A COMBINED APPROACH TO UNDERSTAND PLAYER-SURFACE INTERACTION IN TENNIS

Matt Carré[1], James Clarke[1], Loïc Damm[2], Sharon Dixon[2]
[1]University of Sheffield
[2]Exeter Biomechanics Research Team ExBirt

OBJECTIVES OF THE PROJECT

- Human biomechanical response and Influence of mechanical properties of shoes and surfaces on traction. University of Exeter.
- Tests rig development: Dept of Mechanical Engineering, University of Sheffield

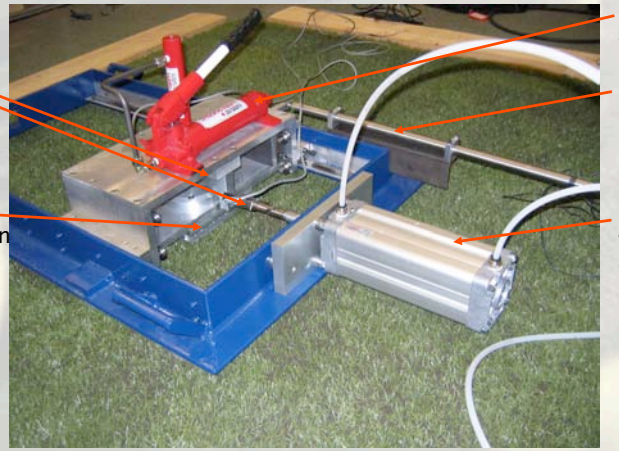
FACTORS OF INJURIES

Sliding is a key parameter for players' safety (Nigg and Segesser, 1998)

➡Translational traction and Rotational traction

➡ Acute injuries, ankle inversion (Hutson, 1982, Joseph and Mark, 1998)

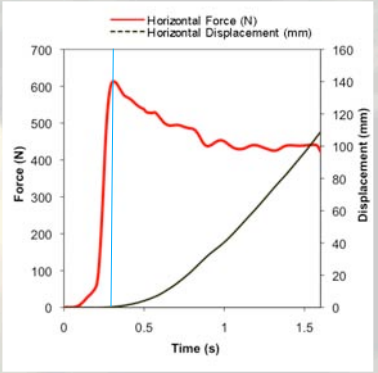
Mechanical Test Rig

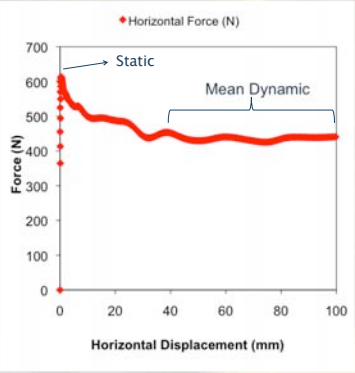


Methods

- 6 acrylic hard-court surfaces (referenced A – F) were tested with the same commercially available tennis shoe outsole.

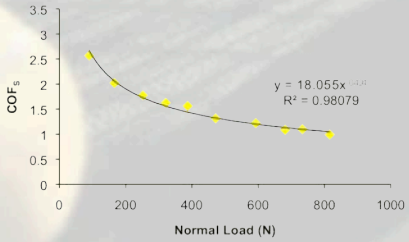
Typical friction traces

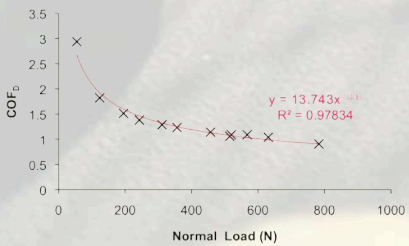




Typical Data

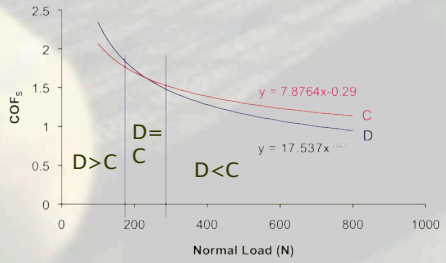
Strong power relationships were found between Normal Force and Friction.

