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Effects of Lumbar Stabilization on Abdominal Muscles Activity During Double Straight Leg Lowering

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Abstract

To improve abdominal muscles strengthening, double straight leg lowering (DSLL) has been widely used in physical therapy, fitness program, and athletic program. The purpose of this study was to investigate the effects of the lumbar stabilization maneuver with a pressure biofeedback unit on the muscle activity of rectus abdominis (RA), external oblique (EO), and internal oblique (IO) during DSLL. Fourteen healthy young men were recruited from university population. The electromyography (EMG) activity was recorded from the RA, EO, and IO of both sides. The normalized EMG activity was compared using a paired t-test. The study showed that EMG activity in the RA, EO, and IO was significantly higher during DSLL with lumbar stabilization (DSLL-LS) compared to performed DSLL ($p<.05$). These results suggest that DSLL-LS is recommended as an effective method for strengthening exercise for the abdominal muscles.

Key Words: Double straight leg lowering; Electromyography; Lumbar stabilization.

Introduction

Adequate strength of abdominal muscle was important in order to prevent work- and sports-related lumbar injures (Ladeira et al, 2005). Therefore, many individuals perform various forms of curl (crunches), cross-curl (diagonal crunches), sit-up, and double straight leg lowering (DSLL) exercise for abdominal strengthening (Sahrmann, 2002). In these exercises, DSLL has been widely used in physical therapy, fitness program, athletic training program (Kendall et al, 1993). The DSLL exercise assesses the ability of abdominal muscle against an external load imparted by the lower extremities as they are lowered from a vertical starting position (Lanning et al, 2006). Many researchers have proposed that the DSLL offers the advantage of providing a wider potential range of resistance than the abdominal curl (Krause et al, 2005; Norris, 1993; Smidt and Blanpied, 1987).

However, without lumbar stabilization during DSLL, the pelvis could be in a position of anterior tilt with the lumbar spine extended (Krause et al, 2005). When the spine was extended, the substantial magnitude of forces by iliopsoas caused anterior shear and compression to lumbar spine (Bogduk et al, 1992). Repetitive lumbar extension or forceful shearing of the vertebrae can lead to compression injury of lumbar spine (Chosa et al, 2004). Therefore,

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many researchers suggested that lumbar spine should be maintained in a neutral range to avoid lumbar spine injury during DSLL (Carter et al, 2006; Durall and Manske, 2005; Richardson et al, 2004). The lumbar spine in neutral range have been advocated to be advantageous for preventing injury and for enhancing DSLL performance (Herring and Weinstein, 1995) Also, if lumbar spine and pelvic movement presented during DSLL, abdominal muscles length extended. It would be difficult to strength abdominal muscles by muscle-length tension relationship (Sahrmann, 2002). Especially when person with back pain performs DSLL, lumbar extension and anterior pelvic tilt can be easily induced. These movements imposed stress to lumbar spine (Sahrmann, 2002). Therefore, Sahrmann (2002) emphasized lumbar stabilization that maintains lumbar and pelvic position during leg loading.

Traditionally, lumbar stabilization during resistive exercise was achieved by the therapist's hands, therapeutic belts, or straps. However, it has been difficult to evaluate the effects of lumbar stabilization during exercise because of the lack of appropriate measurement methods (Oh et al, 2007). We used the method of lumbar stabilization using a pressure biofeedback unit. Currently, a pressure biofeedback unit, originally developed for assessing the ability of abdominal muscles to actively stabilize the lumbar spine, has been used to examine lumbar stabilization in various studies (Cynn et al, 2006; Oh et al, 2007). Also, it has been used to develop a method for the careful monitoring of lumbar stabilization. The pressure biofeedback unit consists of an inflatable cushion connected to a pressure gauge and an inflation device (Jull et al, 1993). When the pressure biofeedback unit is placed and inflated, the subject is required to maintain the desired pressure and a constant lumbar position during lower-extremity movement under external loads. In addition, Changes in the pressure during lower-extremity movement reflect an inability to maintain isometric contraction of the abdominal muscle, resulting in uncontrolled movement and instability of the lumbar spine (Cynn et al, 2006).

Although, many therapists emphasize lumbar stabilization technique during DSLL to improve abdominal muscle strength, there is no information on how effective a DSLL with a pressure biofeedback unit is to control motion and how it may alter the activation level of related muscles. Therefore, this study investigated the effects of the lumbar stabilization maneuver with a pressure biofeedback unit on the muscle activity of RA, EO, and IO during DSLL. Based on published reports and clinical experience, we hypothesized that muscle activity of RA, EO, IO would be increased with the lumbar spine and pelvis stabilization with a pressure biofeedback unit.

Methods

Subjects

Fourteen healthy young men were recruited from Yonsei University, Korea. The subject had a mean age of 24.3±2.8 years, a mean weight of 69.8±4.3 ㎏, and a mean height of 171.2±5.2 ㎝. The subjects participated regularly in physical activities and had no history of low back pain, or of neuromuscular disorders. The subjects were able to perform painless DSLL in supine position. Before the study, the principal investigator explained all the procedures to the subjects in detail.

