J. Phys. Ther. Sci.
25: 793–795, 2013

Effects of a Pelvic Belt on the EMG Activity of the Abdominal Muscles during a Single-leg Hold in the Hook-lying Position on a Round Foam Roll

Yu-Ri Kim, PT, MSc[1)], Ji-Won Kim, PT, MSc[2)], Duk-Hyun An, PT, PhD[3)], Won-Gyu Yoo, PT, PhD[3)], Jae-Seop Oh, PT, PhD[3)]*

[1)] *Department of Physical Therapy, Good Gang An Hospital*
[2)] *Department of Rehabilitation Therapy, Graduate School, Inje University*
[3)] *Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University: 607 Obang-dong, Gimhae-si, Gyeongsangnam-do 621-749, South Korea.*

Abstract. [Purpose] This study investigated the effects of a pelvic belt on the electromyography (EMG) activity of the abdominal muscles during a single-leg hold in the hook-lying position on a round foam roll. [Subjects] Seventeen healthy female volunteers were recruited for this study. [Methods] The participants performed single-leg-hold exercises on a round foam roll with and without a pelvic belt. Surface EMG was recorded from the rectus abdominis (RA), internal oblique (IO), and external oblique (EO) bilaterally. [Results] The EMG activity of the bilateral RA, EO, and IO was significantly lower when the pelvic belt applied. [Conclusions] Our finding that the bilateral EO, IO, and RA muscles were less active with a pelvic belt during trunk-stabilizing exercises on an unstable surface suggests that the pelvic belt provided "form closure".
Key words: Abdominal muscle, Pelvic belt, Round foam roll

(This article was submitted Jan. 22, 2013, and was accepted Mar. 1, 2013)

INTRODUCTION

The single-leg hold exercise in the hook-lying position on round foam roll is often performed for abdominal muscle control in normal people for the promotion of health, the prevention of musculoskeletal disease, and rehabilitation in individuals with back pathologies[1)]. Excessive lumbar spine movements and unwanted pelvic movements frequently occur during these exercises in patients with lumbopelvic instability. Repeated uncontrolled single-leg hold exercise associated with increased lumbopelvic motion may produce or exacerbate low back pain or musculoskeletal disorders in women with lumbopelvic instability[2, 3)]. To prevent lumbopelvic motion during limb movement, patients have been instructed to stabilize the pelvis using various methods.

The pelvis can be stabilized either "force closure" or "form closure"[4)]. Snijders et al. coined the term form closure to describe how the joint's shape contributes to stability, whereas "force closure" refers to other forces acting across the joint to create stability[5)]. According to theoretical modeling of force closure, the anterior attachment of the transverse and internal oblique abdominal muscles to the iliac crest places the muscle ideally to act on the ilium to produce compression of the pelvis[6)]. When force closure is lost, such as with pelvic instability, a pelvic belt increases the passive stability of the SI joints.

A recent study examined the effect of trunk muscle activation during lower-limb movements and functional activities with a pelvic belt[7)]. A pelvic belt often relieves problems with active straight-leg raising (ASLR), which suggests that patients who have difficulty performing ASLR have problems with the active production of force closure[8)]. During the ASLR, transverse and oblique abdominal muscles were lesser activated with a pelvic belt than without[9)]. This suggests that the pelvic belt provides such force closure, thus confirming Snijders' opinion[9)].

Recently, lumbopelvic stability exercises performed on an unstable surface, such as a foam roll, have been shown to improve lumbar stability[10)]. Straight-leg raising exercise on a foam roll in the hook-lying position improved both trunk and lumbar stability in both fitness and clinical settings[11)]. According to Kim et al.[11)], when using an unstable round foam roll as a supporting surface, the muscles crossing the abdomen need to contract simultaneously to maintain a single-leg hold.

