ADAPTATIONS IN RUNNING KINEMATICS ASSOCIATED WITH EXPECTED CHANGES IN CUSHIONING AT THE FOOT-GROUND INTERFACE

Ben L. Patritti 1, Mark J. Lake 2 and Adrian Lees 2

1 Center for BioDynamics, Dept. of Biomedical Engineering, Boston University, Boston MA, U.S.A. patritti@bu.edu
2 Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, U.K.

INTRODUCTION

There is evidence to suggest that there are actively induced changes in lower limb posture and velocity before and at touchdown in response to anticipated increases in the severity of ground impact during running (Dixon et al., 1998; De Wit et al., 2000). These adjustments in landing kinematics may serve to reduce the rate of loads acting on the body and likely rely on the ability to readily perceive changes in the severity of impact (Clarke et al., 1983; Milani et al., 1997; De Wit et al., 2000). Modifications have mostly been characterised between barefoot and shod running (Clarke et al., 1983; De Wit et al., 2000), with few examining changes for barefoot running on different surfaces (Dixon et al., 1998). There may be an experimental confound with the former approach due to the shoe mass and midsole thickness possibly influencing comparisons in touchdown characteristics e.g. heel velocities. The aim of this study was to confirm and further document the presence of adjustments in movement patterns before and at touchdown during barefoot running over two different cushioning surfaces. The adaptations were related to changes in the impact force load rate on ground contact.

METHODS

Eight male subjects (age = 28.5 years, mass = 74.5 kg) ran barefoot at 4.5 m s⁻¹ along a runway of 24mm thick EVA foam mats. The runway comprised foam of medium hardness (shore A35) with only the mat overlying a Kistler force platform exchanged for a softer (S, shore A20) and harder (H, shore A50) EVA foam. Subjects completed 10 trials on each of the soft and hard mats, counterbalanced about 3 alternate blocks of 10 trials on the medium mat. Kinematics of right foot contacts with the mats were captured by a six camera ProReflex system operating at 800 Hz. Impact severity was characterised by the load rate (ROL) of the external impact force sampled at 1600 Hz. Displacement data were low pass filtered at 40 Hz. Pre-contact (t = -30 ms) and touchdown (t = 0 ms) kinematics of the lower limb were described by the posture and velocities of the foot, ankle and shank. Such distal kinematics have been shown to be sensitive to changes in the foot-ground interface (De Wit et al., 2000). Changes between the extreme surface conditions are presented here. Differences between the two conditions at the group level were tested with paired t-tests (α = 0.05).

RESULTS AND DISCUSSION

Large significant differences in mean force load rate were observed between the two surface conditions (S = 130 kN s⁻¹ vs H = 352 kN s⁻¹, P < 0.05). The vertical heel velocity was reduced on touchdown with the hard mat (Table 1), which concurs with previous findings (Dixon et al., 1998; De Wit et al., 2000). This adjustment appears to occur in the last 30 ms prior to touchdown as the heel velocities at -30 ms are very similar (Table 1). A significant correlation (r = +0.72, P < 0.05) between relative decreases in vertical heel velocity and force load rate (Figure 1) suggest this kinematic adjustment likely contributes to a moderation of impact severity. A flatter foot posture was adopted in advance of touchdown, as observed by De Wit et al. (2000), and was likely related to trends toward greater ankle plantarflexion as opposed to alterations in posture of the shank (Table 1).

Figure 1: Relationship between relative change in vertical heel velocity and force load rate.

SUMMARY

The observed pattern of changes in kinematics before contact, which were present on landing, suggest an “active” strategy of adjustment to increases in impact loading and were consistent with previous findings. There was evidence some changes served an impact moderating role, with decreases in vertical heel velocity associated with regulating the relative increase in rate of loading to the body. Future work will explore whether such adjustments are facilitated by ones ability to discern changes in impact severity.

REFERENCES


Table 1: Mean (±SD) pre-contact and contact kinematics for the soft and hard foam surfaces († sig. diff. to Soft, P < 0.05).

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Soft</th>
<th>Hard</th>
<th>Soft</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hor heel vel (m s⁻¹)</td>
<td>2.71 ± 0.59</td>
<td>2.74 ± 0.56</td>
<td>0.83 ± 0.31</td>
<td>0.81 ± 0.29</td>
</tr>
<tr>
<td>Vert heel vel (m s⁻¹)</td>
<td>-1.03 ± 0.18</td>
<td>-1.03 ± 0.19</td>
<td>-0.97 ± 0.13</td>
<td>-0.74 ± 0.15†</td>
</tr>
<tr>
<td>Foot angle (deg)</td>
<td>16.9 ± 5.9</td>
<td>15.4 ± 5.7†</td>
<td>8.8 ± 6.2</td>
<td>7.7 ± 5.5</td>
</tr>
<tr>
<td>Ankle angle (deg)</td>
<td>84.6 ± 5.3</td>
<td>86.1 ± 7.1</td>
<td>84.4 ± 5.7</td>
<td>86.3 ± 7.2†</td>
</tr>
<tr>
<td>Shank angle (deg)</td>
<td>78.5 ± 3.6</td>
<td>78.8 ± 3.8</td>
<td>86.7 ± 3.5</td>
<td>87.1 ± 3.6</td>
</tr>
</tbody>
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