ILIOTIBIAL BAND STRAIN DURING TWO RUNNING SPEED CONDITIONS FOCUSED ON THE HIP JOINT ANGLE

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The purpose of the study is to mitigate Iliotibial band (ITB) syndrome injury by understanding how much stress runners' knees experience as running speed is varied. Subjects included 10 uninjured university male long-distance runners. Subjects ran under two conditions: high speed (18.0 km/h) and low speed (14.4 km/h). ITB strain was calculated by Opensim model during the stance phase. ITB strain at sliding before foot release phase were 1.44±0.61% in high-speed condition and 2.22±1.10% in low-speed condition and low-speed condition was higher than high-speed condition ($p < 0.05$). ITB strain was higher sliding before foot release than sliding after foot contact ($p < 0.05$). We have proven that ITB strain increases and pain occurs during the latter half of the standing phase compared to the initial half when ground impact occurs.

KEY WORDS: iliotibial band, running, compression

INTRODUCTION: The iliotibial band (ITB), which originates from the tensor fasciae latae muscle, gluteus maximus muscle, and iliac crest, attaches to Gerdy's tubercle at the lateral tibia (Kaplan, 1958). The ITB extends between the knee and hip joint. It is located anterior to the lateral femoral epicondyle (LFE) when the knee joint is extended. As the knee flexes, the posterior fibers of the ITB slide over the LFE (Jelsing, 2013). Recurrent compression between the ITB and the LFE associated with knee joint flexion can cause bursa inflammation and lead to ITB syndrome (ITBS) (Fairclough, 2006).

ITBS is often caused by running activities: 12% of running-related knee joint injuries (Tounton, 2002). The high tensile strength of the ITB increases compression force as it slides over the LFE. Accordingly, onset of ITBS is associated with two factors: compression force and frequency of movement over the LFE. Training factors related to ITBS onset exponentially increase with running frequency and running on hard surfaces (Orava, 1987).

Physical factors such as alignment disorder (e.g., of the knee joint varus and pes pronatus) and weakness of the hip joint abduction muscles increase ITB strain (Fredericson, 2000). In this study, ITB strain during running was studied with the aid of digitized musculoskeletal modelling (Hamil, 2008). However, it is not clear how much compression force was exerted on the ITB as running speed increased. Changes in running speed increase or decrease the angle of lower extremity joints during exercise.

A previous study by Noble (1979) showed a knee joint flexion angle of 30° when the ITB slides over the LFE. Informed by this study, researchers were able to report when pain occurred during running with ITBS (Orchard, 1996). However, knee joint flexion angle when the ITB slides over the LFE increases as the hip joint flexion angle increases (Tomiyama, 2011). For this reason, it is not clear when compression occurs between the ITB and the LFE.

METHODS: Subjects included 10 uninjured university male long-distance runners. Anthropometric data of the 10 subjects were recorded (age, 20.8 ± 1.5 years; height, 166.6 ± 3.0 cm; weight, 53.4 ± 1.1 kg). The purpose of the study was explained to the subjects, who agreed to participate after providing informed consent.

Subjects ran on an all-weather track under two conditions: high speed (18.0 km/h) and low speed (14.4 km/h). The running distance was set at 20 m. A metronome was used to determine running speed, and most subjects ran the distance in a time of 4 to 5 seconds. All participants wore Adiprene+ running shoes (Adidas, Herzogenaurach, Germany). Each runner was filmed with six EXILIM FX-FC160S high-speed cameras (Casio, Japan) at 120 fps. For the two speed conditions, measurements were recorded three times in order to obtain an average.

Thirty-three reflective markers were placed on both sides of the body (dorsal foot, lateral foot, heel, medial and lateral malleoli, proximal and distal tibia, posterior shank, lateral and medial femoral epicondyles, anterior thigh, lateral thigh, greater trochanter head, iliac crest, anterior superior iliac spine, acromion) and the sacrum. Coordination of the markers was calculated using a three-dimensional motion analysis system (ToMoCo-VM, Toso System, Inc., Saitama, Japan) for joint flexion angle, hip joint additional angle, hip joint external rotation angle, and knee joint flexion angle. The range of analysis was from foot contact to foot release.

