Modulation of tennis players’ frictional demand according to surface traction characteristics

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SUMMARY
The interaction between footwear and surfaces influences the forces experienced by players. The purpose of this study was to characterize the different components of the ground reaction force (GRF) during a tennis specific movement with changes in traction characteristics of playing surfaces. We hypothesized that players accommodate the different level of static friction by adjusting the balance between vertical and horizontal components of the applied force. More specifically, players were expected to lower the utilized coefficient of friction (COFu) on low frictional surface. Our results support the hypothesis that tennis players adapt the level of utilized friction according to the characteristics of the surface. But this adaptation surprisingly favors sliding on low frictional surface like clay.

INTRODUCTION
The lack of tennis specific research on shoes and surfaces makes it difficult to relate their properties to injury. The interaction between footwear and surfaces influences the forces experienced by players, suggesting a link between footwear/surface combinations and injury [1]: low traction or high level of traction are associated with specific injuries [2,3].

The purpose of this study was to characterize the different components of the ground reaction force (GRF) during a tennis specific movement with changes in common playing surfaces. Our hypotheses were:

I. Players accommodate the different level of static friction by adjusting the balance between vertical and horizontal components of the applied force.

II. More specifically, to keep a good control on a clay surface which has a low level of static friction, players were expected to lower the utilized coefficient of friction (COFu) compared to a high friction surface.

METHODS
Subjects (tennis players, more than 5 hours of practice a week, 6 males, 2 females) were asked to side jump out of stance with forced foot position. Subject’s feet were originally perpendicular to the direction of the jump. The subject was instructed to jump laterally on a force platform at a distance equal to the height of his iliac crest, and to jump back to the original position. This movement is considered to reproduce some of the constraints of tennis movements [4].

GRF was measured using an AMTI force plate (Advanced Mechanical Technology, Inc., Newton, MA) sampling at 960 Hz. Utilized coefficient of friction (COFu) was calculated as the ratio between Fshear, the resultant of the horizontal forces and GRFz, the vertical component of the GRF.

Two common tennis surfaces were used: clay surface (low frictional) and cushioned acrylic hardcourt (high frictional). Vertical GRF was similar across surfaces whereas the peak shear force at impact was higher on clay. As a consequence, the peak COFu was increased on clay. Our results support the hypothesis that tennis players adapt the level of utilized friction according to the characteristics of the surface. But this adaptation surprisingly favors sliding on low frictional surface like clay.

RESULTS AND DISCUSSION
Fshear at impact and at peak COFu were higher on clay. The increase in the peak COFu was due to the increase of shear force because we did not observe a strong variation in the vertical component of the GRF.

These results partly meet our expectations: COFu was indeed modulated across surfaces but increased on the low frictional surface.

<table>
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<tr>
<th></th>
<th>Acrylic</th>
<th>Clay</th>
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<tbody>
<tr>
<td>Peak GRFz</td>
<td>1237 ± 152 N</td>
<td>1181 ± 70.6 N</td>
</tr>
<tr>
<td>Peak Fshear</td>
<td>325 ± 76.1 N</td>
<td>438.3 ± 51.7 N</td>
</tr>
<tr>
<td>Peak COFu</td>
<td>0.22 ± 0.09</td>
<td>0.34 ± 0.07</td>
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CONCLUSIONS
Players’ sliding on clay is due both to the conjunction of the low level of friction, and to the redistribution of the forces applied on the surface: horizontal forces increase whereas the vertical component in not affected. Our results support the hypothesis that tennis players adapt the level of friction according to the characteristics of the surface. But this adaptation surprisingly favors sliding on low frictional surface like clay. To better understand the link between this strategy and the low rate of injuries on low frictional surfaces [3], the biomechanical processes that underlie this adaptation should be further investigated.

REFERENCES
4. Bahlsen, HA and Nigg, BM, Selection of a lateral test movement for tennis shoes in Biomechanical Aspects of Sports Shoes and Playing Surfaces, Nigg, BM, Kerr, BA, University Printing, Calgary, Canada, 1983