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Multifidus Thickness Comparison between the Effectiveness of Abdominal Bracing and Maximum Expiration Maneuvers in Lumbo-Pelvic Upright Sitting Posture

Background: Trunk flexor-extensor muscles' co-activation and upright posture are important for spinal stability. Abdominal bracing and maximal expiration are being used as exercises to excel torso co-contraction. However, no study has on comparison of the effect of this exercise on multifidus in the upright sitting posture.
Objectives: This study aims to verify the effectiveness of abdominal bracing and expiration maneuvers in lumbo-pelvic upright sitting.
Design: Cross-sectional study.
Methods: Eighteen healthy women were recruited for this study. The multifidus muscle thickness of all subjects was measured in three sitting conditions (lumbo-pelvic upright sitting, lumbo-pelvic upright sitting with abdominal bracing, and lumbo-pelvic upright sitting with maximum expiration) using ultrasound. One-way repeated measure analysis of variance was used for the evaluation.
Results: Compared to lumbo-pelvic upright sitting, lumbo-pelvic upright sitting with abdominal bracing and lumbo-pelvic upright sitting with maximum expiration were associated with significantly increment of muscle thickness. There was no significant difference in muscle thickness between lumbo-pelvic upright sitting with abdominal bracing and lumbo-pelvic upright sitting with maximum expiration.
Conclusion: Abdominal bracing and maximum expiration could be beneficial to increasing lumbar multifidus thickness in lumbo-pelvic upright sitting.

Keywords: *Maximum expiration; Abdominal bracing; Multifidus; Lumbo-pelvic upright sitting posture*

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INTRODUCTION

Trunk stability is maintained by passive structure[1] and active muscle contraction. Contraction of trunk core muscles including the transverse abdominis, multifidus, diaphragm, and pelvic floor muscles are thought to contribute mechanical stability of lumbar spine.[2-4] A slumped sitting posture relies on passive lumbo-pelvic structures to maintain an upright position against gravity. The passive structures such as intervertebral disc, ligament, facet joint and facet joint capsule of the spine provide stability and share the load.[1] As a result, the requirement for trunk muscle activity is reduced. Clinically, such passive postures frequently exacerbate low back pain (LBP).[5,6]

The multifidus is a key segmental stabilizer in the lumbar region.[7,8] Lumbar multifidus (LM) among the trunk muscles was preferentially affected in people with LBP and manifests in the form of atrophy or decreased activation speed.[9] Although LM serves as key stabilizer in the lumbar region, isolated contraction poses some difficulty.[7,8,10] LM co-contraction through volitional abdominal activation such as abdominal bracing (AB) maneuvers may serve as a simple and effective strategy for activating a stabilizing response.[10] Ishida et al.[11] reported that the expiration or AB promoted torso co-contraction of external oblique, internal oblique, and L3 erector spinae, reduced lumbar acceleration in response to loading, and increased spinal stability compared to a resting

external oblique, internal oblique, and L3 erector spinae, reduced lumbar acceleration in response to loading, and increased spinal stability compared to a resting condition. Expiration helps increase abdominal muscle activation,[12,13] which is used to train co-contracting deep muscles such as internal oblique abdominals, multifidus, and pelvic floor muscles.[14] Compared to normal breathing, deep breathing significantly increased the activity of external oblique, internal oblique, and LM.[15] Ultrasonography (US) is used to measure changes in muscle thickness as an indicator of deep muscle activity such as that of the transversus abdominis and LM.[16-18] A correlation between changes in muscle thickness and muscle activation in the abdominal muscles and LM was found.[16,19] Abdominal muscle thickness was assessed during abdominal hollowing, AB, and automatic activity with various levels of muscle contraction intensity in the supine position.[20,21] LM was measured during isometric trunk extension in the prone position.[22,23] During movement tasks, isometric contraction could change muscle thickness was considered these muscle activity.[16]

AB and expiration are used for LM training, but few studies have compared the effects of two maneuvers in the same position. There was one study comparing the effects in the semi-sitting position, abdominal muscle and erector spinae were measured but LM was not.[11] Comparing sitting postures, previous study found that the activity of internal oblique and LM increased significantly during lumbo-pelvic upright sitting with maximum expiration (ME) compared with thoracic upright sitting position.[15] However, it is unclear whether AB could influence LM activity during that position. Furthermore, Surface EMG was used to assess muscle activity in both previous studies. Surface EMG is a valid tool and standard method for evaluating muscle activity, but there are some limitations when measuring deep muscles, such as the crosstalk of adjacent muscles.[16,24] However, US is a non-invasive method and is used to measure LM thickness as an indicator of muscle activity.[25] Therefore, the purpose of this study was to clarify the effect of AB and ME maneuvers in lumbo-pelvic upright sitting posture and on multifidus thickness.

