Comparison of Relative Thickness of the Iliotibial Band
Following Four Self-Stretching Exercises

Hyun-sook Kim¹, PhD, PT, Tae-lim Yoon², MA, PT
¹Dept. of Physical therapy, Yeoju Institute of Technology;
²Dept. of Physical Therapy, The Graduate School, Yonsei University

Abstract

The aim of this study was to investigate the effectiveness of self-stretching exercises for iliotibial band (ITB) (Side lying: right hip and knee were flexed to support the pelvis while left hip was extended and adducted, Standing A: side bending of the trunk on standing with crossed leg, Standing B: same as Standing A, except the hands were clasped overhead and shifted right side, and Standing C: same as Standing B, except moving the arms diagonally downward) to help determine the most effective self-stretching method to stretch ITB. Twenty-one healthy subjects who do not have ITB shortness from Yonsei University (14 men and 7 women) between the ages of 18 to 28 years voluntarily participated. Ultrasound was performed to measure the thickness of the ITB between the long axis of the ITB and the level parallel to the lateral femoral epicondyle during four self-stretching exercises. All data were found to approximate a normal distribution. We used a one way repeated measures analysis of variance (ANOVA) to compare the thickness of the ITB among all self-stretching exercises. The level of significance was set at α=0.05. The ANOVA was followed by Bonferroni’s correction. The overall mean of ITB thickness was 1.14±.4 mm (+ standard deviation) in resting status. The change in the ITB thickness in percentages between the tested position of each self-stretching exercises and resting status was significant (p<0.05) (Side-lying 26.62±10.18% with 95% confidence interval [CI] =21.99~31.25%; Standing A 29.46±16.19% with 95% CI =22.09~36.84%; Standing B 44.06±14.82% with 95% CI =37.31~50.81%; Standing C 53.76±12.1% with 95% CI =48.25~59.29%). Results indicated significant differences among four self-stretching exercises except Side-lying versus Standing A (p<.01). Based on these findings, the Standing C self-stretching exercise was the most effective in stretching the ITB thickness among four types of ITB self-stretching exercises. Additionally, the Side-lying self-stretching exercise using gravity to stretch the ITB is recommended as a low-load (low-intensity), long-duration stretch.


Key Words: Iliotibial band friction syndrome; Side-lying; Snapping hip; Ultrasound.

Introduction

The iliotibial band (ITB) is a longitudinal thickening of the lateral distal deep fascia latae and the superficial one-quarter of the fibers of the gluteus maximus (Fairclough et al, 2006; Muhle et al, 1999); the ITB is a dense fibrous connective tissue that passes distally along the thigh (Fairclough et al, 2006). Proximal to the knee joint, the ITB has attachments to the intermuscular septum and the supracondylar tubercle of the femur; it continues distally to insert on the Gerdy tubercle at the anterolateral aspect of the proximal tibia (Fairclough et al, 2006; Muhle et al, 1999). As it approaches the knee,
the ITB separates into two functional components, the iliopatellar band and the iliotibial tract, which attach to the Gerdy’s tubercle of the lateral tibia condyle and the lateral patella retinaculum, respectively (Evans, 1979; Terry et al, 1986).

The tightness of ITB could be a reason for musculoskeletal disorders, such as iliotibial band friction syndrome (ITBFS) and snapping hip. ITBFS was first specifically described by Renne (1975) as a pain felt on the lateral aspect of the knee in lower limb activities, such as running and cycling (Renne, 1975). ITBFS is the second most common injury from overuse and the most commonly diagnosed in running, soccer, basketball, triathlons, and field hockey (Barber and Sutker, 1992; Kirk et al, 2003; Noble, 1980; Strauss et al, 2011). Friction of the ITB against the lateral femoral epicondyle during repetitive flexion and extension activities compresses the fat and connective tissue deep into the ITB (Strauss et al, 2011). Patients with ITBFS complain of severe burning at the area around and under the lateral epicondyle, secondary to tightness, frictional irritation, and inflammation of the posterior fibers of the ITB and the periosteum of the epicondyle (Nishimura et al, 1997; Orchard et al, 1996). Furthermore, external snapping hip is present when the tightened iliotibial tract and/or the anterior border of gluteus maximus slide over the greater trochanter (Allen and Cope, 1995; Brignall and Stainsby, 1991; Choi et al, 2002; Yoon et al, 2009). Symptomatic external snapping hip is a painful condition affecting physical function in people between 15 and 40 years (Provencher et al, 2004). Symptoms are often long-standing, and musculoskeletal pain and activity limitations often dominate the clinical picture (Allen and Cope, 1995; Provencher et al, 2004).

