A STRAIN MODEL OF THE ILIOTIBIAL BAND

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The purpose of this study was to investigate mechanical strain in the iliotibial band as a possible causative factor in the development of iliotibial band syndrome. This syndrome is the leading cause of lateral knee pain in runners. In this syndrome, it is thought that pain develops from friction of the iliotibial band sliding over the lateral femoral epicondyle. The onset of the syndrome may be exacerbated by increasing strain of the iliotibial band. From a large prospective study, female runners who incurred iliotibial band syndrome during the study were compared to a control group who were injury free. Strain, strain rate and impingement were determined from a SIMM model of the lower extremity. The results indicated that iliotibial band syndrome subjects exhibited greater strain throughout the support period but particularly at touchdown and at midsupport. However, there were no differences in strain rate or impingement between the groups.

KEY WORDS: lower extremity injury, iliotibial band, strain, strain rate, impingement

INTRODUCTION

Iliotibial band syndrome (ITBS) is the leading cause of lateral knee pain in runners, accounting for up to 12% of all running-related injuries (Taunton et al., 2002). The iliotibal band (ITB) is a sheet of connective tissue originating at the illiac crest and terminating at Gerdy's tubercle and the fibular head. The ITB runs down the lateral thigh and knee and passes over the lateral femoral epicondyle (LFE). This syndrome is believed to result from friction of the ITB sliding over the LFE. Biomechanical factors, such as pronounced rearfoot eversion and weak hip adductors, may inc.rease strain of the ITB and contribute to the development of this injury (Messier 1995; Orchard 1996). Proximally, the ITB acts as a lateral hip stabilizer resisting hip adduction. It originates in the fascial components of the gluteus maximus, gluteus medius, and tensor fasciae latae muscles. Distally, the ITB is attached to the supracondyle tubercle of the femur, the lateral intramuscular septum and has fibers that articulate with the patella. Because of these attachments, movements such as increased femoral adduction, will likely lead to increased tension on the ITB and possibly increased strain.

The location of symptoms in ITBS has directed attention to knee mechanics. ITBS has been associated with lateral knee pain that occurs just after heel strike when the knee is in approximately in 20^o of knee flexion. In addition, ITBS has been reported to be exacerbated with downhill running (Orchard, 1996). Compared to level running, downhill running is associated with landing with an extended knee position and moving through greater knee flexion excursion. An impingement zone is thought to occur between 20-30^o of knee flexion. In this range, the distal fibers of the ITB are believed to compress with and slide over theLFE. While the etiology of ITBS is still unclear, it has been suggested that strain in the ITB will result in injury. Therefore, the purpose of this prospective investigation was to compare the pre-existing strain and strain rate in the ITB between female runners who developed ITBS compared to healthy controls. We hypothesized that runners who proceeded to develop ITBS will exhibit greater strain throughout the stance period of running, but particularly at touchdown and maximum knee flexion, greater strain rate from touchdown to maximum knee flexion and greater impingment compared to the control subjects.

METHODS

Subjects: The subjects in this study were part of a large ongoing prospective investigation of lower extremity injuries in female runners. To be included, all subjects ran a minimum of 20 miles a week, were between the ages of 18-45, and were free from any injuries at the time of data collection. Prior to participation, each subject signed a consent form approved by the University's Human Subjects Compliance Committee. Upon entry into the study, a detailed subject injury history was taken. Subjects were then followed monthly by e-mail for 2 years and reported any running related injuries and monthly mileage. At the time of analysis, 17 runners, diagnosed by a medical professional, had developed ITBS since starting the study. Subjects were excluded if they had any previous hip or knee injuries. Seventeen mileage and age matched runners with no previous history of knee or hip injuries were chosen for the control group.

Experimental Set-up: Three-dimensional lower extremity kinematic data during running were collected. Kinematic data were collected at 120 Hz with a six camera motion capture system. A force plate, embedded in the center of the runway, sampling at 1080 Hz, was used to define foot contact (i.e. touchdown and toe-off).

Protocol: The injured leg of the ITBS group was compared to the right leg of the control group. Retro-reflective markers were attached to the pelvis, thigh, shank and foot according to McClay and Manal (1999). Anatomical markers were placed over the greater trochanter, lateral and medial femoral epicondyles, lateral and medial malleoli, first and fifth metatarsal heads and the front end of the shoe. All subjects wore a standard neutral running shoe. Subjects ran along a 25m runaway at a speed of 3.7 m/s ($\pm$ 5%) striking a force plate at its center. Five acceptable trials were collected during the stance phase of running.

Data Analysis: Strain in the iliotibial band (ITB) was calculated on a subject-specific basis using a SIMM model of the lower extremity. The model included the pelvis, sacrum, femur, tibia, fibula, patella, talus, calcaneus, and the metatarsals (Figure 1). The ITB was defined as an elastic structure that originated on the iliac crest and terminated on Gerdy's tubercle. The model was driven by three-dimensional Cardan joint angles (hip, knee, and ankle) during the stance phase of running, collected from each of the subjects. Bone sizes and muscle geometries in the SIMM model were scaled to each subject's anthropometrics.

