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Effects of Tensor Fasciae Latae–Iliotibial Band Self–Stretching on Lumbopelvic Movement Patterns During Active Prone Hip Lateral Rotation in Subjects With Lumbar Extension Rotation Syndrome

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Abstract

The purpose of this study was to identify the effects of tensor fasciae latae-iliotibial band (TFL-ITB) self-stretching exercise on the lumbopelvic movement patterns during active prone hip lateral rotation (HLR) in subjects with lumbar extension rotation syndrome accompanying TFL-ITB shortness. Eleven subjects (9 male and 2 female) were recruited for the two-week study. A three dimensional ultrasonic motion analysis system was used to measure the lumbopelvic movement patterns. The TFL-ITB length was measured using the modified Ober's test and was expressed as the hip horizontal adduction angle. The subjects were instructed how to perform TFL-ITB self-stretching exercise program at home. A paired t-test was performed to determine the significant difference in the angle of lumbopelvic rotation, movement onset time of lumbopelvic rotation, TFL-ITB length, and LBP intensity before and after the two-week period of performing the TFL-ITB self-stretching exercise. The results showed that after the intervention, the lumbopelvic rotation angle decreased significantly ($p<.05$), the movement onset time reduced significantly ($p<.05$), and LBP intensity decreased slightly but not significantly ($p=.07$). The hip horizontal adduction angle increased significantly ($p<.05$) after the intervention. These findings indicate that TFL-ITB stretching exercise increased TFL-ITB length, decreased lumbopelvic rotation angle, and delayed the movement onset time of lumbopelvic rotation after two-weeks. In conclusion, the TFL-ITB self-stretching exercise performed over a period of two weeks may be an effective approach for patients with lumbar extension rotation syndrome accompanying TFL-ITB shortness.

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Key Words: Lumbar Extension Rotation Syndrome; Lumbopelvic Movement Patterns; Tensor Fasciae Latae-Iliotibial Band.

Introduction

Low back pain (LBP) is a common musculoskeletal disorder that has an estimated lifetime prevalence of 60~80% in around 15% of the adult population at any one time (Krismer and van Tulder, 2007). LBP is defined as pain in the area between the 12th thoracic vertebra and the gluteal fold (Hoffman et al, 2012; Krismer and van Tulder, 2007). Recent studies have differentiated LBP subgroups among individuals with mechanical LBP (Gombatto et al, 2008; Harris-Hayes and Van Dillen, 2009; Van Dillen et al, 2007). Some investigators developed classification systems to categorize patients with me-

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chanical LBP for homogenous subgroups (McKenzie and May, 2003; O'Sullivan, 2005; Sahrmann, 2002). One classification system is the movement system impairment (MSI) classification system based on movement impairment, and dividing LBP into five subgroups (Sahrmann, 2002). Among the five subgroups, lumbar extension rotation syndrome is the most prevalent category (Sahrmann, 2002).

Sahrmann (2002) stated that people with lumbar extension rotation syndrome showed lumbopelvic rotation during the active hip lateral rotation (HLR) test in the prone position. During the HLR test, increased lumbopelvic rotation occurs in the early part of the HLR movement (Burnett et al, 2004; Gombatto et al, 2006; Hoffman et al, 2011; Luomajoki et al, 2008; Roussel et al, 2009; Shum et al, 2005). The relationship between LBP and limited hip movement is of interest because reduced hip movement leads to compensatory lumbopelvic motion, thus contributing to increased forces in the lumbar region (Ellison et al, 1990; Mellin, 1990; Vad et al, 2004). The increased forces result in low magnitude loading, cumulative microtrauma, increased tissue stress in the lumbopelvic region, and eventually LBP symptoms (McGill, 1997; Sahrmann, 2002).

The tensor fascia latae-iliotibial band (TFL-ITB) shortness contributes to limited HLR and increased lumbopelvic motion in the transverse plane in patients with LBP (Sahrmann, 2002). TFL-ITB acts as a flexor, abductor, and medial rotator of the hip joint, extensor, and lateral rotator of the knee joint (Kendall et al, 2005). The altered TFL-ITB length gives rise to compensatory motions and the development of movement impairment in the lumbopelvic region. Fredericson et al (2002) recommended that TFL-ITB self-stretching in upright standing position with overhead arm extension is effective in lengthening TFL-ITB. However, the effects of the TFL-ITB stretching exercise on lumbopelvic movement patterns (amounts of lumbopelvic rotation angle and movement onset time of lumbopelvic rotation) in subjects with lumbar extension rotation syndrome during active HLR are unknown.