Most rehabilitation plans for managing ITBFS and snapping hip include stretching exercises to increase ITB flexibility as a beneficial treatment (DeFranca, 1998; Jones and James, 1987; Lee et al, 2005; Orchard et al, 1996; Suh et al, 2006). Begun after acute inflammation subsides, stretching exercise is commonly used to increase the length and extensibility of soft tissues (Fredericson et al, 2000; Fredericson and Wolf, 2005). Self-stretching is a one of stretching type, enables a patient to maintain or improving flexibility independently, and is often an essential component of a home exercise program (Kisner and Colby, 2007). Applying an effective and practical self-stretching exercise is essential to stretch the ITB and re-establish functional tissue length. A previous study compared the effectiveness of three common variations of the ITB self-stretching, but only in a standing position (Fredericson et al, 2002). Other ITB self-stretching exercise in side lying positions, similar position of Ober test, has never been investigated by ultrasound (US) (Strauss et al, 2011; Wang et al, 2006).

US is a real time, high resolution, noninvasive imaging tool to assess ITB (Ronaldi et al, 1998; Goh et al, 2003; Wang et al, 2008). Compared with Magnetic resonance imaging, US is a more suitable tool for defining morphologic changes in the ITB in conjunction with the Ober or modified Ober test because of its dynamic examination capability (Wang et al, 2006). A study calculated the length of the extensor carpi radialis muscle from the muscle thickness (Shi et al, 2009). Also, other study conclude that US is a reliable means to directly assess the real time effects of stretching exercises (Wang et al, 2008).

Stretching exercises for the ITB has an important role in maintaining the flexibility of soft tissue. In particular, self-stretching exercises are highlighted in education about home exercise. Therefore, this study should be investigated further to ensure the most effective exercise for stretching the ITB and ameliorating its tightness. Our research objective was to investigate the effectiveness of self-stretching exercises for ITB to help determine the most effective method for ameliorating ITB tightness. This study hypothesized that the changes of ITB thickness in percentage caused by four self-stretching exercises would show statistical differences.
Methods

Subjects

G power software was used for power analysis. From the data of a pilot study of 5 subjects, the necessary sample size was 6 subjects to achieve a power of .80 and the effect size of 2.58 (calculated by partial \( \eta^2 \) of .869) with an alpha level of .05. Twenty-one healthy subjects from Yonsei University (14 men and 7 women) between the ages of 18 to 28 years participated voluntarily. The characteristics of the subjects are presented in Table 1. These healthy volunteers were screened by using historical and physical assessments by an examiner with nine years of clinical experience. The inclusion criteria were as follows: 1) no leg length discrepancy (distance from the anterior superior iliac spine [ASIS] to the superior surface of the most prominent aspect of the medial malleolus) of more than 1.5 cm; 2) no genu varum (tibiofemoral angle < 15°); and 3) no functional over-pronation of the foot arch (the angle formed between the distal medial malleolus, the navicular tuberosity, and the first metatarsal head < 90°) (Wang et al, 2006). Subjects were excluded from this study for the following reasons: 1) showed a positive response in the Ober test, which is consistent with a restricted ITB; 2) had a focally thickened or poorly defined border of ITB, with a fluid collection between the ITB and the lateral femoral epicondyle when the US measurements were conducted; 3) previous history of knee surgery, history of pain in the ITB area; 4) history of anterior or lateral knee pain; 5) history of low back pain in the last six months (Bonaldi et al, 1998; Nishimura et al, 1997; Wang et al, 2006). Prior to their participation, all subjects were informed of the purpose of the study, and informed consent was obtained. This study was approved by the Yonsei University Wonju Campus Human Studies Committee.

Instrumentation

US \(^5\) was performed on 7.5 MHz mode with L5-12EC linear-array transducer (40 mm field of view) to measure the thickness of the ITB during four self-stretching exercises. US was a reliable method for measuring the thickness of ITB. It also has a potentially important role in the diagnosis and follow-up of ITBFS (Goh et al, 2003; Wang et al, 2006).

Procedures

Four ITB self-stretching exercises (Side-lying, Standing A, Standing B, and Standing C) evaluated in this study were selected to compare their widespread usage and prescription, simplicity of performance, and effectiveness (Fredericson et al, 2002; Strauss et al, 2011) (Figure 1). The effectiveness of each self-stretching exercise was evaluated based on change in the thickness of ITB. Change in the thickness of ITB was measured with US and calculated as a percentage (the ITB thickness of resting status - the ITB thickness of self-stretching mm) / the ITB thickness of resting status mm × 100) between a relaxed supine position and the end point of each self-stretching exercise. It was assumed that the most efficient self-stretching exercise would mostly reduce the thickness of ITB (Goh et al, 2003).

