EFFECTS OF RUNNING BIOMECHANICS ON THE OCCURRENCE OF ILIOTIBIAL SYNDROME IN MALE RUNNERS — A PROSPECTIVE STUDY

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This study aimed to determine the gait characteristics that easily induce ITBS and explore the gait changes after the occurrence of ITBS. 30 healthy male runners participated in our study, 15 in ITBS and control group respectively. All participants underwent two gait trials, namely, before the first day of their routine running and after 8 weeks. After 8 weeks of running, the ITBS group exhibited greater peak anterior pelvic tilt and hip flexion angle than the control group. The ITBS group showed increased peak trunk inclination angle, whereas the control group demonstrated lower peak hip flexion and peak hip adduction than those at the beginning of running. Decreased peak hip flexion and peak hip adduction angle was a gait adjustment strategy that could be used to avoid ITBS occurrence. Excessive trunk posture and pelvic activity during running are also ITBS risk factors.

KEY WORDS: gait characteristics, trunk, pelvic, hip, kinematic, kinetic

INTRODUCTION: Running as a sport event is becoming increasingly popular, thereby leading to an increased number of running-related injuries(Foch & Milner, 2014). Iliotibial band syndrome (ITBS) is the second most common running injury, accounts for 1.6%–12% of all running-related injuries (Fredericson et al., 2000) , and is the leading cause of lateral knee pain in runners (Taunton et al., 2002). The exact etiology of ITBS is unclear, but biomechanics is considered one of the factors (Aderem & Louw, 2015). Iliotibial band leads to increased strain with increasing angle of the lower extremity (Hamill, Miller, Noehren, & Davis, 2008). It was reported women ITBS runners exhibit greater peak hip adduction and knee internal rotation angles, and pelvis and trunk gait characteristics are also associated with ITBS in female runners (Foch, Reinbolt, Zhang, Fitzhugh, & Milner, 2015).
However, most of the previous studies on ITBS were retrospective ones, it were difficult to elaborate the pathogenesis. In addition, previous studies mostly focused on stance phases, which were conducted on females or mixed genders. Therefore, the authors designed a prospective study to explore the effects of running biomechanics of male runners on the occurrence of ITBS under the complete gait cycle.

METHODS: Participants: All participants were recruited from a university running club and comprised healthy male recreational runners without any type of neuromuscular problems. They run approximately 24 miles/week with a horizontal velocity of approximately 3.7 m/s. The whole experiment began from November 2016 to March 2017. A total of 192 male runners finished the 8-week running program and our tests. Fifteen of these male runners who were diagnosed with ITBS after the 8-week running program by a medical professional were included in the ITBS group, and a healthy control group was created by recruiting 15 healthy age-, height-, and weight-matched runners.

Testing protocol: All participants were asked to undergo two gait test trials. Trials 1 and 2 were performed in 1 day before their first running day and after 8 weeks of running. In each trial, all participants were asked to run on a 90 cm × 1500 cm platform at a velocity a of 3.7 ± 0.2 m/s, which was tested by a timing system (SmartSpeed, Fusion Sport, Australia).

Data collection: A Kistler force plate with sampling at 1000 Hz was embedded at the center of the platform to collect kinetic data. An eight-camera motion capture system (Vicon, Oxford Metrics Ltd., UK) with sampling at 100 Hz was used to synchronously collect kinematic data.

Data processing: Kinematic and kinetic data were low-pass filtered using a fourth-order Butterworth filter at cutoff frequencies of 8 and 50 Hz, respectively (Noehren, Davis, & Hamill, 2007). All moments were computed as internal moments and normalized by body mass and height. Kinematic data were time normalized to 100 data points.

Data analysis: Sub-group comparisons were assessed via respective 95% confidence intervals of mean difference. The confidence interval of mean difference values between groups were calculated by using independent-sample t-tests and between trials by paired-sample t-test. Significant differences were confirmed if the respective 95% confidence intervals of mean difference did not cross 0. Effect size (Cohen's d) and statistical power were also calculated for each dependent variable. The thresholds for effect size statistics were the following: <0.20, trivial; 0.21–0.60, small; 0.61–1.20, moderate; 1.21–2.00, large; and >2.00, very large.

RESULTS: Table 1 presents the descriptive statistics of the peak trunk inclination angle and peak hip abductor moment between the two groups in the two trials. The ITBS group showed higher peak trunk inclination angle in trial 2 than in trial 1, whereas that of the control group remained unchanged between the two trials. The peak hip abductor moment decreased in trial 2 than in trial 1 in the control group, whereas no differences were found in the ITBS group.

Table1. Descriptive statistics of the peak trunk lateral flexion and trunk inclination angle.

Variables		ITBS group	Control group	95% CI and Cohen's *d*
peak trunk inclination angle (M ± SD, °)	Trial 1	14.88 ± 4.88	19.87 ± 13.51	−8.13–18.12 small
	Trial 2	20.92 ± 5.17	21.13 ± 17.94	−13.39–13.8 trivial
	95%CI and Cohen's *d*	**−11.44–0.64 large****	−10.12–7.61 trivial	—
Peak hip abductor moment (M ± SD, Ng/kg)	Trial 1	6.26 ± 2.77	8.82 ± 2.57	4.26–5.55 small
	Trial 2	7.9 ± 4.67	6.45 ± 3.26	−5.37–2.48 small
	95%CI and Cohen's *d*	−4.96–0.68 small	**0.56–4.17 moderate***	—

* represents moderate effect;** represents large effect.