The aim of this study was to identify the effects of TFL-ITB self-stretching exercise performed for two weeks on the lumbopelvic movement patterns during active prone HLR in people with lumbar extension rotation syndrome accompanying TFL-ITB shortness. It was hypothesized that TFL-ITB length would increase, lumbopelvic rotation angle would decrease, movement onset time of lumbopelvic rotation would be delayed, and LBP intensity would decrease during active HLR following the TFL-ITB self-stretching exercise performed over two weeks.

Methods

Subjects

A priori power analysis with G*Power ver. 3.1.5 software (Franz Faul, University of Kiel, Germany) was performed to calculate the sample size. The data of a pilot study of four subjects was used to achieve the effect size of 1.72, the alpha level of 5%, and the power of 80%. The calculated sample was 5. A sample of 11 subjects with lumbar extension rotation syndrome accompanying TFL-ITB shortness (9 male and 2 female) voluntarily participated. All study subjects reported LBP of more than six months (Von Korff, 1994). Subjects with limited range of hip adduction in the horizontal plane (<10°) caused by TFL-ITB shortness (Kendall et al, 2005) were included. We selected the subjects based on MSI classification criteria for lumbar extension rotation syndrome (Sahrmann, 2002; Trudelle-Jackson et al,

Table 1. General characteristics of subjects (N=11)

Parameter	Mean±SD
Age (yrs)	23.3±1.8
Height (㎝)	171.6±7.2
Weight (㎏)	69.0±13.5
BMI[a] (kg/㎡)	23.2±3.3
Active HLR[b] (°)	44.5±5.6

[a]body mass index, [b]hip lateral rotation.

Figure 1. Prone position with the tested knee flexed 90°.

Figure 2. Knee locking thermoplastic splint.

2008; Van Dillen et al, 1998). These classification criteria consist of alignment and movement tests. Primary tests are provocation tests that are designed to assess movements or stresses in extension and rotation motion. Secondary tests are confirming tests that are designed to correct or inhibit the extension and rotation motion. If the primary test is positive, the secondary test is performed. When movement or symptom reduced in the secondary test, finally it is confirmed as positive. A previous study reported that the percentage agreement was 65% to 100%, the kappa values ranged from .00 to .89 for alignment and movement, and the percentages of inter-rater agreement were 98% to 100%. The kappa values ranged from .87 to 1.00 for the symptom behavior items (Van Dillen et al, 1998). The exclusion criteria for the study were as follows: 1) iliopsoas muscle shortness; 2) rectus femoris muscle shortness; 3) antetorsion or retrotorsion of femur; 4) a significant weakness of the posterior gluteus medius; 5) visually fixed kyphosis or scoliosis; and 6) a history of spinal fracture or surgery, ankylosing spondylitis, spinal deformity, pain or parasthesia below the knee, systemic inflammatory problem, or other serious musculoskeletal problem that could affect the ability to move. The protocol for this study was approved by the Yonsei University Wonju Campus Human Studies Committee. All subjects provided written informed consent to participate in the study. The general characteristics of subjects are presented in Table 1.

Instruments

Three-dimensional motion analysis system

The three-dimensional ultrasonic motion analysis system[1)] was used to measure amounts of lumbopelvic rotation angle, and movement onset times of lumbopelvic rotation during active HLR in prone position. Two sets of ultrasound triple markers were used. One triple active marker was placed at the midline of the pelvis by fastening a strap passing around the pelvis at the level of both posterior superior iliac spines (Cynn et al, 2006; Oh et al, 2007; Park et al, 2011). The other triple active marker was placed under the lateral malleolus of fibula to measure HLR. A measuring sensor consisting of three microphones was positioned next to the test side of the subject to record the ultrasonic signal from the markers. The prone position with the knee flexed 90° was calibrated to zero as a reference position (Gombatto et al, 2006) (Figure 1). The sampling rate was 20 ㎐.

Knee locking thermoplastic splint

The knee locking thermoplastic splint[2)] was applied around the tested knee joint to minimize excessive

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1) CMS-HS, Zebris, Medizintechnik, Isny, Germany.
2) KLARITY Elastic, Klarity Medical & Equipment (GZ) Co. Ltd., Lan Yu, China.

tibial movement, which can be caused by knee joint ligament laxity (Figure 2). We made two different thermoplastic splints for male and female subjects to accommodate the gender difference in circumference and width of the knee joint.

