Association Between Shoe Characteristics and Running Performance in United States Military Academy Cadets

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Introduction

Few studies have directly investigated shoe characteristics’ effect on running performance with the majority of existing research consisting of laboratory studies investigating running economy as a surrogate for performance.[1-4] Large scale prospective studies directly investigating running performance are necessary in order to better understand this relationship.

Purpose

To investigate the relationship between shoe characteristics and running performance.

Methods

Participants:
• 827 subjects (18.3 years ± 0.9 years)
• Inclusion criteria: Department of Defense beneficiaries who could read and speak English between the ages of 17 – 23 years old
• Exclusion criteria: Individuals with a history of lower extremity or back injury within the last three months

Procedures:
• Recorded subjects’ shoe length, stiffness, and heel height
• Calculated medial and lateral torsional stiffness using the equation

\[ \text{Length of shoe (m) - Torque(Nm)} \]

\[ \text{Angle of Displacement between toe box and heel counter (30 degrees)} \]

• Individual demographic data and Army Physical Fitness Test (two-mile run times) data were recorded. Cadets were also queried on their weekly running mileage the three months prior to cadet basic training.

Data Analysis:
• A univariate linear regression was performed to determine if shoe characteristics, specifically torsional shoe stiffness and heel height, were associated with performance during the two-mile run. In addition, a multivariate linear regression was performed to investigate this relationship while controlling for the influence of gender and weekly miles ran in preparation for cadet basic training.

Shoe Stiffness in Torsion Measurement Device

The Shoe Stiffness in Torsion Measurement Device was designed for rapid measurement of torsional shoe stiffness and heel thickness for running footwear.[5] Figure A demonstrates the assessment of a minimalist shoe while Figure B demonstrates the assessment of a stability shoe.

Multivariate Analysis of Running Performance Relative to Lateral Torsional Shoe Stiffness

<table>
<thead>
<tr>
<th>Lateral Torsional Stiffness</th>
<th>Range (Nm²deg)</th>
<th>Time in Seconds (95% CI)</th>
<th>P-value*</th>
<th>Time in Seconds (95% CI)</th>
<th>P-value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal</td>
<td>&lt; 0.0130</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mild</td>
<td>0.0130 – 0.0179</td>
<td>-10.1 (-32.50 – 12.26)</td>
<td>0.376</td>
<td>-12.9 (-40.6 – 14.9)</td>
<td>0.364</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.0180 – 0.0229</td>
<td>-16.0 (-39.0 – 7.25)</td>
<td>0.178</td>
<td>-36.5 (-65.1 – 7.8)</td>
<td>0.0139</td>
</tr>
<tr>
<td>Extreme</td>
<td>≥ 0.0230</td>
<td>-20.1 (-43.0 – 2.82)</td>
<td>0.086</td>
<td>-46.6 (-74.9 – 18.2)</td>
<td>0.0011</td>
</tr>
</tbody>
</table>

Statistical analysis of cadets wearing shoes of different levels of lateral torsional stiffness in Newton meters² (Nm²) - degree (deg), accompanying run time comparisons with confidence intervals (CI) and their statistical significance

\[ p-value < .05 \]

* Values attained controlling for the influence of gender and miles ran per week 3 months prior to cadet basic training.
** Values attained without controlling for the influence of other variables

Results

• Univariate analyses indicate that cadets wearing shoes with mild heel height ran significantly faster than those wearing shoes with minimal heel height. Cadets wearing shoes with mild and extreme medial torsional stiffness ran significantly faster than those wearing shoes with minimal medial torsional stiffness. Cadets wearing shoes with moderate and extreme lateral torsional stiffness ran significantly faster than those wearing shoes with minimal lateral torsional stiffness, 36 and 46 seconds faster, respectively.

• When controlling for the influence of gender and weekly miles ran in preparation for training, there were no statistically significant findings regarding heel height, medial torsional stiffness or lateral torsional stiffness.

Discussion

• Though there were no statistically significant observations with the influence of gender and running preparation prior to basic training controlled for, there remained an apparent dose-response relationship where performance improved by approximately five seconds with each level of increasing lateral torsional shoe stiffness.

Conclusion

• Running performance is influenced by a variety of factors. As it pertains to shoe wear, results indicate that a linear relationship between lateral torsional stiffness and performance may exist as those individuals wearing shoes with greater lateral torsional stiffness ran faster during the two-mile run.

References