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Original Article

The Influence of Dual Pressure Biofeedback Units on Pelvic Rotation and Abdominal Muscle Activity during the Active Straight Leg Raise in Women with Chronic Lower Back Pain

Kyung-Hee Noh[1)], Ji-Won Kim[2)], Gyoung-Mo Kim[3)], Sung-Min Ha[4)], Jae-Seop Oh, PT, PhD[5)*]

[1)] *Department of Rehabilitation Science, Graduate School, Inje University, Republic of Korea*
[2)] *Department of Physical Therapy, Nambu University, Republic of Korea*
[3)] *Department of Physical Therapy, Baekseok University, Republic of Korea*
[4)] *Department of Physical Therapy, Sangji University, Republic of Korea*
[5)] *Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University: 607 Obang-dong, Gimhae-si, Gyeongsangnam-do 621-749, Republic of Korea*

Abstract. [Purpose] This study was performed to assess the influence of applying dual pressure biofeedback units (DPBUs) on the angle of pelvic rotation and abdominal muscle activity during the active straight leg raise (ASLR). [Subjects] Seventeen patients with low-back pain (LBP) participated in this study. [Methods] The subjects were asked to perform an active straight leg raise (ASLR) without a PBU, with a single PBU, and with DPBUs. The angles of pelvic rotation were measured using a three-dimensional motion-analysis system, and the muscle activity of the bilateral internal oblique abdominis (IO), external oblique abdominis (EO), and rectus abdominis (RA) was recorded using surface electromyography (EMG). One-way repeated-measures ANOVA was performed to determine the rotation angles and muscle activity under the three conditions. [Results] The EMG activity of the ipsilateral IO, contralateral EO, and bilateral RA was greater and pelvic rotation was lower with the DPBUs than with no PBU or a single PBU. [Conclusion] The results of this study suggest that applying DPBUs during ASLR is effective in decreasing unwanted pelvic rotation and increasing abdominal muscle activity in women with chronic low back pain.

Key words: Active straight leg raise, Pelvic rotation, Pressure biofeedback unit

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INTRODUCTION

Low-back pain (LBP) is experienced by approximately 70–85% of all people during their lifetimes[1)], and 40% of patients with acute LBP experience chronic pain[2)]. LBP is more common in women than in men and has a variety of causes[1)], including impaired movement patterns, abnormal alignment, and impaired stabilization of the lumbar spine. To prevent these problems, muscle activity patterns should be corrected, and isometric contraction should be properly stabilized during movement of the proximal limbs[3)].

The active straight leg raise (ASLR) is frequently used for rehabilitation in patients with impaired lumbar and pelvic musculature as well as for training of the abdominal muscles in healthy people[4, 5)]. If the lumbopelvic and hip regions are not stabilized while raising the lower extremity, the pelvis rotates, and the lumbar back undergoes excessive movement[6)]. Repeated or sustained pelvic rotation during ASLR or activities of daily living may produce or aggravate LBP[7)]. Many researchers have recently investigated the maneuvers that most effectively minimize movements of the lumbar spine and control rotation of the pelvis during limb movement such as that during ASLR[8–10)].

Pressure biofeedback units (PBUs) have been used to assess control of the abdominal muscles[11, 12)], and they can be used to indirectly monitor changes in abdominal muscle activation[13)]. Oh et al. reported that prone hip extension with PBUs resulted in increased muscle activation and reduced anterior pelvic tilt[10)]. The use of PBUs minimizes pelvic motion because it provides internal stabilization of the lumbopelvic region while raising the leg from the ground[14)].

In clinical practice, it is difficult to control transverse motion such as rotation when applying a single PBU to control sagittal plane motion. Comerford and Mottram suggested that exercise with dual PBUs (DPBUs) should minimize pelvic motion more effectively during lumbar stabilization exercises while lying down than a single PBU[15)]. However, no study has examined whether the use of DPBUs increases activation of the abdominal muscles and properly controls pelvic rotation more effectively than a single PBU. There-

*Corresponding author. Jae-Seop Oh (E-mail: ysrehab@inje.ac.kr)

Table 1. The angle of pelvic rotation during ASLR without PBU, ASLR with PBU, and ASLR with dual PBUs (DPBUs)