Surface Electromyographic Recording and Data Analysis

EMG data were collected using a Biopac MP100WSW[1] data acquisition system and a Bagnoli EMG system[2]. The skin was cleaned with rubbing alcohol, and disposable Ag-AgCl surface electrodes were positioned at an inter-electrode distance of 2 ㎝. The reference electrode was attached to the styloid process of the ulna on the dominant upper

1) Biopac System Inc., Goleta, CA, U.S.A.
2) Delsys Inc., Boston., MA, U.S.A.

Figure 1. Double straight leg lowering in (A) Preferred double straight leg lowering (P-DSLL) and (B) Double straight leg lowering with lumbar stabilization (DSLL-LS).

extremity. EMG data were collected for the following muscles: rectus abdominis (2 ㎝ lateral to the umbilicus), external oblique (on the inferior edge of the 8th rib, superolateral to the costal margin), and internal oblique (in the horizontal plane, 2 ㎝ medial to the anterior superior iliac spine). The sampling rate was 1000 ㎐. The EMG signal was amplified with an overall of 1000 and digitized using Acqknowledge software, version 3.7.2 (Biopac System Inc., Goleta, CA, U.S.A.). Bandpass (20~450 ㎐) and notch filters (60 ㎐) were used. The raw data were processed into the root mean square (RMS) and converted to ASCII files for analysis. For normalization, the mean RMS of 3 trials of 5-second maximal voluntary isometric contraction (MVIC) was calculated for each muscle. The manual muscle testing position for the MVIC were those recommended by Kendall et al (2006). For the testing of DSLL, the EMG signal was collected for 5 seconds, while the hip was maintained in 60° of hip flexion. The data for each trial were expressed as a percentage of calculated means RMS of the MVIC (%MVIC), and the mean %MVIC of 3 trials was used for analysis.

Procedures

Before testing, the researchers explained the testing procedure to the subjects. Each subject was instructed to assume supine position on a firm mattress. The researchers assisted the subject to an initial position in 90° hip flexion. The knees were allowed to flex slightly to reduce the passive tension on the hamstring muscles which would tend to rotate the pelvis posteriorly. From the initial position, the subject was asked to perform DSLL in both the preferred double straight leg lowering (P-DSLL) condition and the double straight leg lowering with lumbar stabilization (DSLL-LS) condition in random order (Figure 1). In the DSLL-LS condition, a pressure biofeedback unit[3] was placed between the firm mattress and the subject's lumbar spine in the supine position (Figure 2). The target pressure was determined at 40 ㎜Hg. Subjects were instructed to use the visual feedback provided by the analog gauge of the pressure biofeedback unit in order to maintain the determined target pressure during DSLL. A researcher monitored the pressure fluctuations. Pressure change of ±10 ㎜Hg was excluded from the data collection. A goniometer was used to determine when the hip was in 60° of flexion. A bar was placed at this level and provided feedback to the subject as they were instructed to lower their legs until both heel touched the bar and to hold the position for 5 seconds. A 5-minute rest was given between the 2 conditions.

Statistical Analysis

The data are expressed as the mean±standard deviation (SD). The significance of the difference between two conditions was assessed using a paired t-test with the significance level set at .05.

3) Chattanooga Group, TN, U.S.A.

Figure 2. Pressure biofeedback.

Results

The study showed that EMG activity in the RA, EO, and IO increased significantly during DSLL-LS ($p<.05$). The result were shown in Table 1 ($p<.05$) (Figure 3).

Discussion

The purpose of this study was to investigate the effects of the lumbar stabilization maneuver with a biofeedback unit on the muscle activity of RA, EO, and IO during DSLL. Although many previous studies have reported the effects of DSLL, our study is the first to determine the effects of the lumbar stabilization maneuver with a pressure biofeedback unit on abdominal muscles activity during DSLL. We found significantly increased activity of abdominal muscles in DSLL-LS. It is possible to understand why the abdominal muscles activity increases during DSLL-LS. DSLL-LS was focused on maintaining of the lumbar spine and pelvic movement by using biofeedback unit. During DSLL-LS, the abdominal muscles resist the pull of hip flexor muscles in order to maintain proper alignment of both the lumbar spine and pelvis (Szasz et al, 2002). Therefore, it is necessary to maintain optimum abdominal muscle length. According to muscle length-tension relationship, the optimum muscle length allows to generate maximum muscle force (Chang et al, 1999). Therefore, DSLL-LS is effective in promoting an isometric abdominal muscles contraction to stabilize the lumbar spine and pelvis.

The IO muscle activity suggested to contribute the stability of the lumbar spine. The lateral fiber of IO muscle originate from the middle one third of the intermediate line of the iliac crest and thoracolumbar fascia. These attachment reinforces the stability of the lumbar spine by increasing intra abdominal pressure or by increasing tension in the lumbar dorsal fascia (Neumann, 2002).