Although the single-leg raising effects of the pelvic belt have been reported in a previous study[9)], no studies on the pelvic belt with subjects using unstable support as a foam roll and unstable pelvic movement were found in the literature. Moreover, when clinical treatment included a pelvic belt, most of the patients improved with the belt, whereas some got worse, and no objective overall effect was established[12)]. Therefore, this study investigated the effects of a pelvic belt on the electromyography (EMG) activity of the abdominal muscles during a single-leg hold in the hook-lying position on a round foam roll. We hypothesized that wearing the pelvic belt produces decreases in trunk muscle activation.

*To whom correspondence should be addressed.
E-mail: ysrehab@inje.ac.kr

SUBJECTS AND METHODS

This study included 17 healthy female volunteers recruited from three university populations in Gimhae City, Korea. The subjects were aged 22.1 ± 1.7 years (mean ± SD) and had a height of 163.3 ± 3.2 cm and body weight of 51.9 ± 2.0 kg. All participants were healthy and had no known metabolic, neuromuscular, or musculoskeletal disorders, no history of low back pain, and no pain in any part of the body at the time of testing. The Inje University Faculty of Health Science Human Ethics Committee granted approval for this study, and all subjects provided written informed consent prior to participation. Leg dominance was determined by asking the subject to kick a ball; the kicking leg was selected as the dominant leg[13]. The dominant leg of all subjects was the right leg.

Surface EMG data were collected using a Trigno wireless EMG (Delsys, Boston, MA, USA) data acquisition system. The EMG data were collected from the rectus abdominis (RA), external oblique (EO), and internal oblique (IO) bilaterally. First, the skin was cleaned with rubbing alcohol. EMG data were collected for the RA (2 cm lateral to the umbilicus), EO (over the inferior edge of the eighth rib, superolateral to the costal margin), and IO (in the horizontal plane, 2 cm medial to the anterior superior iliac spine)[14]. The sampling rate was 2,000 Hz. The root mean square (RMS) values of the raw data were calculated, with the amplitude normalized to the maximum voluntary isometric contraction (MVIC). For each subject, the mean value of the EMG data was expressed as a percentage relative to the MVIC.

Before testing, the subjects were familiarized with the single-leg hold on round foam rolls. The training session was approximately 15 minutes long. Each subject was instructed to lie with both the head and buttocks on a round foam roll (15.2 × 91.4 cm; Sammons Preston Rolyan, Bolingbrook, IL, USA). The subject's bilateral hip and knee joints were flexed so that the lower back was flat on either the floor or foam roll (depending on the surface being tested)[11, 15]. The hip and knee joint angles were maintained at 45° and 70°, respectively, during a single-leg hold under the floor and round foam roll conditions. A target bar was placed so that the subject's ankle would touch it with full extension of the knee joint. Elastic guidelines were aligned with the lower extremity to exclude any possible hip abduction and adduction of both legs.

The single-leg hold exercise was performed on a round foam roll with and without a pelvic belt randomly. The subject was asked to extend the nondominant leg slowly and hold it steady at the target position without falling off the round foam roll. Three trials were performed, with a 30-second rest between trials. The average value for these three measurements was used for the data analysis. A 3-min rest was provided between exercises when changing from one supporting surface to the other, minimizing the chance of fatigue[16]. Muscle activity for 5 seconds of the 7-second measurement period, excluding the initial and final 1 second, was used for data analysis.

The belt was adjusted so that it was positioned below the anterior superior iliac spine[12, 17]. The entire procedure was repeated with a nonelastic pelvic belt (3221/3300, Rafys, Hengelo, The Netherlands)[6, 18].

All data were expressed as the mean and standard deviation. The paired t-test was used to test for differences in EMG activities of the subjects with and without the pelvic belt. The data were analyzed using the Statistical Package for the Social Sciences (SPSS) ver. 12.0, and the significance level was set at $p<0.05$.