Procedures

Procedures included clinical measures for subject selection and then laboratory measures for the HLR movement test. Subjects first completed the following clinical measures: 1) the modified Ober's test for the TFL-ITB length; and 2) the standard 100 ㎜ visual analogue scale (VAS) for LBP intensity. Subjects then completed the laboratory measures.

A. Clinical measures

1) TFL-ITB length

The modified Ober's test was conducted by two examiners to assess the TFL-ITB length (Kendall et al, 2005). The subjects were asked to lie in the side-lying position with flexed hip and knee of the non-tested lower extremity to flatten the low back. One examiner then placed an inclinometer[3] on the distal lateral thigh of the tested lower extremity (Melchione and Sullivan, 1993). The tested lower extremity was held at the knee throughout the tests, with the level of horizontal line defined 0° before passive adduction occurred; this was measured using the inclinometer, as was the final position (Herrington et al, 2006). To measure the amount of hip adduction, the tested hip was then extended and lowered from the starting position. The examiner tried to prevent internal rotation of the subject's hip joint to measure the amount of hip adduction accurately. The other examiner tried to stabilize the subject's pelvis to prevent lateral pelvic tilt. The positive sign of the modified Ober's test was that the tested lower extremity remained abducted and did not fall toward the floor. In other words, if the tested lower extremity dropped less than 10° below the horizontal line, it was interpreted as a positive sign (Kendall et al, 2005). A previous study reported good intrarater and interrater reliability for the modified Ober's test (intraclass correlation coefficient; ICC=.94 and .73, respectively) (Melchione and Sullivan, 1993).

2) LBP intensity

The standard 100 ㎜ VAS was used to assess the LBP intensity. The VAS line was presented with "no pain" at the 0 end and "worse pain imaginable" at the 100 ㎜ end. The subjects were instructed to mark their pain level on the line.

B. Laboratory measures

The subject was required to assume a prone position with tested knee flexed at 90° (Gombatto et al, 2006) (Figure 1). If the subject had TFL-ITB shortness of both lower extremities, the shorter lower extremity was determined as the test side. The non-tested lower extremity was positioned in full hip and knee extension.

The laboratory procedures were as follows: 1) the amount of active HLR was determined by asking the subject to laterally rotate the hip as far as possible; 2) the target bar was positioned at 50% of the maximum amount of active HLR, so that excessive stretching of the soft tissue of the hip was prevented and tactile feedback was provided to stop active HLR when the lateral aspect of the foot touched the target bar. The subjects were given 10 seconds to complete this movement (initial 5 seconds, moving to target position; last 5 seconds, staying in the target position). A metronome was used to control the speed and duration of the movement. The starting signal was provided by a beeper sound using the Noraxon TeleMyo system (Noraxon TeleMyo 2400T, Noraxon Inc., Scottsdale, AZ, U.S.A.) (Park et al, 2011).

Prior to testing, all subjects were familiarized with the standard position and movement for approx-

3) Johnson Magnetic Angle Locator, Johnson, Mequon, WI, U.S.A.

imately 30 minutes. To minimize muscle fatigue, the subjects were instructed to rest for 10 minutes after the familiarization session.

Intervention

The TFL-ITB self-stretching exercise was performed as a home exercise program (Figure 3). The subjects were instructed to perform TFL-ITB self-stretching as follows: 2 sets of 10 repetitions a day, 7 days a week, over a 2-week period. The subject assumed a standing position with the hands clasped overhead. The leg to be stretched was extended, adducted, and externally rotated and then placed behind the non-tested leg. The subject exhaled while slowly laterally bending the trunk in the direction opposite the tested leg (Fredericson et al, 2002). The subjects were asked to sustain this stretched position for 10 seconds and then rest for two minutes between each set. The subjects were informed that if the TFL-ITB self-stretching exercise induced sharp pain or discomfort in lumbopelvic region, the hip joint exercise should be stopped. The subjects were also informed that muscle fatigue and stretching sensation at the TFL-ITB could be expected after each stretching session.

Data collection

The kinematic data were collected and analyzed by Win-data ver. 2.19 software (Zebris, Medizintechnik, Isny, Germany) at pre- and post-intervention sessions. The mean of three trials was calculated for the amount of lumbopelvic rotation angle and the movement onset time of lumbopelvic rotation. We collected the lumbopelvic rotation angle at the final 5 seconds. Movement onset time was defined the time when the angle of lumbopelvic movement exceeded a threshold of 1° (Gombatto et al, 2006). In addition, the ICC (3,1) was used to calculate the intra-rater reliability of the active HLR and lumbopelvic rotation in the pre-intervention session. The intra-rater reliability of the active HLR and lumbopelvic rotation was excellent (ICC=.97 and .92).