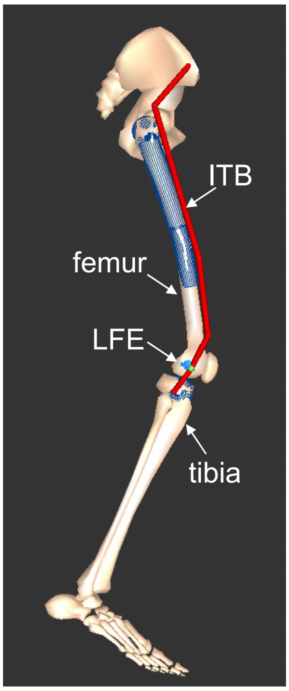

Figure 1 - Musculoskeltal model of the ITB. Dark band along the lateral femur is the ITB.

Strain in the ITB was computed as the percent change in length of the ITB from its length during a standing calibration trial ($\Delta L/L$). Strain rate was determined from the strain-time profile and was defined as the slope of the curve from touchdown to mid-support. Impingement between the ITB and the LFE was modeled by defining a wrapping sphere whose surface was flush against the outer surface of the LFE. Impingement was defined as the range of knee flexion angles during which the ITB encounters friction with the LFE.

Statistical Analysis: The dependent measures, strain, strain rate and impingement, were analyzed using an independent t-test. In order to further evaluate mean differences, effect size (ES) was calculated to express such differences relative to the pooled standard deviation. ES was calculated as the mean difference between genders divided by the pooled standard deviation. Cohen (1990) proposed that ES values of 0.2 represent small differences; 0.5, moderate differences; and 0.8+, large differences. Together, the effect sizes and p-values were evaluated as the basis for discussing mean differences.

RESULTS:

Figure 2 is a graphical representation of the strain in the ITB during stance for both the ITBS and control groups. Strain was greater for the ITBS group versus the control group throughout all of stance. Peak strains were 9.0% for ITBS versus 7.7% for control (p = 0.15, ES = 0.38). Strains at heel-strike were 7.3% for ITBS versus 5.5% for control (p = 0.08, ES = 0.51). The percentage of stance during which impingement occurred (75% for ITBS versus 80% for control, p = 0.11, ES = 0.44) was smaller for the ITBS group.

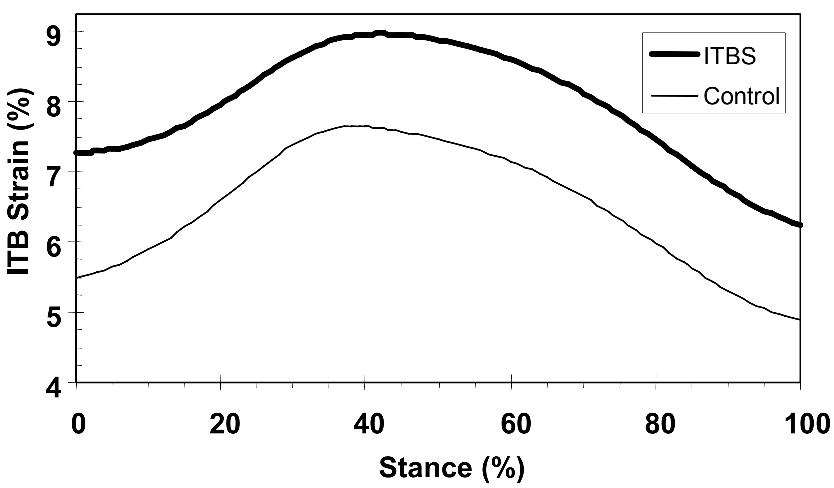

Figure 2 – Group means of ITB strain during stance.

DISCUSSION:

The purpose of this investigation was to compare the pre-existing strain, strain rate and impingement in the ITB between female runners who developed ITBS compared to healthy controls. We hypothesized that runners who proceeded to develop ITBS will exhibit greater ITB strain, strain rate and impingement than the non-injured control group. These hypotheses were only somewhat supported. There appeared to be small differences in terms of peak strain between the groups (p = 0.15). Additionally, there was an effect size of 0.38 indicating a small to moderate difference. Strain at heel strike also revealed a small difference in the means (p = 0.08) and resulted in a moderate effect size (0.51). In addition, we did not find any differences in impingement between the groups. The number of runners whose ITB was impinged at the LFE at heel-strike was the same (4 for ITBS versus 4 for control) for both groups.

It has been theorized that friction of the ITB on the LFE is a primary causative factor in ITBS. Further, it would seem likely that increased strain on the ITB would increase the friction on the LFE causing knee pain that is generally associated with ITBS. The results of this study indicate only moderate support for this theory. These data do indicate that ITBS runners exhibit greater strain during the critical period of loading in support (i.e. touchdown to midsupport). If we assume that increased strain places a greater stress on the ITB, then it would seem likely that the ITBS runners were more likely to develop an ITB injury.

It has also been suggested that increased knee flexion at touchdown may also result in ITBS. Miller et al. (2006) suggested that a more flexed knee at touchdown would lead to a greater degree of impingment and greater stress on the ITB. In this study, we found that knee flexion at touchdown in the ITBS group was essentially the same in the control group (11.2 ± 4.3^o and 12.8 ± 5.2^o respectively). At midsupport, the maximum knee angle of the ITBS group was less than the Control group (42.5 ± 4.3^o and 46.9 ± 5.4^o respectively). These results are contrary to Miller et al. (2006).

CONCLUSION:

This study modeled the strain on the ITB during running in a group that had prospective ITBS and a non-ITBS control group. Our results indicated that there was only a moderate difference in strain and no difference in either strain rate and impingement between the groups. These results suggest that joint kinematics play a larger role in prospective ITB strain than ITB impingement.

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Acknowledgement

This study was supported by Department of Defense grant DAMD17-00-1-0515.