As shown in Figure 1a, the ITBS group had a greater anterior pelvic tilt angle than the control group in trial 2 (I_{t2}=19.17°, C_{t2}=11.82°, $CI_{95\%}$: −11.23/−3.49, very large effect). There were differences between the ITBS and the control group in the peak hip flexion angle in trial 2

(I_{t2}=42.80°, C_{t2}=32.85°, $CI_{95\%}$: −17.0/ −2.91, large effect), and that of the control group in trial 2 was significantly smaller than in trial 1 (C_{t1}=37.99°, C_{t2}=32.85°, $CI_{95\%}$: 1.54/ 8.75, moderate effect) (Figure 1b). The peak hip adduction angle of the control group decreased in trial 2 (C_{t1}=14.38°, C_{t2}=11.77°, $CI_{95\%}$: 1.69/ 6.22, moderate effect), but no significant difference was found in the ITBS group or between two groups (Figure 1c).

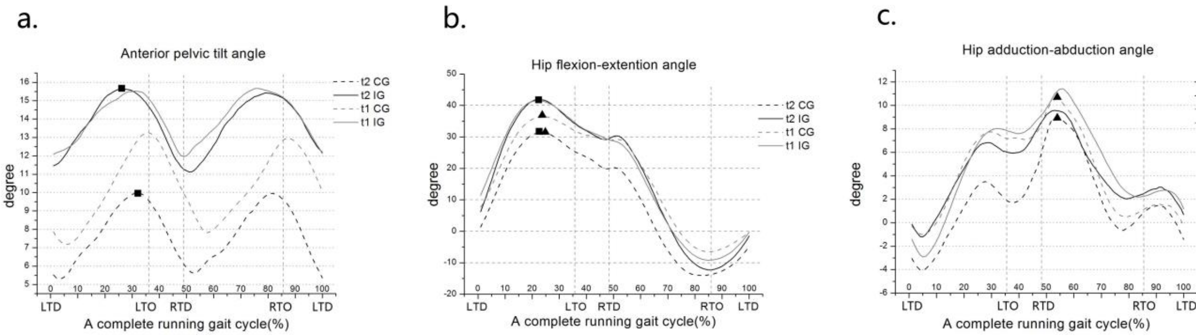

Figure 1. Comparison of a complete running gait cycle joint activity between the two groups

■■ Represent significant differences between the two groups in trial 2. ▲▲ Significant differences in the control group compared with trial 1. Abbreviation: t1: trial1 before running; t2: trial2 after 8 weeks running; CG=control group; IG=ITBS group; LTD=left foot touch down; LTO=left foot take off; RTD=right foot touch down; RTO= right foot take off.

DISCUSSION: The control group significantly decreased the peak hip flexion at the swing phase and decreased the peak hip adduction at the stance phase in trial 2. No significant differences were observed in the ITBS group. The authors believed that this is a gait adjustment strategy to avoid ITBS occurrence. The decreased peak hip flexion may make result in an ITB position that is closer to the neutral position of the human body and reduce the friction range of the distal ITB and the lateral femoral condyle (Orchard, Fricker, Abud, & Mason, 1996). Increasing the hip adduction can increase the tension, strain, and strain rate of the ITB (Hamill et al., 2008). In the current study, long-term running led to excessive tightening of the ITB; thus, participants were on the verge of developing the disease. This risk was detected in the control group, which exhibited reduced angle of the hip adduction to reduce strain and relieve tension in the ITB. However, no response was observed in the ITBS group. The authors speculated that the ITBS group's proprioception was too poor for the participants in this group to sense the muscle tension and changes in the position in time.

The control group decreased peak hip abductor moment in trial 2 than in trial 1. No differences were found in the ITBS group. This finding indicates that the reduction in peak hip adduction may be the reason for the decreased peak hip abductor moment in the control group. Theoretically, increased hip adduction may require the hip abductor to undergo eccentric contraction to increase strength and to resist adduction, thereby resulting in increased peak hip abductor moment (Noehren et al., 2007). Similarly, during a decreased hip adduction angle, the hip abductor muscle is relatively not fully activated for eccentric contraction. Thus, the control group in the current study exhibited a small peak hip abductor moment.

A greater anterior pelvic tilt angle showed in the ITBS group compared with the control group. The increased anterior pelvic tilt may be due to weakness in the core muscle, particularly the rectus abdominis. The trunk moves relative to the pelvis to achieve balance. The ITBS group moved their trunk in a vertical direction for compensation. In another interpretation, this increased anterior pelvic tilt may be due to the tightness of the hip flexor musculature, such as iliopsoas and tensor fascia late, or the surrounding anterior hip capsular and ligamentous structures (Schache, Blanch, & Murphy, 2000). The ITB is a sheet of connective tissue that includes the fascia of the gluteus maximus, gluteus medius, and tensor fascia (Miller, Lowry, Meardon, & Gillette, 2007). In the current study, the ITBS group did not feel tension in the ITB in time, thereby leading to an increase in the anterior pelvic tilt angle. In conclusion, excessive trunk posture and pelvic activity during running are also ITBS risk factors.

CONCLUSION: Decreased peak hip flexion and peak hip adduction angle was a gait adjustment strategy that can be used to avoid the occurrence of ITBS. Illness in the ITBS group may be due to their lack of timely gait adjustment. Excessive trunk posture and pelvic activity during running are also ITBS risk factors.

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