Figure 3. Tensor fasciae latae-iliotibial band (TFL-ITB) self-stretching exercise.

Statistical Analysis

Statistical analysis was performed using the PASW ver. 18.0 software (SPSS, Inc., Chicago, IL, U.S.A.). Descriptive statistics were calculated for all variables. The one-sample Kolmogorov-Smirnov test was performed to determine whether continuous data approximated a normal distribution. The paired t-test was used to compare differences in TFL-ITB length, the amount of lumbopelvic rotation angle, movement onset time of lumbopelvic rotation, and VAS between pre- and post-intervention sessions. The level of significance was set at α=.05.

Results

The hip horizontal adduction angle increased significantly after two-week TFL-ITB self-stretching exercise (pre-intervention=8.27±1.48°; post-intervention=11.00±1.61°; mean difference=2.73°; $p<.001$) (Table 2). The hip horizontal adduction angle measured using the modified Ober's test and expressed TFL-ITB length. The lumbopelvic rotation angle de-

Table 2. Lumbopelvic rotation angle, movement onset time, tensor fasciae latae-iliotibial band length, and visual analogue scale (N=11)

Outcome measures	Pre-intervention	Post-intervention	Mean difference	t	p
TFL-ITB[a] length (°)	8.27±1.48[c]	11.00±1.61	2.73	10.00	<.001
Lumbopelvic rotation angle (°)	5.41±.88	4.30±.65	-1.11	-14.70	<.001
Movement onset time (sec.)	1.33±.14	1.66±.24	.33	3.34	.007
VAS[b] (㎜)	56.36±9.24	52.72±8.76	-3.64	-2.02	.070

[a]tensor fasciae latae-iliotibial band, [b]visual analogue scale, [c]mean±standard deviation.

creased significantly after two-week TFL-ITB self-stretching exercise (pre-intervention=5.41±.88°; post-intervention=4.30±.65°; mean difference=-1.11°; p<.001) (Table 2) (Figure 4). The lumbopelvic movement onset time reduced significantly after two-week TFL-ITB self-stretching exercise (pre-intervention=1.33±.14 sec.; post-intervention=1.66±.24 sec.; mean difference=.33 sec.; p=.007) (Table 2) (Figure 4). The VAS decreased, but not significantly after two-week TFL-ITB self-stretching exercise (pre-intervention=56.36±9.24 ㎜; post-intervention=52.72±8.76 ㎜; mean difference=-3.64 ㎜; p=.070) (Table 2).

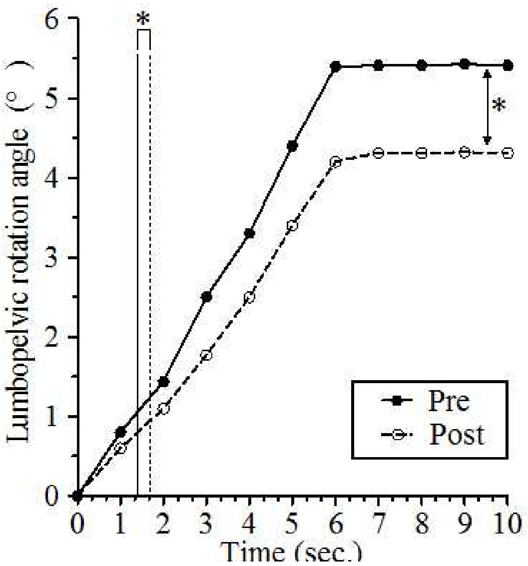

Figure 4. Lumbopelvic rotation angle and movement onset time during hip lateral rotation (HLR) (vertical solid line: onset time of pre-intervention, vertical dotted line: onset time of post-intervention) (*p<.05).

Discussion

TFL-ITB shortness contributes to limited HLR and increased lumbopelvic motion in the transverse plane in patients with LBP (Sahrmann, 2002). Therefore, the current study was undertaken to determine the effect the two-week TFL-ITB self-stretching exercise on TFL-ITB length, amounts of lumbopelvic rotation angle, movement onset time of lumbopelvic rotation, and LBP intensity in patients with lumbar extension rotation syndrome. To our knowledge, this is the first study to show that the two-week TFL-ITB self-stretching exercise significantly elongated TFL-ITB length, reduced lumbopelvic rotation angle, delayed the movement onset time of lumbopelvic rotation during HLR, and reduced slightly LBP intensity in subjects with lumbar extension rotation syndrome. The results of this study support the research hypothesis.

