

## The Effects of Leg Raising with Voluntary Lumbo-pelvic Contraction on Abdominal Muscle Activation

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### 허리 골반의 수의적 조절을 병행한 다리 들기가 배근육 활성화에 미치는 영향

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#### | 국문초록 |

**연구목적:** 본 연구는 허리 골반의 수의적 조절을 동반한 다리 들기 운동이 배 근육에 미치는 영향을 알아보기 위하여 엉덩 관절의 벌림 각도에 따라 다리 들기 시 배근육의 활성도를 확인하였다.

**연구방법:** 20대 정상성인을 대상으로 엉덩 관절 벌림 각도(0°, 30°)에서 압력 센서 사용 그룹과 사용하지 않는 그룹으로 나누어 다리 들기를 실시하는 동안 복부 근육의 근활성도를 측정하였다.

**연구결과:** 엉덩 관절 벌림 0°와 30° 모두에서 오른쪽 다리를 들어 올리는 동안 반대측 내복사근과 동측 외복사근에서 수의적 조절을 한 그룹과 하지 않은 그룹 사이에 통계적인 유의한 차이를 보였다(p<.05).

**결론:** 허리 골반의 수의적 조절을 통한 다리 들기 시 몸

통 안정성의 증가를 통하여 안정적인 배 근육 강화 훈련을 수행 할 수 있을 것으로 생각되며 요통 환자에게도 안정적인 임상적용이 기대된다.

**주제어:** 다리 들기, 수의적 수축, 허리 골반

#### I . Introduction

The abdominal muscles that comprise the rectus abdominis, the external oblique, the internal oblique, and the transverse abdominis are attached to the body from the surface layer to the deep layer with bilateral symmetry. These muscles not only serve important roles in trunk movements such as trunk bending and turning but also are involved in respiration and serve important functions maintaining trunk stability while the upper and lower extremities are moving(Neumann, 2002; Richardson et al., 2004).

Abdominal muscles contract in order to control the trunk when the lower extremities move. Since low back pain

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patients have problems in this action, method to train muscles that affect trunk control were widely used based on active participation of patients(Kim et al., 2006).

Of them, leg raising in a supine position is a training method to strengthen trunk muscles using external resistance caused by leg weight that may break the static balance of the trunk and induce un-wanted movements of the pelvis(Neumann, 2002; Sahrmann, 2002). However, the leg raising exercise may cause trunk instability by providing strong external resistance there by inducing un-wanted movements. Since individual abdominal muscles have diverse muscle fiber running directions, different muscle activities may appear against given loads depending on leg moving directions. In particular, since the external oblique and the internal oblique act jointly to control trunk turning and resist against turning caused by leg weight(Kim et al., 2007), these muscles are considered to be greatly affected by the abduction angles of the hip joint. Although previous studies reported that during one leg raising, as hip joint abduction angles increased, the muscle activity of the ipsilateral external oblique increased, it was said that this result appeared because the leg raising was performed in a comfortable state without any voluntary control of the trunk or the pelvis(Park, 2011).

Therefore, leg raising combined with voluntary control should be able to further activate trunk muscle movements. Therefore, the present study was to examine differences in the muscle activity of the external oblique and the internal oblique between when performing one leg raising in a supine position while voluntarily controlling the stability of the lumbar-pelvic regions by applying a pressure sensor(Stabilizer bio-feedback) to the waist forward bending region and when performing one leg raising in a comfortable position without any voluntary control at different hip joint opening angles.

## II. Methods

### 1. Study subjects

The subjects of the present study were 19 adult males and females who voluntarily agreed to participate in the present study among those who had not experienced low back pain for the last six months. As for the general characteristics of the subjects of the present study, of the 19 subjects, 10 were males and 9 were females, the subjects' average age was  $23.69 \pm 2.00$  years, average height was  $164.47 \pm 8.83$ cm, and average weight was  $58.15 \pm 10.93$ kg.

### 2. Measurement position and procedure

The subjects randomly selected memo pads in which hip joint opening angles( $0^\circ$ ,  $30^\circ$ ) and whether a pressure sensor is to be used or not were written to perform leg raising pursuant to the memo pads selected by them. To make the subjects' leg raising heights the same, the subjects performed leg raising to the point 10cm above the ground(Park, 2012).

Each of the subjects took a supine position on a table marked with a hip joint opening angle, placed his/her right leg along the line that indicated the opening angle and performed leg raising in a comfortable position when the pressure sensor(Stabilizer bio-feedback) was not used. When the pressure sensor was used, it was applied to the subject lumbar forward bending region. The pressure of the pressure sensor was increased to the point at which the subject felt comfortable and the subject raised his/her leg to the point 10cm above the ground and maintained the leg while monitoring the gradation of the pressure sensor to maximally prevent the gradation from moving.

### 3. Muscle activity measuring method

Abdominal muscles' muscle activity was used using a surface electromyography system Noraxon relemyo 2400(USA). The surface electromyography signal sampling rate was set to 1,000Hz and as the frequency band width,

20~450Hz which is the measurement frequency band filter of Noraxon EMG systems was used. Before measurement, foreign substances on electrode attachment points were removed using alcohol swabs and surface electrodes were attached to both sides of the external oblique and the internal oblique.

Muscle activity signals were measured while the raised leg was maintained for 10 seconds in each position. Among the values obtained as such, values for five seconds were used to calculate root mean square(RMS) values and the values were normalized into ratios to the maximum voluntary isometric contraction(%MVIC) for individual muscles to conduct comparison and analysis.