Table 1. Abdominal muscle activity (%MVIC) during single-leg hold exercise (N=17)

Muscles		Without belt	With belt
		Mean±SD	Mean±SD
RA	Rt.	20.59±9.89	14.26±6.91
	Lt.	23.03±7.64	15.34±5.21
EO	Rt.	48.45±23.09	37.65±19.93
	Lt.	49.74±18.06	34.15±15.12
IO	Rt.	25.91±12.32	19.05±10.21
	Lt.	32.08±10.45	25.33±11.40

*p< 0.05
Lt, left; Rt, right; RA, rectus abdominis; EO, external obliques; IO, internal obliques

RESULTS

The EMG activity (%MVC) of all bilateral abdominal muscles (RA, EO, IO) decreased significantly ($p<0.05$) during the single-leg hold exercise on a round foam roll with the pelvic belt. The results are shown in Table 1.

DISCUSSION

This study investigated the effects of a pelvic belt on the activity of the bilateral RA, EO, and IO muscles during a single-leg hold on a round foam roll. The results showed that the pelvic belt decreased the EMG activity of the bilateral RA, EO, and IO during single-leg hold exercises on a round foam roll.

Several possible explanations exist for lesser muscle activity on a round foam roll while wearing a pelvic belt. In this study, the decreased RA, EO, and IO activity indicated that the single-leg hold at the same knee extension angle and for the same time required less effort when wearing a pelvic belt[6]. Bilateral anterior compression of the pelvis allows a patient to lift one leg with less effort[9]. When raising the leg, the mechanical effect of the RA, EO, and IO muscles is to pull the upper part of the ilium forward[19]. The pelvic belt appears to produce stabilizing anterior compression activity[20].

When participants lie on a round foam roll as compared with the floor, the contact area is smaller[11]. Therefore, lying on a smaller base of support on a round foam roll could induce greater activity of abdominal muscles than lying on the floor[11]. Our finding was in accordance with those of previous researchers demonstrating lesser muscle activity during single-leg raising on a stable surface while wearing a pelvic belt[9].

Decreasing activation of abdominal muscles on an un-

stable surface using an external support, such as a pelvic belt, is suitable to improve abdominal muscle control and improve lumbopelvic stability. Passive external support methods are mainly used for women with pelvic instability and/or pain. A study by Hu et al. found that the transverse and oblique abdominal muscles were less active with the pelvic belt in healthy subjects because these coordinated muscles are activated to press the ilia against the sacrum, creating a force closure, and the pelvic belt may have substituted for this stabilizing activity[9, 20]. The results demonstrated that the belt was effective only on a stable surface of active production of force closure and that it was not effective on an unstable surface such as a round foam roll. On the other hand, our results suggest that single-leg hold exercise with pelvic belt would be valuable for improving the effect of force closure on an unstable surface.

This study found that external support provided by a pelvic belt should be used only as an adjunct to the restoration of force closure. If transverse and oblique abdominal muscles press the ilia against the sacrum, the pelvis may move as one unit in the sagittal plane. External support with a belt can help to control the excessive translation until such time as force closure and motor control can be restored[9].

This study has some limitations. First, we did not measure the activity of the diaphragm and pelvic floor muscles as indications of primary trunk and pelvic stabilization. Second, the compression force of the pelvic belt was not controlled, although the belt was adjusted by a skilled physical therapist. In our study, we recruited healthy young women without a history of low back pain or sacroiliac joint pain; thus, our findings cannot be generalized to other populations. Lastly, we could not measure the degree of pelvic rotation during the single-leg hold.

Further studies are needed to measure the degree of pelvic rotation when subjects perform the single-leg hold on a foam roll while wearing a pelvic belt. Also, investigating a more diverse sample of normal subjects and patients with sacroiliac joint instability is required.

ACKNOWLEDGEMENT

This work (grant No. C0027363) was supported by Business for Cooperative R&D between Industry, Academy, and Research Institute funded by the Korea Small and Medium Business Administration in 2012.