Pelvic rotation	Mean ± SD (angle)		
	ASLR without PBU	ASLR with PBU	ASLR with DPBUs
	4.70±1.72	3.98±1.85†	2.95±2.03 ‡§

ASLR, active straight leg raising; PBU, pressure biofeedback unit; DPBUs, dual pressure biofeedback units.
†Significant difference between ASLR without PBU and ASLR with PBU ($p<0.05$).
‡ Significant difference between ASLR without PBU and ASLR with DPBUs ($p<0.05$).
§ Significant difference between ASLR with PBU and ASLR with DPBUs ($p<0.05$).

fore, the purpose of this study was to investigate the effects of DPBU application during ASLR. We hypothesized that the angle of pelvic rotation would be reduced and that the EMG activity of the abdominal muscles would be higher during ASLR with DPBUs than with a single PBU or with no PBU.

SUBJECTS AND METHODS

Seventeen women with LBP were recruited for this study. The subjects were 34.65 ± 10.3 years of age (mean ± SD) and had a body weight of 54.24 ± 5.9 kg, height of 161.94 ± 4.4 cm, and Korean Oswestry Disability Index of 30.94 ± 5.8%. Subjects were excluded if they had undergone lumbar surgery; had a serious neurological disease, scoliosis or kyphosis; had orthopedic damage; had lower extremity pain or injury during the last 6 months; or were pregnant. All subjects provided written informed consent before participation. This study was approved by the Inje University Faculty of Health Science Human Ethics Committee.

The electromyographic (EMG) activity of the bilateral internal oblique abdominis (IO), external oblique abdominis (EO), and rectus abdominis (RA) was measured using a Trigno Wireless EMG System (Delsys Inc., Boston, MA, USA). The electrode sites were located bilaterally parallel to the muscle fibers >2 cm lateral to the umbilicus for the RA, 2 cm inferior and medial to the anterior superior iliac spine for the IO, and 12 to 15 cm lateral to the umbilicus, directly above the anterior superior iliac spine, for the EO[16]. The electrode sites were cleaned and swabbed with alcohol before the electrodes were placed to minimize skin impedance. The EMG data were sampled at 2,000 Hz, and a bandwidth of 20–450 Hz was used. The EMG signal for each muscle was analyzed using the root mean square. For normalization, the maximal voluntary isometric contraction (MVIC) was calculated for each muscle and measured using the manual muscle testing positions described by Kendall et al[17].

To measure the rotation angle of the pelvis, a three-dimensional ultrasonic motion analysis system was used (CMS-HS; zebris Medical GmbH, Isny, Germany). Active triplet markers were attached at the iliac crest and the femoral head of the raised leg. The subjects performed the ASLR without a PBU, with a single PBU, and with DPBUs. For the ASLR with no PBU, the subjects lay in the supine position and actively raised the dominant leg (the right leg in all subjects) without bending the knee. The leg was raised until the ankle joint contacted a target bar placed 20 cm above the table for 5 s. For the ASLR with a single PBU (Stabilizer; Chattanooga Group, Inc., Hixson, TN, USA), a pressure bladder was placed between the therapeutic table and the lumbar spine. In the ASLR with DPBUs, two joined biofeedback units were placed under the center of the back at the L3 level and connected along the spine. The exercises were performed three times with a 5-min rest between exercises[18]. During the ASLR, the subjects were asked to sustain a pressure of 40 mmHg on the PBU (or DPBUs) based on a visual analog gauge. Changes in pressure less than ±5 mmHg were acceptable for data collection[15].

One-way repeated-measures analysis of variance (ANOVA) was used to determine the main effects of the ASLR on each muscle. To compare the three different conditions, a post hoc test with Bonferroni's correction was performed. SPSS ver. 18.0 (SPSS, Inc., Chicago, IL, USA) was used for all analyses, and statistical significance was set at $p < 0.05$.