Modeling during running was achieved using Opensim 3.2 (MusculoGraphics, Inc., Santa Rosa, CA, United States of America) (Delp 1995). The ITB model was used. The model calculated the simulated length of each runner's ITB. ITB strain and ITB strain rate were calculated by OpenSIM during the stance phase. ITB strain was computed as follows: (difference between ITB length at time and ITB length during standing) / (ITB length during standing). ITB strain rate was computed as the change in ITB strain per time.

With the subject lying on his or her side, knee joint flexion angle was measured when the ITB slid over the LFE as the hip joint flexion angle changed. The hip joint flexion angle was determined for five conditions: 10° extension, 0° flexion, 20° flexion, 40° flexion, and 60° flexion. In the prescribed hip joint conditions, the LFE was palpated and the knee joint was flexed. A goniometer was used to measure the knee joint flexion angle when the ITB was located over the LFE.

The following were compared for the two running speed conditions: hip joint flexion angle, knee joint flexion angle, ITB strain, and ITB strain rate with one-way analysis of variance (ANOVA). ITB strain was calculated for the intersection points for hip and knee flexion angle when the ITB slid over the LFE, with measurements taken as subjects lay on their side. The data on transition of hip joint flexion angle and knee joint flexion angle during running was recorded for each subject (i.e., the inferred point when compression occurred between the ITB and the LFE). Two inferred points were analyzed for all subjects: the point of knee flexion after foot contact (sliding after foot contact) and the point of knee extension before foot release (sliding before foot release). ITB strain during each phase for all subjects was calculated and compared between the high-speed condition and the low-speed condition using a paired t-test. Furthermore, ITB strain was compared between sliding after the foot contact phase and prior to the foot release phase using a paired t-test under both conditions. The level of significance was set at less than 5% for each statistical analysis.

RESULTS: Figure 1. shows ITB strain during running for the two running speed conditions. ITB strain was higher for the high-speed condition during 58–75 ms, and higher for the low-speed condition during 117–150 ms ($p < 0.05$). Hip joint flexion angle and knee joint flexion angle under the two running speed conditions, no significant difference was noted throughout the running duration.

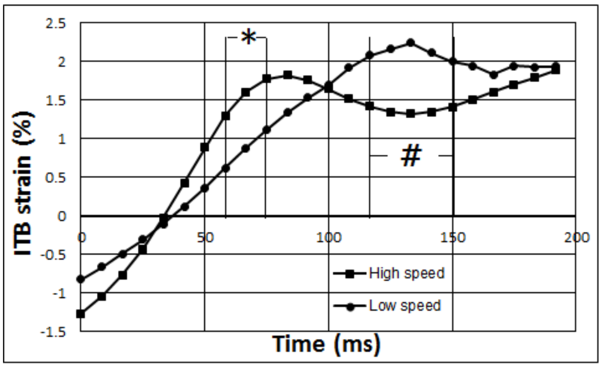

Figure 1: ITB strain druing running for two running speed conditions. The symbol (*) denotes significantly greater high-speed than low-speed (p<0.05). **The symbol (#)** denotes significantly greater low-speed than high-speed (p<0.05).

Table 1. shows ITB strain when the compression occured under high-speed and low speed condiions. ITB strain at sliding after the foot contact phase (43 ± 17ms) were -0.07 ± 1.65% in high-speed condition and 0.61 ± 1.16% in low-speed condition. ITB strain at sliding before foot release phase (132 ± 20ms) were 1.44 ± 0.61% in high-speed condition and 2.22 ± 1.10% in low-speed condition and low-speed condition was higher than high-speed condition($p < 0.05$). In both the low-speed and high-speed conditions, ITB strain was higher sliding before foot release than sliding after foot contact ($p < 0.05$).