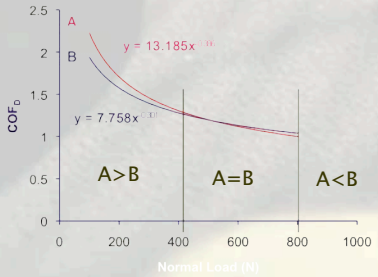




Effects of Loading Condition

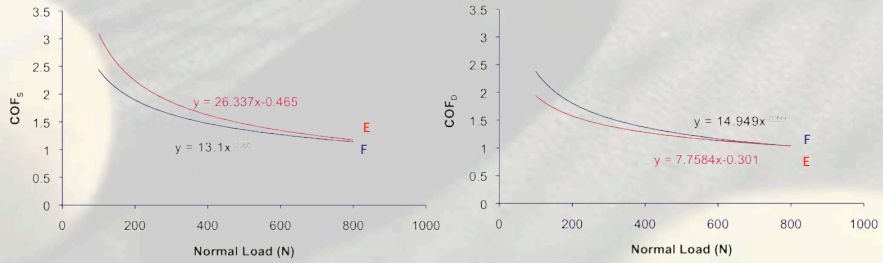
Testing under inappropriate loading conditions may give misleading results.





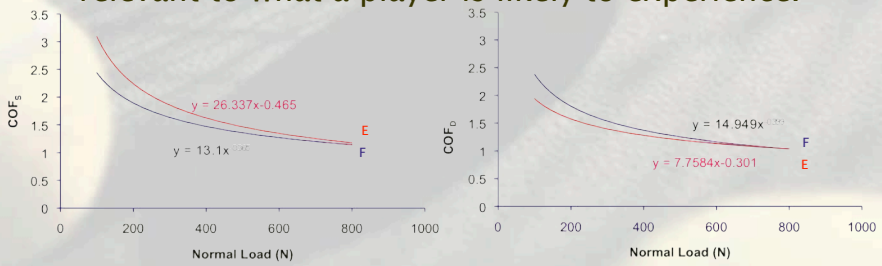
Discrepencies between

At lower loads: $E_{COF_S} > F_{COF_S}$ BUT $E_{COF_D} < F_{COF_D}$



Discrepancies between

Highlights the importance of extracting a friction measurement
relevant to what a player is likely to experience.



Key Message

- Testing under inappropriate loading conditions may give misleading results
- Boundary conditions relevant to the movement being simulated mechanically are required.

Next Step

- The generation of boundary conditions via biomechanical testing.

MEASURES

Force plate data:

Calculation of the utilized coefficient of friction

COFu = Fshear/GRFz

QUESTION

Natural lower coef. of friction on clay than on acrylic:

➡ How do players adapt their traction demand on clay compared to acrylic ?

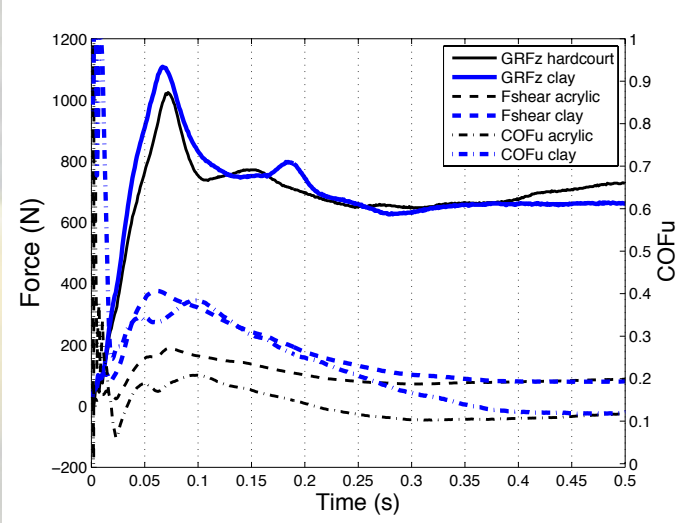
SURFACES

	Cushioned acrylic hardcourt (Rebound Ace®)	Clay surface Pavitex
Pendulum test Slip resistance value	67	50.5 ± 3.9
	High coef. of static friction	Low coef. of static friction