RESULTS

The rotation angle of the pelvis and the activity level of each muscle during the ASLR under the three conditions are shown in Table 1. According to the post hoc analysis, the rotation angle of the pelvis was significantly lower during ASLR with DPBUs compared with a single PBU ($p < 0.007$) and with no PBU ($p < 0.000$), and it was significantly lower with the single PBU than with no PBU ($p < 0.034$). Furthermore, post hoc analysis showed that the EMG activity of the ipsilateral RA was significantly higher with DPBUs than with one PBU ($p < 0.003$) and with no PBU ($p < 0.002$). Additionally, ipsilateral IO activity was significantly increased in the ASLR with DPBUs compared with that with a single PBU ($p < 0.049$) and no PBU ($p < 0.004$), and the contralateral EO activity was significantly higher in the ASLR with DPBUs than with no PBU ($p < 0.015$) (Table 2).

DISCUSSION

In this study, the angle of pelvic rotation was significantly lower during ASLR with DPBUs (2.95° ± 2.03°) than during ASLR with a single PBU (3.98° ± 1.85°) and with no PBU (4.70° ± 1.72°). We found that the angles of pelvic rotation during the ASLR with one PBU and with DPBUs were also significantly lower than that with no PBU. Libenson et al. reported that internal lumbopelvic stabilization, such as that during active abdominal bracing, reduced lumbar

Table 2. EMG activity (%MVIC) of abdominal muscles during ASLR without PBU, ASLR with PBU, and ASLR with dual PBUs (DPBUs).

Muscles		Mean ± SD (%MVIC)		
		ASLR without PBU	ASLR with PBU	ASLR with DPBUs
RA	Lt.	12.6±6.3	13.9±6.9	16.6±7.6
	Rt.	13.9±4.4	15.0±5.6	18.7±6.5‡§
IO	Lt.	19.8±11.0	23.2±16.8	26.5±19.1
	Rt.	19.2±8.8	21.2±12.2	27.5±12.9‡§
EO	Lt.	22.3±14.0	22.7±15.4	27.8±15.2‡
	Rt.	26.6±18.1	27.7±19.4	30.9±17.1

ASLR, active straight leg raising; PBU, pressure biofeedback unit; DPBUs, dual pressure biofeedback units; RA, rectus abdominis; IO, internal oblique abdominis; EO, external oblique abdominis.

†Significant difference between ASLR without PBU and ASLR with PBU (p<0.05). ‡ Significant difference between ASLR without PBU and ASLR with DPBUs (p<0.05). § Significant difference between ASLR with PBU and ASLR with DPBUs (p<0.05).

axial rotation[9]. Internal stabilization can be accomplished through co-contraction of intrinsic and extrinsic muscular stabilizers of the trunk. In our study, as the subjects raised their legs, they tried to sustain a pressure of 40 mmHg based on visual analog scales on both sides using the DPBUs, which served to facilitate lumbopelvic stabilization by proper contraction of the abdominal muscles. When using a PBU for lumbar stabilization exercises such as abdominal bracing, a drawing-in maneuver and pelvic backward tilt are needed to confirm that the abdominal muscles are optimally active[14]. The angle of pelvic rotation was lower using DPBUs than it was using a single PBU. Like the pelvic rotatory control method in which subjects lightly touch both hands on their anterior superior iliac spine[6], the DPBU method also maintains pressure on the PBUs under both the right and left sides of the pelvis. Our study suggests that the use of DPBUs during ASLR facilitates control of lumbopelvic axial rotation in the transverse plane. Therefore, our research results suggest that to avoid excessive lumbopelvic motion, DPBUs rather than a single PBU should be used during ASLR.

The results of the present study also showed that EMG activity of the right IO and right RA was significantly higher during the ASLR when DPBUs were used than when a single PBU or no PBU was employed ($p < 0.05$), and the activity of the left EO during the ASLR was significantly greater with DPBUs than with no PBU. In our study, when the extremity was raised from the ground while using DPBUs, the angle of axial rotation in the lumbopelvic region would be expected to decrease because the ipsilateral IO and contralateral EO muscles showed isometric co-contraction. The internal and external oblique muscles show co-contraction during flexion and rotation of the trunk[5]. Furthermore, the pelvic control method during the ASLR increased the activity of all abdominal muscles and reduced the amount of pelvic rotation[19] in a study conducted in healthy adults. The results of the present study suggest that performing this exercise while using DPBUs may be related to pelvic rotation, not the strength of the abdominal muscles.