SUBJECTS AND METHODS

Research Subjects

This study enrolled 18 healthy women (mean age, 33.1±5.1 years; mean height, 163.0±4.3 cm; mean weight, 52.3±5.0 kg). A power analysis, using large effect size (d=0.8) with a power of 0.8 at a level of .05, determined that at least 15 subjects were required to detect difference in multifidus thickness between three conditions. As gender differences in multifidus thickness have been reported by a previous study,[26] we chose only female subjects. All subjects reported no instance of low back or thoracic pain within the last year or musculoskeletal and pulmonary disorders that would limit AB and ME. Participants who had a history of lumbar spine surgery or difficulty maintaining the sitting postures were excluded from the study. All subjects provided adequate explanation of the method and purpose of the experiment before participating and signed an informed consent form. This study approved by the Institutional Research Review Committee of Inje University (INJE 2018-07-020-001).

Lumbo-pelvic upright sitting

As shown in Figure 1, a height-adjustable chair without a back rest was used for the lumbo-pelvic upright sitting position.[27] Participants were seated with their feet 20 cm apart and hips and knees at 90° alignment. To maintain a neutral lordosis of the lumbar spine, they anteriorly rotated their pelvis. At the same time, they relaxed the thoracic spine.[27] The subjects were instructed to lightly touch both their hands on their anterior superior iliac spine to keep monitoring and to hold their position.

Abdominal bracing and maximal expiration

The subjects were asked to sit in lumbo-pelvic upright sitting position and were provided the following verbal instructions. Verbal instructions for AB and ME were as follows: AB, "Tighten your abdominal

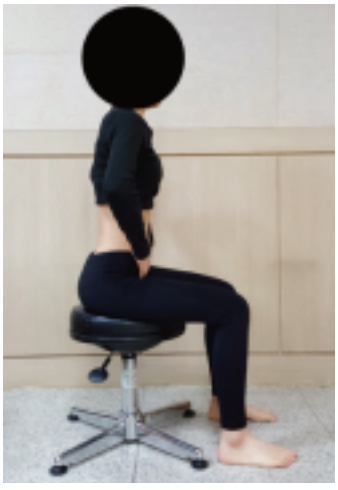

Figure 1. Lumbo-pelvic upright sitting

wall as though you will be hit in the belly, hold this contraction"; ME, "Do not focus on the abdominal muscles, breathe out maximally with almost maximal effort, and then hold your breath."[10,11] The subjects practiced until they were familiar with AB and ME. A 5-minute rest was provided after the familiarization period.

Outcome Measures

The right multifidus thickness was obtained using real-time B mode ultrasound imaging (Telemed Ltd., Vilnius, Lithuania, EU) by one trained investigator. An ultrasound transducer (from 5 MHz) was used to assess the multifidus. Gel was interposed between the transducer and the skin. In order to measure the thickness of the multifidus, the transducer was positioned longitudinally along the spine with the midpoint over the L4 spinous process.[28] It was moved laterally and angled slightly medially until the L4/5 zygapophyseal joint could be identified.[28] This scan point is directly over the multifidus and a measurement from this landmark to the plane between the muscle and subcutaneous tissue was used for the linear measurement of the multifidus.[28]

Experimental Procedures

The first measurement for thickness of the multifidus was performed with the subjects in lumbo-pelvic upright sitting without any maneuvers. And then, lumbo-pelvic upright sitting with AB and lumbo-pelvic upright sitting with ME conditions were performed in random orders. During the examination, care was taken to maintain the same standardized position between subjects and the exact location of the transducer. Each sitting condition was held for 5s and repeated three times, with a 1-minute rest between trials.