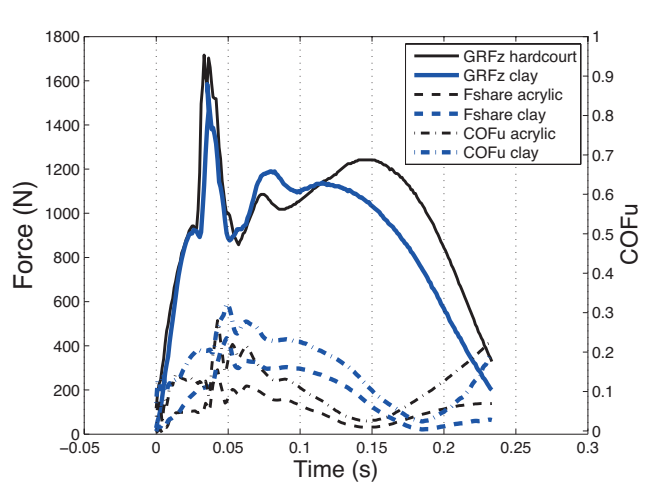
SPORT SPECIFIC LOADING CONDITION

Running forehand and side jump

SURFACES: GRF AND UTILIZED COEF. OF FRICTION, SIDE JUMP



SURFACES: GRF AND UTILIZED COEF. OF FRICTION, RUNNING FOREHAND



SURFACES: GRF AND UTILIZED COEF. OF FRICTION, SIDE JUMP

	Acrylic	Clay
Peak GRFz	1159.3 ± 153.6 N	1035.6 ± 162.6 N
Peak Fshear	284.1 ± 87.1 N	442.3 ± 65.7 N *
Peak COFu	0.26 ± 0.06	0.35 ± 0.06 *

* $p < 0.05$

SURFACES: GRF AND UTILIZED COEF. OF FRICTION, RUNNING FOREHAND

	Acrylic	Clay
Peak GRFz	1465.3 ± 494	1453 ± 462 N
Peak Fshear	360.8 ± 243 N	586.1 ± 274.7 N*
Peak COFu	0.25 ± 0.07	0.4 ± 0.08 *

* $p < 0.05$

TEST OF 2 PAIRES OF SHOES

Adidas® Barricade 6.0 (acrylic specific)

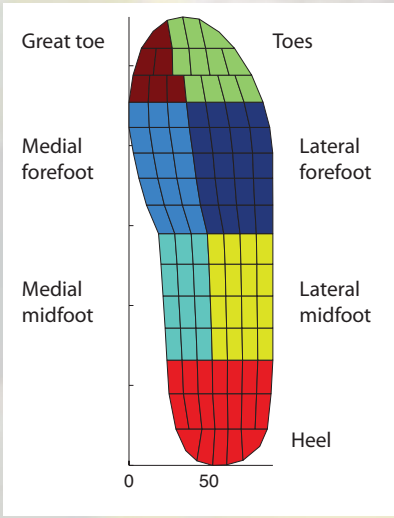
Adidas® Barricade 6.0 clay

SHOES AND SURFACES, SIDE-JUMP

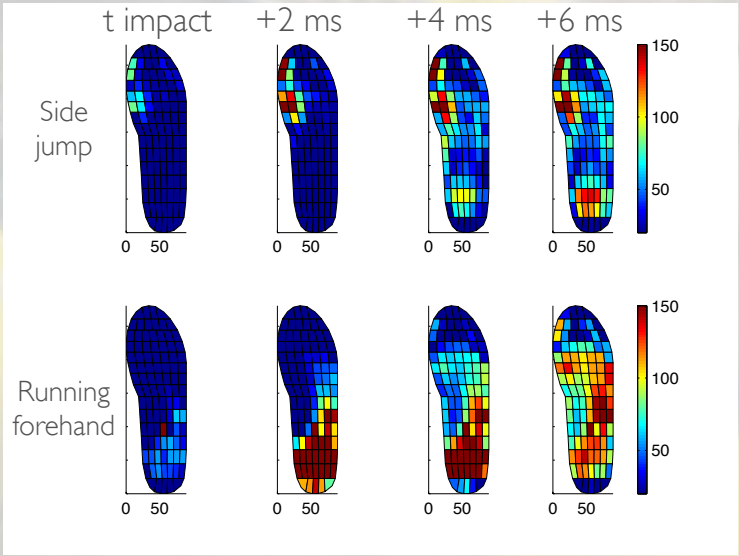
	Acrylic		Clay	
	Acrylic shoes	Clay shoes	Acrylic shoes	Clay Shoes
Peak GRFz	1159.3 ± 153.6 N	1163 ± 131.1 N	1035 ± 162.6 N	1022 ± 90 N
Peak Fshear	284.1 ± 87.1 N	272 ± 85.8 N	442.7 ± 65 N	433 ± 112 N
Peak COFu	0.26 ± 0.06	0.23 ± 0.05	0.44 ± 0.06	0.42 ± 0.07

PRESSURE INSOLES DATA

Assessment of pressure distribution between plantar surface of foot and shoe insole



PRESSURE AT IMPACT



REDISTRIBUTION OF GRF COMPONENTS: WHICH MECHANISMS?

Propensity to slide on clay

Measure of internal loads

IMPORTANCE OF BIOMECHANICAL TESTS

Biomechanical measures
=
∑(kinematic, dynamic, neuromuscular factors…)

Essential basis for mechanical testing

The University Of Sheffield.

UNIVERSITY OF EXETER

Future Project Direction

- Development of an improved test rig.
- Use the boundary conditions to mechanically simulate real-life movements.
- Improved understanding the physical interaction between the player and the surface.