The present study had several limitations. First, we are unable to generalize the findings to all patients with LBP because all the subjects were women with chronic LBP, and our study did not include a control group of healthy people. Second, we did not measure the pain level under the three conditions. Third, although we measured pelvic rotation angles, they were not measurements of the axial rotation of the pelvis because pelvic rotation is defined as motion in the transverse plane. Finally, we did not measure the degree of anterior and posterior pelvic tilt during the ASLR. Further study is required to assess whether DPBUs can control pelvic motion in the frontal plane during ASLR in subjects with LBP as well as anybody else using DPBUs.

REFERENCES

1) Andersson GB: Epidemiological features of chronic low-back pain. Lancet, 1999, 354: 581–585. [Medline] [CrossRef]
2) Costa L C, Maher CG, McAuley JH, et al.: Prognosis for patients with chronic low back pain: inception cohort study. BMJ, 2009, 339: b3829. [Medline] [CrossRef]
3) Sahrmann S: Diagnosis and treatment of movement impairment syndrome, St. Louis: Mosby, 2002.
4) Gatti R, Corti M, Cervi P, et al.: Biomechanics of lower limb raising from the supine position. Eura Medicophys, 2006, 42: 185–193. [Medline]
5) Neumann DA: Kinesiology of the musculoskeletal system, 2nd ed. St. Louis: Mosby Elsevier, 2010.
6) Lee DG: The pelvic girdle, 3rd ed. Edinburgh: Churchill Livingstone, 2004.
7) Hoffman SL, Johnson MB, Zou D, et al.: Effect of classification-specific treatment on lumbopelvic motion during hip rotation in people with low back pain. Man Ther, 2011, 16: 344–350. [Medline] [CrossRef]
8) Beales DJ, O'Sullivan PB, Briffa NK: The effects of manual pelvic compression on trunk motor control during an active straight leg raise in chronic pelvic girdle pain subjects. Man Ther, 2010, 15: 190–199. [Medline] [CrossRef]
9) Liebenson C, Karpowicz AM, Brown SH, et al.: The active straight leg raise test and lumbar spine stability. PM R, 2009, 1: 530–535. [Medline] [CrossRef]
10) Oh JS, Cynn HS, Won JH, et al.: Effects of performing an abdominal drawing-in maneuver during prone hip extension exercises on hip and back extensor muscle activity and amount of anterior pelvic tilt. J Orthop Sports Phys Ther, 2007, 37: 320–324. [Medline] [CrossRef]
11) Jull GA, Richardson CA, Toppenberg R, et al.: Towards a measurement of active muscle control for lumbar stabilisation. Aust J Physiother, 1993, 39: 187–193.
12) Mills JD, Taunton JE, Mills WA: The effect of a 10-week training regimen on lumbo-pelvic stability and athletic performance in female athletes: a randomized-controlled trial. Phys Ther Sport, 2005, 6: 60–66. [CrossRef]
13) Cairns MC, Harrison K, Wright C: Pressure biofeedback: a useful tool in the quantification of abdominal muscular dysfunction? Physiotherapy, 2000, 86: 127–138. [CrossRef]
14) Kisner C, Colby LA: Therapeutic Exercise: Foundations and Techniques. Philadelphia: Davis, 2007.
15) Comerford M, Mottram S: Kinetic Control: The management of uncontrolled movement. Australia: Elsevier, 2012.
16) Marshall P, Murphy B: The validity and reliability of surface EMG to assess the neuromuscular response of the abdominal muscles to rapid limb movement. J Electromyogr Kinesiol, 2003, 13: 477–489. [Medline] [CrossRef]
17) Kendall FP, McCreary EK, Provance PG, et al.: Muscles: Testing and function with posture and pain, 5th ed. Baltimore: Lippincott Williams & Wilkins, 2005.
18) Mens JM, Vleeming A, Snijders CJ, et al.: The active straight leg raising test and mobility of the pelvic joints. Eur Spine J, 1999, 8: 468–473. [Medline] [CrossRef]
19) Park KH, Ha SM, Kim SJ, et al.: Effects of the pelvic rotatory control method on abdominal muscle activity and the pelvic rotation during active straight leg raising. Man Ther, 2013, 18: 220–224. [Medline] [CrossRef]