REFERENCES

1) Mitchell DA, Esler DM: Pelvic instability − painful pelvic girdle in pregnancy. Aust Fam Physician, 2009, 38: 409–410. [Medline]
2) Adams MA, Dogduk N, Burton K, et al.: The biomechanics of back pain. Edinburgh: Churchill Livingstone, 2002.
3) 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]
4) Vleeming A, Albert HB, Ostgaard HC, et al.: European guidelines for the diagnosis and treatment of pelvic girdle pain. Eur Spine J, 2008, 17: 794–819. [Medline] [CrossRef]
5) Snijders CJ, Vleeming A, Stoeckart R: Transfer of lumbosacral load to iliac bones and legs. Part 1: biomechanics of self-bracing of the sacroiliac joints and its significance for treatment and exercise. Clin Biomech (Bristol, Avon), 1993, 8: 285–294. [CrossRef]
6) Pel JJ, Spoor CW, Goossens RH, et al.: Biomechanical model study of pelvic belt influence on muscle and ligament forces. J Biomech, 2008, 41: 1878–1884. [Medline] [CrossRef]
7) Verrall GM, Hamilton LA, Slavotinek JP, et al.: Hip joint range of motion reduction in sports-related chronic groin injury diagnosed as pubic bone stress injury. J Sci Med Sport, 2005, 8: 77–84. [Medline] [CrossRef]
8) Hodges PW, Richardson CA: Inefficient muscular stabilization of the lumbar spine associated with low back pain: a motor control evaluation of transvers abdominis. Spine, 1996, 21: 2640–2650. [Medline] [CrossRef]
9) Hu H, Meijer OG, van Dieën JH, et al.: Muscle activity during the active straight leg raise (ASLR), and the effects of a pelvic belt on the ASLR and on treadmill walking. J Biomech, 2010, 43: 532–539. [Medline] [CrossRef]
10) Haynes W: Core stability and the unstable platform device. J Bodyw Mov Ther, 2004, 8: 88–103. [CrossRef]
11) Kim SJ, Kwon OY, Yi CH, et al.: Comparison of abdominal muscle activity during a single-legged hold in the hook-lying position on the floor and on a round foam roll. J Athl Train, 2011, 46: 403–408. [Medline]
12) Damen L, Spoor CW, Snijders CJ, et al.: Does a pelvic belt influence sacroiliac joint laxity? Clin Biomech (Bristol, Avon), 2002, 17: 495–498. [Medline] [CrossRef]
13) Van Deun S, Staes FF, Stappaerts KH, et al.: Relationship of chronic ankle instability to muscle activation patterns during the transition from double-leg to single-leg stance. Am J Sports Med, 2007, 35: 274–281. [Medline] [CrossRef]
14) Cram JR, Kasman GS, Holtz J: Introduction to surface electromyography, 5th ed. Gaithersburg: Aspenn, 1998.
15) Creager C: Therapeutic Exercises using Foam Rollers. Berthoud: Executive Physical Therapy Inc, 1996.
16) Kendall FP, McCreary EK, Provance PG: Muscles: testing and function with posture and pain, 5th ed. Blatimore: Williams and Wilkins, 2005.
17) Lantz SA, Schultz AB: Lumbarspin orthosis wearing: II. Effect on trunk muscle myoelectric activity. Spine, 1986, 11: 838–842. [Medline] [CrossRef]
18) Mens JM, Damen L, Snijders CJ, et al.: The mechanical effect of a pelvic belt in patients with pregnancy-related pelvic pain. Clin Biomech (Bristol, Avon), 2006, 21: 122–127. [Medline] [CrossRef]
19) Viktrup L: The risk of the urinary tract symptoms five years after the first delivery. Neurourol Urodyn, 2002, 21: 2–9. [Medline] [CrossRef]
20) Richardson CA, Snijders CJ, Hides JA, et al.: The relation between the transverses abdominis muscles, sacroiliac joint mechanics, and low back pain. Spine, 2002, 27: 399–405. [Medline] [CrossRef]