) Sato H, Maruyama H: The effects of indirect treatment of proprioceptive neuromuscular facilitation. J Phys Ther Sci, 2009, 21: 189–193. [CrossRef]
24) Koppenhaver SL, Fritz JM, Hebert JJ, et al.: Association between history and physical examination factors and change in lumbar multifidus muscle thickness after spinal manipulation in patients with low back pain. J Electromyogr Kinesiol, 2012, 22: 724–731. [Medline] [CrossRef]
25) Richardson C: Spinal segmental stability. In: Therapeutic Exercise for Spinal Segmental Stabiliationin Low Back Pain. Edinburgh: Churchill Livingstone, 1999, pp 16–26.
26) Pool-Goudzwaard AL, Vleeming A, Stoeckart R, et al.: Insufficient lumbopelvic stability: a clinical, anatomical and biomechanical approach to 'a-specific' low back pain. Man Ther, 1998, 3: 12–20. [Medline] [CrossRef]
27) Caplan N, Gibbon K, Hibbs A, et al.: Phasic-to-tonic shift in trunk muscle activity relative to walking during low-impact weight bearing exercise. Acta Astronaut, 2014, 104: 388–395. [CrossRef]
28) Richardson CA, Snijders CJ, Hides JA, et al.: The relation between the transversus abdominis muscles, sacroiliac joint mechanics, and low back pain. Spine, 2002, 27: 399–405. [Medline] [CrossRef]