COMPARISON OF VARIABILITY BETWEEN OVERGROUND AND TREADMILL RUNNING

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INTRODUCTION

Treadmill analyses have multiple advantages to overground analyses including ease of collecting multiple sequential footfalls and less required space. During overground running, individuals are free to vary their speed from stride to stride. But, with treadmill running, the runner is constrained to the same speed during each stride. Because speed is constant with treadmill running, it is possible there is less variation between strides. In a study comparing overground and treadmill running, Wank and colleagues (1998) found less variation during treadmill running than overground running. Specifically, they found lower standard deviations in knee and ankle joint angles. However, they did not report standard deviations at the hip, and their analyses were limited to the sagittal plane.

Therefore, the purpose of this study was to compare the variability of treadmill and overground running through a 3D lower limb kinematic analysis. We hypothesized that lower limb hip, knee and rearfoot angles would exhibit decreased variability during treadmill running compared to overground running.

METHODS

This study included 20 male and female individuals (25.2 ± 6.2 yrs), who run at least 10 mpw. All subjects were rearfoot strikers and comfortable with treadmill running. Retroreflective markers were applied to the right lower extremity of each subject. Subjects then completed both the overground (OG) and treadmill (TM) running in the same laboratory, within the same calibrated volume. The order of OG and TM running was counterbalanced. For the OG trials, subjects ran along a 25m runway. Speed was monitored via photocells, and trials within 3.35 m/s ±5% were accepted. A VICON (Oxford, UK) motion analysis system captured kinematic data at 120Hz. Kinematic data were filtered at 12Hz.

Although a forceplate was available for OG trials, stance was determined using kinematic methods for both conditions to ensure consistency. Footstrike was identified at the change in vertical velocity from negative to positive of the distal heel marker. Toe-off was identified at peak knee extension. These methods were previously validated for OG running (Fellin and Davis, 2007). Using an instrumented treadmill in another location, an analysis of 10 recreational runners confirmed that these methods are similarly accurate in estimating footstrike and toe-off during treadmill running. Errors of less than one video frame at 120Hz for toe-off and less than 3 video frames for footstrike were obtained.

For each trial, hip, knee and rearfoot angles were calculated at both initial contact (IC), and at peak (PK) (first 75% of stance). Five trials were averaged for each subject. The standard deviations of the 3D hip, knee and rearfoot angles (IC and PK) were computed for each condition. Next, the difference between the conditions was calculated for each subject, and then averaged across subjects.
RESULTS

At initial contact, subjects exhibited smaller standard deviations during TM running for seven of nine joint angles (Table 1). For peak angles, there were smaller standard deviations during TM running for eight of the nine angles. All of these standard deviation differences were less than half a degree. Overall, 15 out of 18 measures supported our hypothesis of TM running being less variable than OG running. The largest difference between the two modes (0.45 degrees), occurred at the rearfoot in the frontal plane for initial contact.

DISCUSSION

Overall, variability of TM running was lower than OG running. These results agreed with Wank and associates (1998). However, their differences were greater than those found in this study. They reported decreases in standard deviations of 0.6 degrees in PK knee angle and 1.7 degrees in ankle angle at IC during TM running. Their subjects ran 4 m/s compared to 3.35 m/s in this study. Additionally, their subjects exhibited 10 times the SD for IC ankle angle and 1.5 times the SD for PK knee angle compared to the results of this study. Both of these differences may have contributed to the smaller differences in standard deviations found in this study.

The relatively large reduction in rearfoot variability for the frontal plane at IC on the TM was surprising. Individuals often drift side-to-side while running on a TM, which could potentially increase frontal plane variability. However, the narrow width of the TM belt (45 cm) may have constrained footstrike position resulting in lower variability.

Previous research suggested that variability in movement patterns may reduce the risk of running-related injuries. (Hamill et al., 1999). These authors promoted the theory that reduced variability of movement causes very consistent loading patterns in the lower extremity, leading to overuse. However, TM surfaces are typically more compliant than those surfaces that individuals run OG. In fact, compared to OG running, TM running external loads were reduced (Willy and Davis, 2008). Thus it is unclear as to which mode of running results in lowered injury risk.

CONCLUSIONS

Subjects exhibited decreased variation during TM running compared to OG running for 15 out of 18 lower limb 3D kinematic variables. The largest difference was frontal plane rearfoot position at initial contact.

REFERENCES


Table 1: Group mean standard deviations for TM and OG running. Differences are the average of the individual differences between conditions. Negative differences indicate TM SD < OG SD. (All units degrees)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Joint</th>
<th>Sagittal</th>
<th></th>
<th>FrONTAL</th>
<th></th>
<th>Transverse</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>TM SD</td>
<td>OG SD</td>
<td>Diff</td>
<td>TM SD</td>
<td>OG SD</td>
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<tr>
<td>Initial Contact</td>
<td>Hip</td>
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<td>1.40</td>
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<td></td>
<td>Knee</td>
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<td>0.46</td>
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<tr>
<td></td>
<td>Rearfoot</td>
<td>1.80</td>
<td>1.95</td>
<td>-0.15</td>
<td>1.37</td>
<td>1.82</td>
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<tr>
<td>Peak</td>
<td>Hip</td>
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<td>1.51</td>
<td>-0.27</td>
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<td>Rearfoot</td>
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<td>-0.23</td>
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<td>-0.20</td>
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