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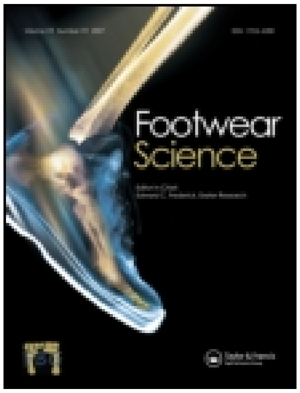

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Effect of shoe orientation on shoe-surface traction in tennis

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Effect of shoe orientation on shoe-surface traction in tennis

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Introduction

Tennis is a sport characterised by dynamic movements which play an important role in the performance and risk of injury of the player (Reinschmidt and Nigg 2000). These manoeuvres require sufficient traction between the shoe and surface interface. However, excessive traction has been linked with an increase in the risk of injury (Nigg 2003). Repeatable mechanical test devices have been developed to reliably measure shoe-surface traction (Clarke *et al*. 2013). The purpose of these mechanical devices is to measure either the translational and/or rotational traction force generated at the shoe-surface interface. This article examines translational traction. The translational traction the shoe provides is related to player performance. For example, the execution of a deliberate sliding movement will depend on the dynamic traction developed (Driscoll *et al*. 2012). In tennis an understanding of translational traction for varying shoes, surfaces and loading conditions via mechanical testing has been reported (Clarke *et al*. 2011, 2012a, 2012b, 2013). In tennis, players continuously perform sideways movements yet there is little reported literature to date that examines the influence the shoe orientation has on traction (Driscoll *et al.* 2012).

To develop a traction test device that is more representative of the motion of the shoe during realistic movements, the shoe orientation needs to be assessed.

Purpose of the study

The purpose of this pilot study was to investigate the influence of shoe orientation on traction testing under a range of normal loads, with the objective to assess future methodologies and testing.

Methods

Traction tests were conducted on an acrylic hard court tennis surface using a bespoke laboratory based traction testing device developed at The University of Sheffield (fully described in Clarke *et al*. 2013). A high pressure pneumatic ram provides a controlled normal force to a test shoe. Once the desired normal force has been reached a second pneumatic ram provides a driving force in the horizontal direction. For this study it was assumed that during a sliding movement, flexion of the shoe occurs at the Metatarsal-Phalangeal (MP) joint. Therefore, the forefoot segment ahead of the MP joint of a commercially available tennis shoe (EU size 42) was used as the test shoe. Tests were conducted with the test shoe attached in four orientations in relation to horizontal movement (Figure 1). Prior to testing under each condition, the sole was prepared in accordance with parts of BS EN ISO 13287:2007.

Results

For this study traction was considered using the mean dynamic traction force in the direction of movement between 10 mm and 30 mm horizontal displacement (as discussed in Clarke *et al.* 2013). Traction force data was collected for a range of normal loads (500–1000 N), to assess the influence of shoe orientation.

Figure 2 shows the strong and significant linear regressions found between normal force and dynamic traction force ($R^2 > 0.95$), ($p < 0.05$) where ($n = 22$) for each orientation. Each linear fit has a low root mean

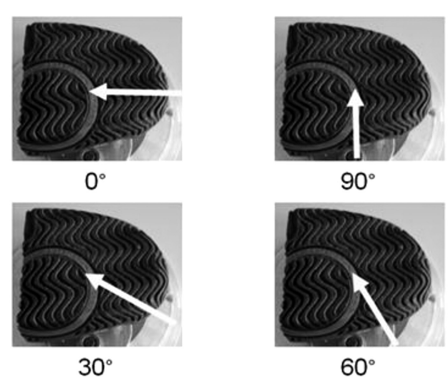

Figure 1. Shoe orientation tested (arrows indicate direction of shoe movement).