Data and Statistical Analysis

The average value of the three trials of each condition was used for the data analysis. PASW Statistics software (ver. 18.0; SPSS Inc., Chicago, IL, USA) was used for the statistical analyses. One-way repeated measures analysis of variance with the Bonferroni correction was used for determination of differences in multifidus thickness according to lumbo-pelvic upright sitting, lumbo-pelvic upright sitting with AB, and lumbo-pelvic upright sitting with ME. The level of statistical significance was set to .05. To avoid type I errors, statistical significance within the pair comparison was reduced to $\alpha=.05/3$ ($\alpha=.017$).

RESULTS

There were significant differences found among the three conditions for the multifidus analyzed ($P<.001$) (Table 1). Compared to lumbo-pelvic upright sitting (control), lumbo-pelvic upright sitting with AB and lumbo-pelvic upright sitting with ME were associated with significantly increment of muscle thickness ($P<.001$, $P<.001$, respectively). There was no significant difference between lumbo-pelvic upright sitting with AB and lumbo-pelvic upright sitting with ME ($P=.156$).

DISCUSSION

In this study, muscle thickness in three lumbo-pelvic upright sitting conditions were compared to clarify the differences in multifidus thickness. First, LM thickness was significantly increased in lumbo-pelvic upright sitting with AB and ME compared to lumbo-pelvic upright sitting. The thickening of the LM during AB and ME was consistent with the results of previous studies, showing that when the abdominal muscles contract, the opposite vertebral erect muscles also contract.[14] Co-activation of trunk muscles was suggested to increase spinal stability and to maintain upright postures.[29] Previous study reported that activation of the abdominal wall by using AB and abdominal drawing-in maneuver was appropriated for co-activating the multifidus in supine, 4-point kneeling, and upright standing

Table 1. Multifidus thickness in the three conditions

	Control Mean ± SD	AB Mean ± SD	ME Mean ± SD	*P*
Multifidus thickness (mm)	24.91 ± 3.75	27.33 ± 4.18[a]	28.16 ± 4.54[b]	< .001[†]

[†] $P<.05$

[a]Significant difference between control and AB ($P<.017$), [b]Significant difference between control and ME ($P<.017$)

SD: Standard deviation, AB: Abdominal bracing, ME: Maximal expiration

positions.[16] Another previous study found that AB in a semi-seated position principally activated the internal oblique muscle, but also generated an antagonistic co-contraction, which stiffened the trunk and increased spinal stability.[4,11,30-32] These data are consistent with this study's results and provide further evidence for the inclusion of the co-contractive response of the LM to volitional abdominal contraction for spinal stability in upright sitting. Additionally, AB and ME in the lumbo-pelvic upright sitting position can be used clinically as exercises to increase the activity of LM since a significant correlation between thickness and muscle activation has been reported.[16,18]

There was no significant difference in LM thickness between AB and ME in this study. It seems to be due to the similar muscle function used in the two conditions. The AB used in this study was known to maintain trunk stability by increasing pressure in the abdominal cavity through strong co-contractions of the abdominal wall.[10,33] Increasing the pressure in the abdominal cavity is also necessary for a strong exhalation. A previous study showed that the two mechanisms as antagonistic flexor-extensor muscle co-activation and abdominal muscle activation, along with generation of intra-abdominal pressure, were effective in providing mechanical stability to the spinal model when activated simultaneously rather than when activated separately.[30] Therefore, it might be effective to use AB and ME together as an exercise to increase the stability of the lumbar spine.

Previous researches reported that the correlation exists between the increased pulmonary functions and segmental lumbar lordosis.[34,35] An increase in spinal lordosis in the lumbar region is likely to induce a decrease in thoracic kyphosis, thus giving the ribcage greater room to expand during inspiration, while slumped sitting posture decreases trunk muscle activity and lung function.[34-37] Consequently, AB and ME in lumbo-pelvic upright sitting could be beneficial to increase pulmonary function, so further studies will be needed. However, there are limitations to generalizing these results to other populations or patient populations because only healthy women were recruited in this study. Therefore, future studies are needed to investigate the effects of AB and ME in patients with LBP or pulmonary dysfunction or in different gender populations.

CONCLUSION

AB and ME may help increase LM thickness when sitting upright in the lumbar pelvis. In clinical practice, the results could be used as evidence for the rehabilitation of lumbar segmental stabilization using AB or ME.

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