INTRODUCTION

Iliotibial band syndrome is a common overuse in runners. The iliotibial band (ITB) is a band of connective tissue that originates at the iliac crest, crosses the hip joint, travels down the lateral portion of the thigh and inserts at Gerdy’s Tubercle on the proximal tibia, the distal femur and the patella. Hip adduction and knee internal rotation angles have been positively associated with ITB syndrome in a prospective study [1] and linked with elevated ITB strains and strain rates [2].

Many studies have assessed the effect of stride length manipulations on lower extremity kinematics; however, relatively few published studies have examined the effect of step width on gait mechanics. Studies that have strategically manipulated step width during running report greater pronation, pronation velocity, and tibial excursion with a cross over pattern [3,4]. However, hip and knee kinematics have not been assessed. A narrower step width is likely to increase hip adduction and knee internal rotation as well as result in greater ITB strains and strain rates. Therefore, the purpose of this study was to evaluate the effect of step width on ITB strain and strain rate.

METHODS

Fifteen experienced runners free from injury volunteered for this study (8 males and 7 females, 23.7±5.4 years, 70.3±9.2 kg, 1.7±.08 m). Anthropometric data were collected for later use in a musculoskeletal model.

Subjects ran at their preferred 5k running speed over a force platform (1600 Hz, AMTI, Watertown, MA) until 10 trials of three step width conditions were successfully completed. Motion capture data were concurrently collected with an 8 camera 3D motion capture system (Vicon Nexus, Centennial, CO) at a sampling rate of 160 Hz. Step width was measured as the mediolateral distance between the right and left heel markers during consecutive steps. The mean step width value obtained in the preferred running style condition was then used to calculate minimum target values for the narrow and wide conditions. Minimal acceptable narrow step width was calculated as normal step width minus 5% of leg length; minimal acceptable wide step width was normal step width plus 5% of leg length. The normal step width condition was performed first and order of narrow and wide conditions was balanced to minimize fatigue effects.

Motion capture data and force platform data were exported to MATLAB (The Mathworks, Natick, MA) for signal processing and analysis. Kinematic data were low-pass filtered at 8Hz and imported into a scaled SIMM model [5]. Length of the ITB was calculated by summing the individual segments of the SIMM musculotendinous unit for each frame of data. ITB strains and strain rates were calculated using the equations:

$$Strain = \frac{L_i - L}{L} = \frac{\Delta L}{L} \times 100$$

$$Rate \ of \ strain = \frac{\Delta Strain}{\Delta Time}$$

where $L_i$ is equal to the length of the ITB during time $i$ in the stance phase of the run and $L$ is equal to the resting ITB length calculated during the standing calibration trial [2].

Repeated measures ANOVA was used to evaluate step width effects on the dependent variables of interest. Tukey post-hoc comparisons were performed and Cohen’s $D$ effect sizes $(ES)$ were calculated.
RESULTS AND DISCUSSION

Table 1 indicates subjects were able to manipulate their step widths during running while maintaining a consistent running velocity and without changing their heel strike patterns. ITB strain increased as the step width became narrower (Figure 1). Differences were found in ITB peak strain across conditions with the narrow step width condition (3.7±0.5%) having the greatest level of strain compared to normal running (3.1 ± 0.5%) ($p<0.01$; $ES=1.0$). Strain during normal step width was also greater than the wide condition (2.7±0.5%) ($p<0.01$; $ES=0.8$).

Strain rates generally increased with the narrowing step width. Minimal differences were found in peak strain rate between the narrow (12.8±8.4%/s) and normal step widths (10.8±10.3%/s) ($p=0.22$; $ES=0.2$). Larger differences existed between the narrow and wide step widths (7.4±8.9%/s) ($p<0.01$; $ES=0.5$) and the normal and wide step widths ($p=0.02$; $ES=0.3$).

ITB impingement occurs at approximately 30° of knee flexion. Greater strain in the ITB was observed at this critical point in the gait cycle with narrower step widths in this study. As expected, hip adduction angle increased with decreasing step length. Knee internal rotation did not differ across conditions. Increased hip adduction, likely the main explanation for the increased strain during narrower step widths, increases the length of the ITB and thus the passive tension. However, activation of the muscles inserting into the ITB can increase active tension. Interestingly, the hip abductor moment was 35% greater in the narrow condition compared to the wide condition ($p = 0.07$; $ES = 0.5$) suggesting that increased active tension, in addition to passive tension, occurred during narrower step widths.

CONCLUSIONS

The current study shows that there is an inverse relationship between step width and ITB strain and strain rates. Rate of strain development is a key factor in the development of ITB syndrome [2]. The lower rate strain rates seen in the wider running conditions of this study suggest that a wider step width may be beneficial in the prevention and treatment of ITB syndrome. These findings, in combination with findings from previous studies of injury, suggest that future gait retraining efforts consider step width characteristics, especially if persons demonstrate a crossover pattern. Prior to prescribing step width changes to modulate ITB strain, consideration of the overall coordination and mechanics of the system must be made. Future studies are needed to ascertain the relationship between step width and injury and to identify optimal step characteristics for minimization of tissue loads during running.

REFERENCES


Table 1. Mean values (SD) of study design variables. Superscripts indicate $p \leq 0.05$ for respective comparisons.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Velocity (m/s)</th>
<th>Step width (cm)</th>
<th>Heel Strike Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal step width</td>
<td>4.04 (0.57)</td>
<td>2.6 (0.04)</td>
<td>27.4 (18.2)</td>
</tr>
<tr>
<td>Narrow step width</td>
<td>4.04 (0.58)</td>
<td>-6.3 (0.05)</td>
<td>31.2 (21.6)</td>
</tr>
<tr>
<td>Wide step width</td>
<td>4.03 (0.58)</td>
<td>10.2 (0.04)</td>
<td>27.8 (18.2)</td>
</tr>
</tbody>
</table>

$^1$normal, $^2$narrow, $^3$wide step width