Both DSLL and DSLL-LS apparently require high external oblique muscle activity than other abdominal muscles. The origin of this muscle from the rib cage and its insertion into the pelvis are consistent with the most effective action of this muscle, that is, the posterior tilt of the pelvis (Sahrmann, 2002). The external oblique is referred to as a lower abdominal

Table 1. Comparison of electromyography in abdominal muscles

Muscles		P-DSLL[a]	DSLL-LS[b]	t	p
		Mean±SD	Mean±SD		
Rectus abdominis	Rt.	14.17±4.79	40.09±13.97	-7.51	.000
	Lt.	12.85±5.30	40.13±13.97	-8.77	.000
External oblique	Rt.	29.52±8.87	61.26±17.26	-9.34	.000
	Lt.	31.55±7.86	69.07±16.05	-11.41	.000
Internal oblique	Rt.	14.13±6.96	43.86±20.51	-5.95	.000
	Lt.	13.03±7.79	39.57±16.95	-5.71	.000

[a]P-DSLL: preferred double straight leg lowering.
[b]DSLL-LS: double straight leg lowering with lumbar stabilization.

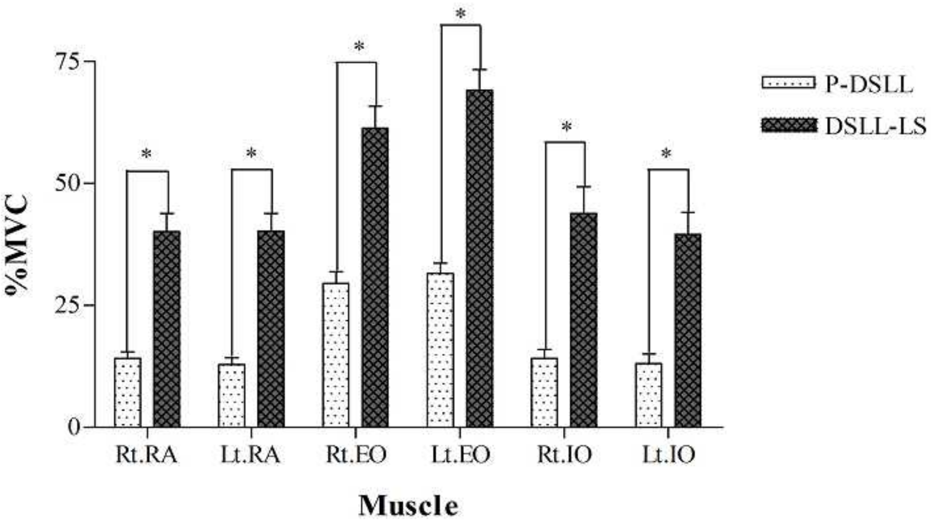

Figure 3. The %MVIC data of the abdominal muscles between double straight leg lowering with lumbar stabilization (DSLL-LS) and preferred double straight leg lowering (P-DSLL). RA: rectus abdominis, EO: external oblique, IO: internal oblique (*p<.05).

muscle because its angle of pull controls the lower half of the body by tilting the pelvis posteriorly (Kendall, 1993). Also, RA is considered an essential component for maintaining the pelvis posteriorly. The RA muscle originates from the pubic crest and symphysis pubis. The fibers runs longitudinally from pubic crest and symphysis to costal cartilage and sternum (Neumann, 2002). Thus, this muscle could have led to maintain posterior pelvic tilt.

Zannotti (2002) questioned the subjectivity of pelvic monitoring because of early pelvic movement in the DSLL. To detect rocking the pelvis, we used the method of lumbar stabilization using a pressure biofeedback unit which gives immediate feedback of any change in lumbar and pelvic movement. The subjects were instructed to maintain 40 ㎜Hg pressure during DSLL-LS. This method maintains proper alignment of the lumbar spine and pelvis. Although the position of the lumbar spine and pelvis may explain the discrepancy between the published findings and clinical observation, clinicians regard the ability to maintain the posterior pelvic tilt through isometric contraction of the abdominal muscles as key to the successful performance of the DSLL (Shields and Heiss, 1997). Therefore, DSLL-LS is an effective method which keeps the position of lumbar spine and pelvis.

Our study had several limitations. First, because we did not use kinematic device for pelvic movement, we do not know whether pelvic movement occurred during DSLL. Second, because the activity of the transversus abdominis was not measured in our study, we can not confirm that lumbar stabilization was achieved during DSLL. Therefore, further studies are warranted to assess deep muscle activity during DSLL with lumbar stabilization. Third, our results cannot be generalized to other populations because all the subjects who participated in the study were healthy young individuals. Therefore, the benefits of the lumbar stabilization maneuver using a pressure biofeedback unit during DSLL should be confirmed in other patient populations. Fourth, surface EMG was used to monitor muscle activity, leaving the possibility of crosstalk from adjacent muscles. Fifth, we collected EMG data at target angle of 60° during DSLL in our study. Therefore, further studies are needed to measure the muscles activity at various degrees of hip flexion.

Conclusion

This study investigated the effects of the lumbar stabilization maneuver with biofeedback unit on the muscle activity of RA, EO, and IO during DSLL. We found that the activity of RA, EO, and IO was significantly higher during DSLL-LS compared to preferred DSLL. Therefore, lumbar stabilization is recommended as an effective method for excluding unwanted lumbar extension and pelvic movement during DSLL.

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