Table 1
ITB strain when the compression occured between ITB and LFE under high-speed condition and low-speed condition.

	high−speed	low−speed	p−value
After the foot contact (%)	-0.07 ± 1.65	0.61 ± 1.16	0.21
Before the foot release (%)	1.44 ± 0.61	2.22 ± 1.10	0.04
p−value	< 0.01	< 0.01	

DISCUSSION: Greater ITB tension increases compression between the ITB and the LFE as well as the risk of ITBS. The ITB is like fascia tissue and does not contract voluntarily. Because of this, the ITB is viewed as a passive tissue that absorbs increased tension during stretching. In the standing position, ITB hardness increases during adduction of the hip joint and stretching of the ITB (Tateuchi 2014). Therefore, a change in ITB length during movement indicates a change in tightness (Hamil, 2008). In this study, ITB strain was calculated using the SIMM model (MusculoGraphics, Inc., Santa Rosa, CA, United States of America) that has been successfully employed in previous studies.

Traditionally, researchers believe that the ITB sliding over the LFE creates frictional irritation of the ITB or its underlying bursa. Recently, studies have shown that friction does not occur in knee joints at 30° flexion. However, using sonography, Jelsing has shown that posterior fibers of the ITB are involved in translation. This translation may increase with greater conversion angles. When compression occurs, the knee joint flexion angle is increased as the hip joint flexes (Tomiyama 2011). Runners with ITBS complain of pain during the standing phase (i.e., when the knee flexes after the foot makes contact and extends before release), although it is not certain precisely when compression occurs during a runner’s stride.

It is estimated that twice the compression occurs during the standing phase (Fig. 2). ITB stress transfers from anterior to posterior LFE after foot contact, and the ITB transfers from posterior to anterior LFE before foot release. In both the low-speed and high-speed conditions, ITB strain was higher before foot release than during foot contact ($p < 0.05$). In other words, it is suggested that the compression force of the ITB is greater during the phase before foot release than during the phase of knee joint 30° flexion after foot contact, which is the traditional assumption.

In this study, there was no significant difference in hip flexion angle and knee flexion angle according to running speed. However, for the initial portion of the standing phase, ITB strain was more pronounced in the high-speed condition; conversely, ITB strain was higher in the latter portion of the low-speed condition ($p < 0.05$). During the time prior to foot release when the ITB slid over the LFE, ITB strain was higher in the low-speed condition ($p < 0.05$). Running under low-speed conditions creates greater compression on the ITB, and it is presumed that the risk of ITBS is greater in the context of persistent low-speed running.

In general, athletes run at a low speed when recovering from injury. However, results of this study show that slow running can produce greater ITB stain and thus a higher risk of ITBS. Low-speed conditioning is a practice of many long-distance runners, and it is not certain how ITB strain changes in relation to varying speed conditions. However, there is no research examining ITBS risk according to running speed, and this study shows promising results in this area. Furthermore, we have proven that ITB strain increases and pain occurs during the latter half of the standing phase compared to the initial half when ground impact occurs.

CONCLUSION: In this study, ITB strain was calculated and compared between the high-speed condition and the low-speed condition. It is confirmed that twice the compression occurs between ITB and LFE during the standing phase. In both the low-speed and high-speed conditions, ITB strain was higher sliding before foot release phase than sliding after foot contact phase ($p < 0.05$). Because of that, during the time prior to foot release when the compression occurs, ITB strain was higher in the low-speed condition, it is presumed that the risk of ITBS is greater in the context of persistent low-speed running. There is no research examining ITBS risk according to running speed, and this study shows promising results in this area and lead to ITBS prevention.

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Acknowledgement

This study was made possible by the Research fellowship of Japan society for the promotion of science for young scientists.