The pre-intervention value of TFL-ITB length was 8.27±1.48°, and the post-intervention value was 11.00±1.61°. The present study showed that shortness of TFL-ITB was elongated significantly after the two-week TFL-ITB self-stretching exercise. Shortening of tensor fasciae latae increases iliotibial band tension and cause the lumbopelvic to move excessively as a compensatory function. The results of the present study are in accordance with a previous study, which reported that TFL-ITB self-stretching in upright standing position with overhead arm extension is an effective TFL-ITB stretching exercise to increase TFL-ITB flexibility (Fredericson et al, 2002).

Previous studies indicated that patients with lumbar extension rotation syndrome demonstrate excessive and increased lumbopelvic rotation during lower limb movements (Gombatto et al, 2006; Hoffman et al, 2011; Sharmann, 2002). In our study, when the HLR test was performed, lumbopelvic rotation was significantly reduced by 1.11° after the intervention. Although there was a significant decrease in the lumbopelvic rotation angle after the two-week TFL-ITB self-stretching, it remains unclear whether this statistically significant decrease would lead to clinical significance. Sahrmann (2002) proposed that TFL-ITB shortness could contribute to the presence of certain movement patterns; however, the results of this study only suggest that TFL-ITB length was increased. However, this study did not investigate the effect of increased TFL-ITB length on improvement in the movement pattern. The inability to improve lumbopelvic rotation with stretching exercise is supported by research on healthy subjects who demonstrated no change in hip or lumbar motion during early forward bending following a three-week hamstring stretching (Li et al, 1996).

Previous studies reported that some people with LBP demonstrate lumbopelvic rotation during first 50% of HLR (Hoffman et al, 2011; Sahrmann, 2002; Van Dillen et al, 2007). The current study showed that when the lumbopelvic rotation was plotted as a function of time during HLR to examine the movement onset time (Figure 4), the movement onset of lumbopelvic rotation was significantly delayed after the intervention. Although this study showed that the movement onset time of lumbopelvic rotation was significantly delayed following post-intervention session, lumbopelvic rotation onset still occurred in the early phase of HLR after two-week TFL-ITB self-stretching exercise (Figure 4). Thus, even though TFL-ITB length increased after stretching, earlier lumbopelvic rotation was evident, indicating that TFL-ITB stretching failed to prevent early lumbopelvic motion during the HLR. These results also suggest that lumbopelvic stabilization by active abdominal muscle contraction should be incorporated into TFL-ITB stretching to alter premature kinematics (i.e., compensatory lumbopelvic rotation) during HLR in subjects with lumbar extension rotation syndrome.

The perceived level of LBP measured by VAS did not reduce significantly after the two-week TFL-ITB self-stretching exercise. A previous study suggested that intervention success is defined as a minimum of a 1.5 ㎝ reduction in pain on each 10 ㎝ VAS. A 1.5 ㎝ change has been considered clinically significant (Crossley et al, 2002). The current study showed that -3.46 ㎜ VAS reduced after two-week TFL-ITB stretching exercise. Therefore, two-week TFL-ITB stretching exercise was not effective exercise to reduce LBP intensity.

This study has several limitations. First, the subjects participated in only a two-week period of the TFL-ITB self-stretching exercise. The effect of long-term TFL-ITB stretching exercise on LBP, EMG activity, and the lumbopelvic motion in subjects with lumbar extension rotation syndrome should be determined. Second, we studied the effect of the TFL-ITB stretching exercise during a standardized movement test. However, it is not known whether the effects of the TFL-ITB stretching observed in this study will generalize to the performance of other functional activities in subjects with lumbar extension rotation syndrome. Hence, further studies are required to confirm whether the TFL-ITB stretching exercise can prevent lumbar extension rotation stress in daily living.

Conclusion

The study examined the effect of two-week TFL-ITB self-stretching exercise on lumbopelvic movement patterns during active prone HLR in subjects with lumbar extension rotation syndrome accompanying TFL-ITB shortness. The results showed that two-week TFL-ITB self-stretching exercise significantly increased TFL-ITB length, decreased lumbopelvic rotaion angle, delayed movement onset time of lumbopelvic rotation, and LBP intensity decreased slightly, but not significantly. In conclusion, the two-week TFL-ITB self-stretching exercise could be an effective approach for patients with lumbar extension rotation syndrome accompanying TFL-ITB shortness.

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