Table 1. General characteristics of the subjects

<table>
<thead>
<tr>
<th>Variables</th>
<th>Male (n=14)</th>
<th>Female (n=7)</th>
<th>Total (N=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>21.0±2.8</td>
<td>21.0±2.8</td>
<td>21.0±2.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.0±5.5</td>
<td>162.4±4.4</td>
<td>168.8±7.3</td>
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<tr>
<td>Weight (kg)</td>
<td>68.9±8.1</td>
<td>51.1±4.4</td>
<td>63.0±11.1</td>
</tr>
<tr>
<td>BMI* (kg/m²)</td>
<td>22.5±2.7</td>
<td>19.4±1.2</td>
<td>21.5±2.7</td>
</tr>
</tbody>
</table>

*Body mass index, values are presented as mean±standard deviation.

1) SonoAce X8, Medison Co., Ltd, Seoul, Korea.
Lai et al, 2011). We investigated the left leg only. Before the measuring of ITB, familiarization with four self-stretching exercises was performed for an hour. At first, the subject was positioned as supine on an examination table with knee extended at 0°. The ITB was easily visualized and then palpated on its long axis. A line crossing the long axis of the ITB at the level parallel to the lateral femoral epicondyle, which was identified by palpation 2 cm above the corresponding lateral joint line, was marked with a pen on the subject’s skin to indicate the placement position of the ultrasonic transducer (Goh et al, 2003; Gyaran et al, 2011; Wang et al, 2006). A water-based hypoallergenic ultrasound gel was applied to the marked area on the lateral femoral epicondyle. The transducer was positioned parallel to the previously marked line and was held vertical to the skin surface to prevent compressing the skin and underlying tissues. The thickness of ITB was measured as a reference of resting status of ITB at the level parallel to the lateral femoral epicondyle (Figure 2). After measuring resting status of ITB, the subjects were then allocated in random order to perform the Side-lying, Standing A, Standing B, and Standing C self-stretching exercises (Goh et al, 2003; Wang et al, 2006). The US measuring performed in real-time, usually no more than 10 seconds, at the final angle of hip abduction, and then moved back starting position. All stretches were performed without aid and observed by investigator to prevent compensation movement. When compensation movement was presented, the trial was not measured. All data collection was repeated three times, with a five-minute rest between each trial (Wang et al, 2006). The results for each test were averaged for statistical analysis.

1) Side-lying self-stretching of ITB

The subjects lay on their right side, aligning their shoulders and pelvis with the edge of the examination table. The hip and knee of the right leg were flexed to support and stabilize the pelvis. To stretch the ITB, the left hip was in a straight line to torso of subject with the knee extended at 0° and dropped down by gravity into the available range of hip abduction for self-stretching the ITB until hip movement stopped. During asking the subject to not rotate their trunk, pelvic and hip and to use only hip abduction movement. The thickness of ITB was measured by US at the final angle of hip abduction (Wang et al, 2006).
2) Standing A, Standing B, and Standing C self-stretching of ITB

Standing A self-stretching began with the subject standing upright. The left leg was in a straight line to the torso of subject and adducted across the right leg till shoulder width. And then, the foot position was marked with marking tape to maintain same foot position in every trial. The subject exhaled while slowly flexing the trunk in a direction lateral to the right side. This movement continued until a stretch was felt on the side of the left hip around the greater trochanter. Standing B was the same as Standing A, except the hands were clasped overhead and shifted to a right side direction until a stretch was felt on the side of the left hip. The subject was asked to not rotate their trunk, pelvic and hip and to use only hip abduction movement during Standing A and Standing B self-stretching. Standing C was the same as Standing B, except the subject no longer extended the arms overhead but diagonally downward as possible (Fredericson et al, 2002).

Statistical Analysis

Descriptive statistics were calculated for all variables. All the continuous variables were found to approximate a normal distribution (Kolmogorov-Smirnov Z test, p>.05). We used a one-way repeated measures analysis of variance (ANOVA) with four within-subject factors (Side-lying, Standing A, Standing B, and Standing C) to compare the thickness of the ITB between all self-stretching exercises. The level of significance was set at α=.05. If a significant difference was found, a Bonferroni’s correction was performed. All statistical analyses were performed with SPSS, ver. 14.0 software.

Result

At the level of the lateral femoral condyle, the thickness of the ITB ranged from .8 to 1.8 mm on the left side, with an overall mean of 1.14±.4 mm.