#### 4. Data processing and analysis

Collected data were statistically processed using the SPSS Win 2.0 statistical program. The subjects' general characteristics were checked through percentage and frequency analyses and differences in the muscle activity of each muscle between when there was voluntary control using a pressure sensor and when there was no voluntary control at different hip joint angles were analyzed using independent sample t-tests. The statistical significance level was set to  $\alpha=.05$ .

### III. Results

In the present study, muscle activity during leg raising combined with voluntary control of the trunk and muscle activity during leg raising without any voluntary control at different hip joint abduction angles were compared.

In positions without any hip joint abduction, the muscle activity of the contralateral internal oblique was  $14.05\pm 4.25$  during right leg raising combined with voluntary control of the trunk and  $4.53\pm .70$  during right leg raising without any voluntary control and these values were shown to be statistically significantly different. The muscle activity of

the ipsilateral internal oblique was  $30.39\pm 5.20$  during right leg raising combined with voluntary control of the trunk and  $4.53\pm .70$  during right leg raising without any voluntary control and these values were shown to be statistically significantly different ( $p<.05$ ) (Table 1).

Table 1. Comparison of abdominal muscle activation between 'with control' and 'without control' according to hip abduction angle during single leg raising

(unit : %MVIC)

|               | muscle | without control | with control | p     |
|---------------|--------|-----------------|--------------|-------|
| abduction 0°  | LEO    | 16.68±5.65      | 29.82±7.48   | .170  |
|               | LIO    | 4.53±0.70       | 14.05±4.25   | .034* |
|               | REO    | 16.99±3.17      | 30.39±5.20   | .034* |
|               | RIO    | 19.31±5.06      | 24.91±4.57   | .417  |
| abduction 30° | LEO    | 33.78±5.98      | 92.23±31.25  | .075  |
|               | LIO    | 12.74±1.92      | 28.67±6.19   | .019* |
|               | REO    | 44.09±9.89      | 96.41±18.23  | .016* |
|               | RIO    | 36.02±9.49      | 58.70±11.03  | .128  |

LEO: left external oblique, LIO: left internal oblique, REO; right external oblique, RIO: right internal oblique

\* : Statistically significant at the level of  $p<.05$

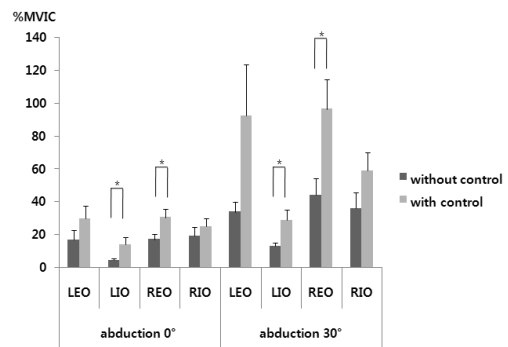


Fig. 1. Comparison of abdominal muscle activation between 'with control' and 'without control' according to hip abduction angle during single leg raising

In 30° hip joint abduction positions, the muscle activity of the contralateral internal oblique was  $28.67 \pm 6.19$  during right leg raising combined with voluntary control of the trunk and  $12.74 \pm 1.92$  during right leg raising without any voluntary control and these values were shown to be statistically significantly different. The muscle activity of the ipsilateral internal oblique was  $96.41 \pm 18.23$  during right leg raising combined with voluntary control of the trunk and  $44.09 \pm 9.89$  during right leg raising without any voluntary control and these values were shown to be statistically significantly different. ( $p < .05$ ) (Table 1).

#### IV. Discussion

In terms of functional anatomy, the external oblique muscle is located on the lateral side of the trunk and serves the role of contralaterally turning the trunk by contraction and is involved in trunk pressure control together with the transverse abdominalis muscle. The internal oblique muscle serves the role of ipsilaterally turning the trunk by contraction and is involved in trunk pressure control together with the transverse abdominalis muscle. (Houlum and Bertoti, 2012). The external oblique and internal oblique muscles serve the role of controlling the stability of the trunk through co-contraction. Such stability control is necessary to maintain static positions when the legs are moving.

Therefore, in the present study, the effects of the provision of stability through a stabilizer during abdominal muscle strengthening exercises through leg raising on the abdominal muscles were examined. According to the results of the present study, leg raising exercises using a stabilizer enhanced the activity of all of the left external oblique, the left internal oblique, the right external oblique, and the right internal oblique muscle at both hip joint abduction angles of 0° and 30°. Of these muscles, the left internal oblique and the right external oblique showed statistically significant differences.

Given these results, the use of the stabilizer seems to have helped maintaining the balance of the pelvis while maintaining stability even in environments where external force might induce trunk instability. The weight of the raised leg acted as external resistance to break trunk stability and this was resisted by the joint action to prevent the rotation of the trunk and the pelvis of the activation of the left internal oblique and right external oblique muscles increased through the voluntary control using a stabilizer. Given these results, the voluntary control is considered to be able to reduce lumbar region instability that may occur during abdominal muscle strengthening exercises for improving trunk stability proposed in previous studies. The strengthening exercise training method combined with voluntary active control is considered to be widely used on low back pain patients with declined proprioceptive senses.

#### V. Conclusion

Given the results of the present study, stable abdominal muscle strengthening exercises can be performed through voluntary control of the trunk and the pelvis during leg raising and stable clinical application of voluntary control of the trunk and the pelvis to low back patients is expected.

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