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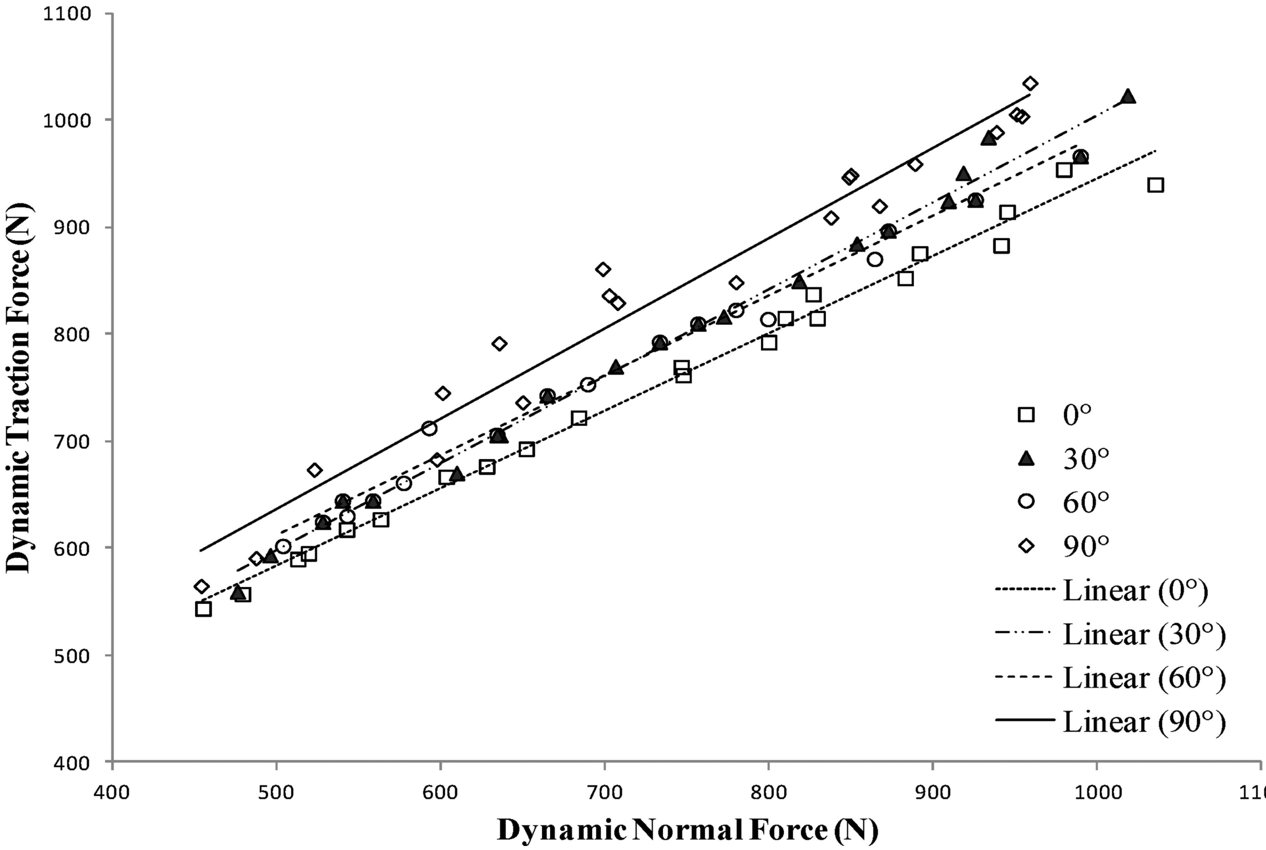

Figure 2. Plot of the normal force against traction force for each shoe orientation condition.

squared error (RMS: 0° = ±53.1, 30° = ±62.2, 60° = ±67.6 and 90° = ±99.7) with varying gradients, showing differences between the orientations. Each relationship was specific to the particular normal force-shoe orientation combination.

Discussion and conclusion

Significant linear relationships exist between normal force and traction force under the normal loading conditions investigated in this study. Shoe orientation and normal force affect the influence of the traction mechanisms present during a dynamic sliding movement. The applied normal force during a tennis movement and the shoe orientation will therefore significantly affect the traction available to a tennis player. It is therefore recommended to consider shoe orientation when considering mechanical testing to improve the relevance of the test.

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