![Figure 3. Change in ITB thickness (*p<.05).](image)

Figure 3. Change in ITB thickness (*p<.05). (+standard deviation). During, all self stretching exercises, the ITB thickness is reduced and shown in Figure 3 in percentage change (Side-lying 26.62±10.18% with 95% confidence interval [CI]=21.99~31.25%; Standing A 29.46±16.19% with 95% CI=22.09~36.84%; Standing B 44.06±14.82% with 95% CI=37.31~50.81%; Standing C 53.76±12.1% with 95% CI=48.25~59.29%). Results indicated significant differences among four self stretching exercises (Side-lying, Standing A, Standing B, and Standing C) (p<.05). Figure 3 also shows that there were significant differences between all self-stretching exercises except between Side-lying versus Standing A (p<.01).

Discussion

This research purpose was to assess the thickness of ITB by US to help determine the effectiveness of ITB self-stretching exercises. At the parallel level of the lateral femoral condyle, the thickness of the ITB ranged from 8 to 1.8 mm on the left leg, with an overall mean of 1.14±.4 mm (+standard deviation). The result was similar with a previous study that the
mean values of sonographically measured ITB thickness were 1.1±.2 mm at the lateral femoral epicondyle. On the other hand, two other studies reported that mean ITB values of 1.9±.3 mm and 1.9±.2 mm at the lateral femoral epicondyle, respectively (Goh et al., 2003; Wang et al., 2006). The results of this investigation suggested that Standing C self-stretching exercise was the most successful method for generating change in ITB thickness among four types of ITB self-stretching exercises. In addition, the Side-lying self-stretching exercise using gravity to stretch the ITB was considered a low-load (low intensity), long-duration stretch.

The Standing C self-stretching exercise was the most effective technique among four types of ITB self-stretching exercises because the biggest change of ITB thickness in percentage was presented in the Standing C self-stretching exercise. The reason would be facilitation of hip rotation by adding flexion and rotation of trunk movement while other stretch exercises only had hip adduction movement. This result is not in line with a previous study that used three-dimensional image measurement, which indicated that Standing B was the most effective method between Standing A, B, and C self-stretching exercises (Fredericson et al., 2002). Fredericson’s study had main limitation, such as not directly measuring the ITB. Instead, the study estimated changes in length according to angular changes in markers of the iliac crest, greater trochanter, and lateral midline of the knee (Fredericson et al., 2002). Therefore, this study directly measuring the change in thickness of ITB by US would be more objective and apparent indicator of stretching effects. However, extreme flexion with rotation of the trunk was observed in Standing C self-stretching and would aggravate symptoms for patient with disc disorders (Cohen et al., 2009). Consequently, the Standing C self-stretching should be recommended for someone who does not have disc disorders.

Interestingly, Standing A was the second least effective method to stretch ITB among the four self-stretching exercises although it is one of the most common and well-known ITB self-stretching exercises. In addition, Standing A was the only technique showing no change in ITB thickness (2 out of 21 subjects) from the ITB thickness in resting status. These results indicated that the Standing A self-stretching exercise was a complicated method for stretching the ITB and was not so effective. Furthermore, the effectiveness of the Side-lying self-stretching exercise using gravity to stretch ITB was not significantly different from Standing A although it was reported as the least effective method in stretching the ITB. The Side-lying self-stretching exercise had an advantage of performing stretch effortlessly for a long duration. Two previous studies claimed that a low-load (low intensity), long-duration stretch is considered the safest form of stretch and yields the most significant, elastic deformation and long-term, plastic changes in chronic contractures (Kottke et al., 1966; Light et al., 1984). Therefore, the Side-lying self-stretching exercise is recommended over the Standing A self-stretching exercise, especially for chronic contractures of ITB.

A limitation of this study is the sample size. However, despite the small sample size, the response of ITB thickness to self-stretching was sufficient to identify a statistically significant difference between self-stretching exercises (p<.05). In addition, because only healthy young adults were investigated, the results should not be generalized. Moreover, this study did not directly assess ITB length but ITB thickness to estimate ITB length. The change in ITB thickness does not give perfect assurance of the change in ITB length. Furthermore, the errors present in using US were dominated by the position of the transducer because it was not exactly the same for each trial. However, the potential error was minimized in this study because all data were collected by one well-experienced investigator. A longitudinal study is needed to confirm the immediate effect of the stretching exercises used in this study in a patient population or different age groups.
Conclusion

This research investigated the effectiveness of self-stretching exercises for ITB to help determine the most effective method for ameliorating ITB tightness. The results of this investigation showed that the Standing C self-stretching exercise was the most successful among four types of ITB self-stretching exercises and recommendable method for someone who does not have low back pain. Furthermore, the use of the Side lying self-stretching exercise using gravity to stretch the ITB is recommended as a low-load (low-intensity), long-duration stretch.

References


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